International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-4, February 2020

Influence of Albite Activator in Geopolymerisation of Slag Wastes from Iron and Aluminium Industry

Nagashree B, Mourougane R, R Hari Krishna

Abstract: ***Geopolymerization mechanism involves the reaction between materials rich in silica and alumina in the presence of alkaline medium to form a polymer structure. Present study involves in usage of the raw materials, which are the waste slag products from iron industry (GGBS) and aluminum industry (RED MUD – RM) in the various proportions of RM: GGBS as 0:100,25:75,50:50,75: 25,100:0 in presence of albite activator(AA) and NaOH which initiates polymerization and finally resulted in obtaining geopolymer concrete(GPC). Various experiments were conducted to analyze the mechanical and microstructure performance of the obtained GPC and therefore compared with the normal conventional concrete. Results showed that with 0% RM and 100% GGBS performs best when compared to Normal conventional concrete(NCC).***

Keywords: Red Mud (RM), Ground Granulated Blas Furnace Slag (GGBFS), Albite (AA), GPC, NCC

I. INTRODUCTION

In construction industry, cement is the material used in a great extent. India being the second largest cement producer across the globe next to China. Ordinary Portland Cement is commonly used to bind the aggregates to form concrete as a result of which cement industry has grown to an enormous extent. In the present days, the major problem is environmental quality depletion. Cement production industry is the one, responsible for causing 5 – 7% of total environmental pollution in the world (Ref: www.flsmidth.com). The production of one ton of Ordinary Portland Cement releases 900kg of carbon-di-oxide, which leads to greenhouse effect.

To overcome this problem, a rigorous research started in search of cement alternatives in order to reduce consumption of natural resources as well as environmental quality deterioration. One such attempt led to the invention of geopolymer concrete which involves either full replacement or partial replacement of Cement by geopolymer like Red mud, fly ash, GGBS, rice husk ash etc.

Revised Manuscript Received on February 28, 2020.
* Correspondence Author

Nagashree B*, Department of Civil Engineering, Ramaiah Institute of Technology, Bengaluru, Affiliated to Visvesvaraya Technological University Belagavi, Karnataka India

Dr Mourougane R, Department of Civil Engineering, Ramaiah Institute of Technology, Bengaluru, Affiliated to Visvesvaraya Technological University Belagavi, Karnataka India.

Dr R Hari Krishna, Department of Chemistry, Ramaiah Institute of Technology, Bengaluru, Affiliated to Visvesvaraya Technological University Belagavi, Karnataka India

In reference to the cement alternative, a new technology developed by Davidovits in 1980s known as Geopolymer concrete. This led to the discovery of Geopolymer cement.

Geopolymer, it is the combination of two words "geo" and "polymer". Geo means earth and polymer means a compound having a large-molecules made up of a linked series of repeated simple monomers. Geopolymer is defined as an inorganic polymeric material with a large quantity of silica and alumina. These materials are obtained either from earth origin or as a by-product from industry such as fly ash (thermal power plant), GGBS (steel plant), Red mud (Alumina industry), rice husk ash (rice milling) etc… Geopolymer cement is the binding material prepared from geopolymer materials. In pursuance of limiting the environmental pollution and to cut down the dependency of cement and preponderantly for the effective disposal of red mud and GGBS, we have used Red mud and GGBS as a geopolymer binder material. In order to accomplish the Geopolymerization alkali activator solution is added to give initiation to reaction. Various research works were carried out to achieve geopolymer concrete by using either sodium based or potassium based alkali activator, But the present study concentrates on using the rock based alkali activator for initiation of geopolymerization reaction.

