GGBS BASED REINFORCE GEOPOLYMER CONCRETE

Mayuri Latke[1] A.Waghmare[2]
PG Scholar,Department of Civil Engineering,Dr.Vithalrao Vikhe College of Engineering,Ahmednagar414111,India.
Assi. Professor,Departmentof Civil Engineering,Dr.Vithalrao Vikhe College of Engineering ,Ahmednagar 414111,India.

ABSTRACT

In an attempt to improve the sustainability of construction and reduce portland cement, the use of supplementary cementitious materials, such as ground granulated blast-furnace slag (GGBS), has become a common practice. Concrete is one of the most widely used construction materials which are usually associated with Portland cement as the main ingredient for making concrete. The global warming is caused by the emission of greenhouse gases such as CO_2 into the atmosphere by human activities. Among the greenhouse gases, CO_2 contributes about 65% of global warming. A geo polymer or alkali-activated cement is an inorganic, alumino-silicate based material. The strengths of geo polymer mortar and concrete are of the same order as those made with normal Portland cement. A wide range of materials is being used for Geo polymerization including materials rich in Si(e.g. fly ash, GGBS and rice husk) and materials rich in Al (e.g. clays like kaolin, betonies, and burned clays). Because of its availability, fly ash is considered among the important sources of geopolymer. As per IS 3812 (Part II): 2013, fly Ash is defined as pulverized fuel ash extracted from flue gases by any suitable process such as by cyclone separator or electro-static precipitator'. It is a byproduct of thermal power plants which is facing the problems of its disposal. Government of India has taken initiative through 'Fly Ash Utilization Programme' to increase utilization of fly ash in concrete, brick, agriculture etc. It is expected that such program will help to meet the reduction of CO_2 emission.

INTRODUCTION

1.1 Introduction to Geo polymer Concrete

The granulated slag is ground to desired fineness for producing GGBS, But research was going on since 1930 for complete replacement of cement as binder material. Due to presence of SiO_2 and Al_2O_3 in fly ash, it is very useful in making of special cement.

The name "Geo-polymer" was coined by Prof. J. Davidovits in 1978 and he found that the polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that result in 3D polymeric chain and ring structure consisting of Si-O-Al-O bonds.

1.2 Properties of Geo-Polymer Concrete :

- Set at room temperature
- Early strength gain is possible
- Bleed Free
- Long working life
- Impermeable
- Higher resistance to heat & resist all inorganic solvents.

1.3 Need for the Study

- To find an alternative for the ordinary Portland cement.
- To reduce CO_2 emission and produce eco-friendly concrete.
- To develop a cost efficient product.
- To provide high strength concrete than ordinary Portland concrete.

1.4 Objectives

1. To study the effect of various percentage of CaO content on GGBS based geo polymer concrete.

2. To study the effect of various percentages of GGBS on GGBS based geo polymer concrete .

3. To study the different mechanical properties of GGBS based geo polymer concrete.

4. To study the effect of 12 molarity and 16 molarity NaOH solution on GGBS based geo polymer concrete.

1.5 Limitations of work

1. Geo polymer concrete is not widely used in applications.
2. Durability of geo polymer concrete need to be studied.
3. Geo polymer solution of the required specification is not easily available.

1.6 Scope of work

1. Effect of fineness of fly ash on properties of geo polymer concrete.

2. Effect of different curing methods on properties of geo polymer concrete.

3. Study of durability of geo polymer concrete.

1.7 Problem Statement

At present time there is a large focus on the environment and associated environmental impact of products and materials. The production of concrete is responsible for 4 % of man-made global warming. It has been reported in literature that Geo polymer concrete has the potential to reduce the carbon emission. Sustainable development goals can be achieved through the use and development of different applications of geo polymer concrete in construction industry.

Literature Survey Concrete is the most widely used construction material in the modern world. Cement production consumes huge energy and causes about 6 % of total greenhouse gas emission in the world. Hence utilization of alternative binding material adds sustainability to concrete by reducing the CO_2 emission of cement production and to enhance durability. The positive effects of fly ash and GGBS as a full replacement of cement on the durability of concrete are recognized through numerous researches.

Davidovits introduced the name Geo polymer in 1978 to represent a broad range of materials characterized by networks of inorganic molecule . The results of a study on Ground Granulated Blast Furnace Slag (GGBS) and Rice Husk Ash (RHA) used in the Production of Geo polymer Concrete was studied by Sundeep et al (2016).The results of the study indicates that GGBS and RHA use in the production of geo polymer mortar or concrete depends on the ratio of SiO_2 to Al_2O_3. Higher proportion of Al_2O_3 is desired in order to completely replace fly ash in geo polymer. The results of this study are based on a single fly ash, GGBS, and RHA. Results needed to be validated by using materials from different sources. Further study is recommended by changing the proportions of SiO_2/Na_2O and molarity of NaOH of alkaline solutions to study their impact on properties of Geo polymers made with different base materials. The result of the study on the Mechanical Properties of High Strength Geo polymer Concrete was determined by Nagesh Kumar et al (2016). Hence GPC can be considered an eco friendly material. Workability characteristics of GPC depend on mixing time of GPC that is workability of GPC is directly proportional to the mixing time. To check the suitability of GPC in cast-in-situ conditions, specimens are cured at room temperature, which gave good results. When compared with plain GPC and OPC concrete, Compressive Strength and Split Tensile Strengths at 7 days

and 28 days are higher in GPC. Experimental investigation has been carried out by Patankar et al (2015) for the gradation of geo polymer concrete and a mix design procedure is proposed on the basis of quantity and fineness of fly ash, quantity of water, grading of fine aggregate and fine to total aggregate ratio .The result of a study on Setting Time, Strength, and Bond of High-Calcium Fly Ash Geo polymer Concrete was studied by Prinya Chindaprasirt et al (2014). The results in this study indicated that high-calcium fly ash was suitable to use in producing high strength geo polymer concrete with high bond strength between concrete and rebar. The splitting tensile strengths of HCGC were relatively high in terms of percentage of compressive strength, which was probably due to the strong interfacial zone of the aggregate and the high calcium geo polymer matrix. Rao and Acharya (2014) studied use of geo polymer in place of ordinary Portland cement is favored owing to the possible energy and carbon dioxide savings. River sand is another construction industry material that needs development of a sustainable alternate in Indi

MATERIALS AND METHODOLOGY

3.1 General

This Chapter presents the details of development of the process of making geopolymer concrete by effect of percentage of CaO content on strength of GGBS based geopolymer concrete using various percentage of GGBS.