II. EXPERIMENTAL WORK

The work involved in production of geopolymer concrete with varying proportion of Red Mud and GGBS with rock based alkali activator. The work involved production of Geopolymer concrete and comparison of its mechanical properties with that of OPC concrete of grade M_{40}. GPC production involves of RM, GGBS and Feldspar along with an alkaline solution (NaOH) of 10M in design quantities and the so produced concrete was subjected to one-day steam curing. The strengths of GPC and OPC concrete were studied and reported

III. MATERIALS USED

Materials used for the present work is as follows

A. Red Mud (RM)

Red Mud is the slag obtained from Bayer's process during extraction of aluminum from Bauxite ore. For our present study Red Mud is procured from HINDALCO, Belagavi Elemental composition for the procured red mud is analyzed by EDAX and results are shown in table1

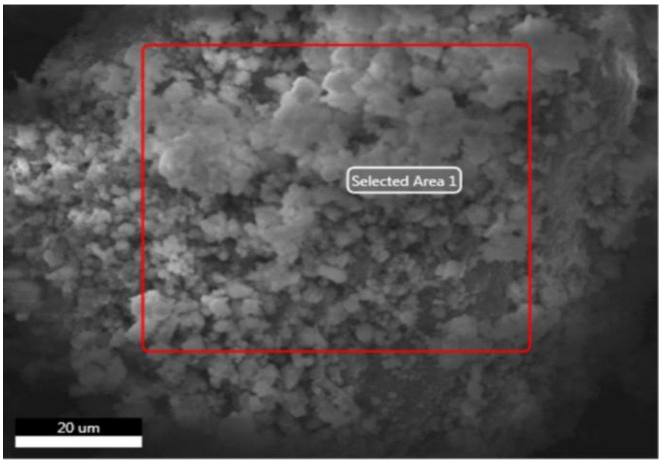


Fig 1: EDAX analysis of Red MUD

Table 1: Elemental composition of Red mud

eZAF Smart Quant Results		
Element	**Weight%**	**Atomic%**
C K	5.25	10.68
O K	34.33	51.5
Na K	9.38	9.45
Al K	10.88	9.33
Si K	5.44	4.34
Ca K	1.21	0.55
Ti K	4.37	2.12
Fe K	26.86	10.55

B. Ground Granulated Blast Furnace slag(GGBFS)

GGBS is a waste by-product obtained from the iron industry. Elemental composition of GGBS are shown in table 2

Fig 2: EDAX analysis of GGBS

Table 2: Elemental composition of GGBS

eZAF Smart Quant Results		
Element	**Weight%**	**Atomic%**
C K	5.00	8.55
O K	45.44	59.88
Mg K	3.24	2.66
Al K	8.22	6.26
Si K	14.04	10.28
Ca K	22.87	11.76
Fe K	0.12	0.03

C. Alkali Activator

It is the combination of Albite ($NaAlSi_3O_8$) and sodium hydroxide (NaOH).

NaAlSi3O8 + NaOH = Alkaline solution

D. Cement

Ordinary Portland Cement of 53 grade has been used for work.

E. Aggregates:

Coarse Aggregates and fine aggregates confirming to of IS 383:1970 are used in the present work.

IV. MIX DESIGN

Since Mix design for geopolymer concrete is not available in IS codal provisions Hence concrete density method given by Lloyd and Rangan (2010)[1]was adopted for the present work. Density of concrete was assumed as 2400kg/m^3 having a combined aggregate volume of 75%, out of which 70% is coarse aggregate and 30% is fine aggregate. Alkaline to binder ratio 0.35 is adopted. The conventional concrete of M_{40} grade was designed as per IS 10262-2009. Water cement ratio of 0.4 is adopted for mix design.

V. METHODOLOGY

- The work involves in production of geopolymer concrete by varying the proportion of RM: GGBS -0:100,25:75,50:50,75: 25,100:0.
- Trial mix for the above mentioned proportions were done by taking alkaline to binder ratio of 0.35,0.4 and 0.45, further with 0.35 of alkaline to binder ratio obtained the best results.
- Appropriate quantity of Albite powder and Sodium Hydroxide pellets are mixed in a liter of water to get the alkali solution of 10M.
- With 0.35 alkaline to binder ratio and 0.4 of W/C ratio the cubes were casted for the above mentioned binder proportions and cured in steam curing chamber for 7,14 and 28 days.
- The cured specimens were tested for the mechanical and microstructure behavior and then it is compared with the normal conventional concrete of grade M_{40}

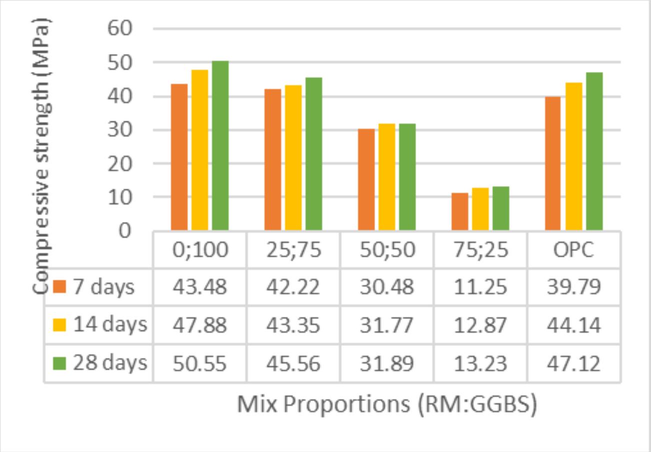
VI. EXPERIMENTAL STUDY

Mechanical properties were studied for the casted specimens by conducting compressive strength, split tensile strength and flexural strength tests. Microstructure analysis was carried out using Scanning Electron Microscope for the optimum proportion and results are tabulated as follows

1. **Compressive Strength Test** was conducted concrete specimens of size 100 mm × 100 mm × 100 mm as per IS 516: 1959 using Universal Testing Machine. Compression test was carried out for various proportions of GPC for curing period of 7,14 and 28 days and then compared with that of OPC. The results were expressed table 3 and graphical form in graph 1

Table 3: Compressive strength for various curing periods

RM:GGBS	Compressive strength in N/mm^2		
	7 days	14 days	28 days
0:100	43.88	47.88	50.55
25:75	42.22	43.35	45.56
50:50	30.48	31.77	31.89
75: 25	11.25	12.87	13.23
100:0	0	0	0
OPC	39.79	44.14	47.12



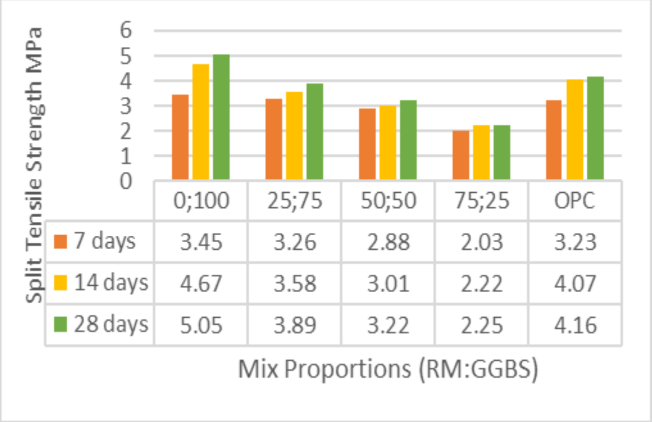
Graph 1: Mix Proportion versus compressive strength of GPC and OPC.

From the graph, it was clear that as the percentage of RM increases the strength of the specimen decreases. Since it has been observed from Fig1 that the element bonding in red mud is weak, hence the GPC with increase in RM content makes the concrete weak, whereas, from Edax analysis of GGBS it can be seen that the bond strength of the elements in GGBS is more hence porosity of GPC with less with higher GGBS content. RM: GGBS (100:0) is not shown in the graph since could not take any load. Thus 0:100 (RM: GGBS) ratio provide better strength than compared other proportions.

2. **Split tensile strength** for concrete specimens with size 100mm in diameter and 200mm height were evaluated as per the code IS516: 1999 using UTM. Split tensile test for GPC and OPC concrete was conducted at 7, 14, and 28 days. The results were expressed in table 4 and graphical form in graph 2

Table 4: Split Tensile strength for various curing periods

RM:GGBS	Split strength in N/mm^2		
	7 days	14 days	28 days
0:100	3.45	4.67	5.05
25:75	3.26	3.58	3.89
50:50	2.88	3.01	3.22
75: 25	2.03	2.22	2.25
100:0	0	0	0
OPC	3.23	4.07	4.16



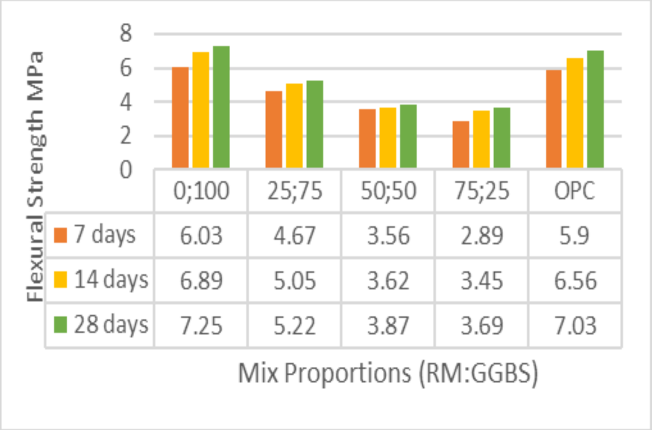
Graph 2: Mix Proportion versus Split tensile strength of GPC and OPC.

From the above graph it is clear that as the RM percentage increase the split tensile strength decreases.

3. **Flexural strength** of GPC specimens and OPC specimens were determined by conducting flexural strength test using two-point loading technique on samples of standard size 450mm x 75mm x75mm. The results were expressed in table 5 and graphical form in graph 3

Table 5: Flexural strength for various curing periods

RM:GGBS	Split strength in N/mm^2		
	7 days	14 days	28 days
0:100	6.03	6.89	7.25
25:75	4.67	5.05	5.22
50:50	3.56	3.62	3.87
75: 25	2.89	3.45	3.69
100:0	0	0	0
OPC	5.9	6.56	7.03



Graph 3: Mix Proportion versus Flexural strength of GPC and OPC.

Energy Dispersive X-ray Spectroscopy (EDAX) analysis of GPC for optimum proportion (0:100)-RM: GGBS

Energy Dispersive X-ray spectroscopy is an analytical technique used for the elemental analysis or chemical characterization of a sample. It relies on an interaction of some source of X-ray excitation and a sample. Its characterization capabilities are due in large part to the fundamental principle that each element has a unique atomic structure allowing a unique set of peaks on its electromagnetic emission spectrum

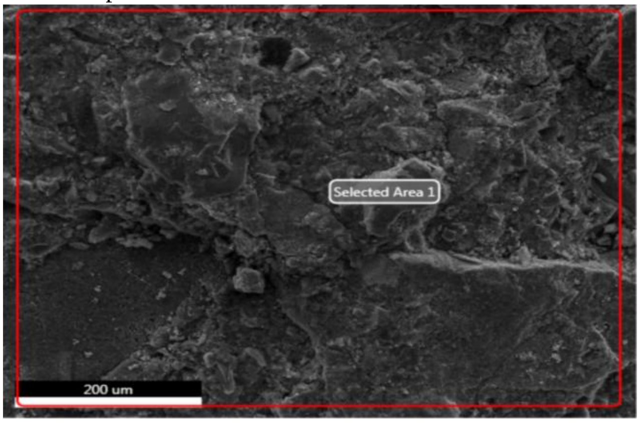
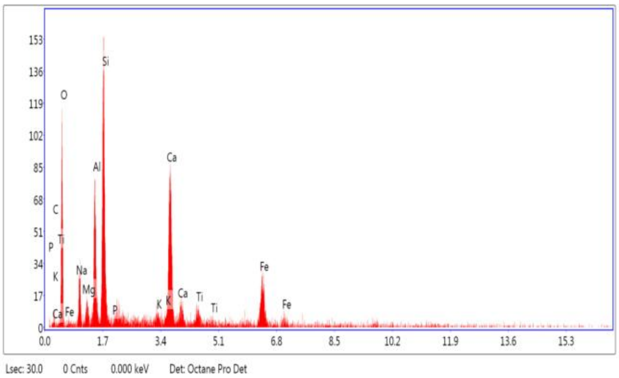


Fig 3: EDAX analysis of optimum proportion(O:100-RM:GGBS)

Table 6: Elemental composition of the optimum proportion(O:100-RM:GGBS)

eZAF Smart Quant Results		
Element	**Weight%**	**Atomic%**
C K	5.56	9.72
O K	42.20	55.30
Na K	7.05	6.47
Mg K	1.75	1.52
Al K	7.82	6.20
Si K	15.02	11.02
K K	0.57	0.33
Ca K	11.36	6.04
Ti K	1.33	0.62
Fe K	7.82	2.98



Graph 4: EDAX analysis of optimum proportion(O:100-RM:GGBS)

From the above EDAX analysis for the optimum specimen, the weight percentage of Silica is more in ratio 0:100 (RM: GGBS), Since fineness of silica is more hence bonding strength will be more which contribute for the ultimate strength of concrete.

VII. CONCLUSIONS

From the various trial mixes, it has it has been suggested that alkaline to binder ratio of 0.35 and water cement ratio of 0.4 produced optimum mix proportion.

The mechanical strength of the GPC increases with increase in the GGBS proportion and decrease in the RM proportion.

By EDAX result (table 1 & 2) it has been observed that GGBS contains more silica content and RM contains more Alumina content.

Therefore, the as the GGBS content in the concrete increases, silica percentage in the concrete will be more so that the strength of the concrete will be more due to the higher bond strength in GPC.

Further it has been observed that RM contains more alumina content which makes the weak. Therefore as the RM content increases the strength decreases.

REFRENCES

1. Singh SP, Samantasinghar S, Sindhuja D. Influence of GGBS on strength of Red mud stabilized by alkalination process. In: Indian Geotechnical Conference. 2016, December 15–16, pp. 1–4.
2. Nain V, Usman M, Kumar A, Sangwan S. Properties of red mud admixed concrete. Int J Res Appl Sci Eng Technol. 2015; 3(1): 7–13p. ISSN 2321-9653.
3. John E, Chalapuram KM, Shebin P, Mohan HK, Frazana Z. Geopolymer concrete using red mud and GGBS. Int Res J Eng Technol. 2016; 03(05): 668-671p. e-ISSN 2395-0056, pISSN 2395-0072.
4. Singh S, Biswas RD. Experimental study on red mud based geopolymer concrete with fly ash & GGBS in ambient temperature curing. Int J Adv Mech Civ Eng. 2016; Special ISSUE – Sept.2016: 5–8p. ISSN 2394-2827.
5. Ananya A, Avarebeel PB, Sambasivam MC, Aswath MU, Singh S. Experimental studies on red mud based geopolymer bricks. Int J Adv Res Eng Sci Technol. 2015; 2(8): 76– 83p. ISSN 2394-2444.

AUTHORS PROFILE

Mrs. Nagashree B, is working as Assistant professor in Civil engineering department at Ramaiah Institute of Technology Bangalore. She holds a M.Tech degree in structural engineering from VTU, Belagavi. Presently she is pursuing Ph D in the field of Structural Engineering from VTU, Belagavi. Her areas of interests include Concrete Technology, Earthquake Engineering, Material Engineering and structural Dynamics. She is a life member of ASCE and IAENG. She has published several technical papers in national and international conferences/journals.

Dr. R. Mourougane, is working as an Associate Professor in civil engineering department of MSRIT. His areas of interests are structural materials and structural steel. He holds PhD from JNTU and is a life member of ICI. He has published several technical papers in national and international conferences/journals.

Dr. R. Hari Krishna, is working as an Assistant Professor in the Department of Chemistry, RIT. He is interested in subjects related to optical studies of Nano materials, luminescence spectroscopy of solids and Nano cellulose based composites.