3.2 Materials

The main ingredients of geo polymer concrete are as follows,

1. Fly ash
2. GGBS
3. Alkaline solution
4. Fine aggregate
5. Coarse aggregate.

3.4 Methodology for mix design of Geo polymer Concrete

As Geo polymer concrete is new invention, the procedure for mix design of conventional concrete as per the procedure of Bureau of Indian Standards IS 10262: 2009 is not applicable. In the present study, mix design procedure suggested by prof. S.V. Patankar is used for M40 grade

of geo polymer concrete. Mix design procedure as proposed is based on quantity and fineness of fly ash, quantity of water, grading of fine aggregate and fine to total aggregate ratio.

3.4.1 Parameters considered for mix proportioning of Geo polymer Concrete

For the development of fly ash based geo polymer concrete mix design method, detailed investigations have been carried out and following parameters were selected on the basis of workability and compressive strength.

3.4.1.1 Fly ash

3.4.1.2 Alkaline activators

3.4.1.3 Water

3.4.1.4 Aggregates

3.4.1.5 Degree of Heating

3.4.1.6 Water-to-Geo polymer binder ratio

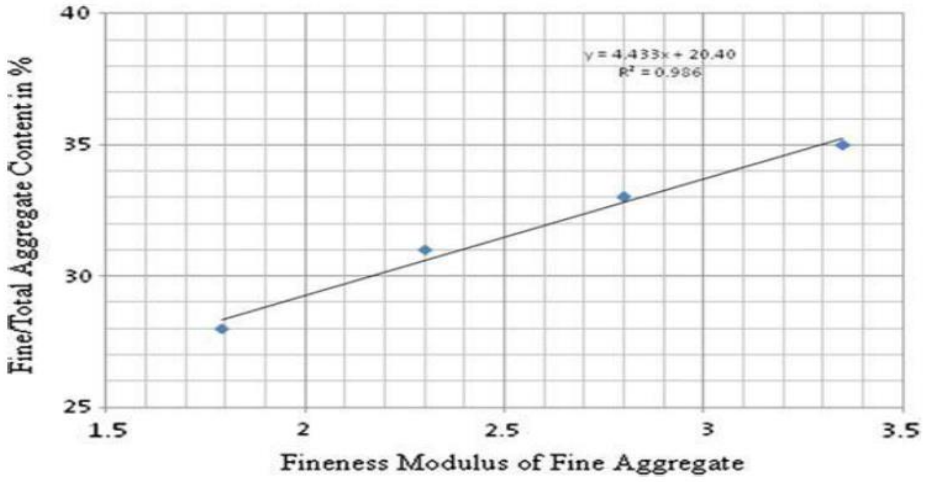

Figure No.3.2 Relation between fineness modulus of fine aggregate and fine to total aggregate content (Source: Patankar et al 2015).

Table No. 3.9 Effect of heating temperature, duration and test period on compressive strength of Geo polymer Concrete (Source: Patankar et al 2015).

Sr. No	Temperature(^{0}C)	Duration of heating (h)	Compressive strength in MPa				
			Tested after heating @ 45^{0}c				
			1 DAY	2 DAY	3 DAY	4 DAY	5 DAY
1		8	-	-	11.56	17.76	38.78

2	60	12	5.67	9.11	15.67	22.56	40.22
3		24	13.11	19.67	26.78	36.00	42.33

3.4.1.7 Solution to fly ash ratio

.3.4.2 Preparation of Geo polymer Concrete Mixes

Preparation of geo polymer concrete is similar to that of cement concrete. Two types of coarse aggregates, sand and fly ash were mixed in dry state. Then add prepared mixture solution of sodium hydroxide and sodium silicate along with extra water based on water-to-geopolymer binder ratio and mix thoroughly for 3–4 min so as to give homogeneous mix.

3.4.3 Method Proposed for mix proportioning

Based on the experimental investigation carried out in the present study the following mix proportioning method is proposed.

3.4.3.1 Data required for mix design

1. Characteristic compressive strength of Geo polymer Concrete (fck)
2. Fineness of fly ash in terms of specific surface in m^2/kg
3. Workability in terms of flow
4. Oven curing (heating) 45°C for 24 h and tested after 7 days
5. Fineness modulus of fine aggregate
6. Water absorption and water content in fine and coarse aggregate.

3.4.3.2 Mix Design for M40 grade of Geo polymer Concrete

Using proposed method by Prof. S.V.Patankar, a sample mix proportioning for M40 grade of geo polymer concrete is carried out using proposed method. Following preliminary data is considered for mix design.

1. Characteristic compressive strength of geo polymer concrete (fck) = 40mpa
2. Type of curing: oven curing at 45ºC for 24hr and tested after 1 day
3. Workability in terms of flow : 50-100%(degree of workability high)
4. Fly ash : fineness in term of specific surface = $430m^2/kg$
5. 5.Alkaline activators (Na_2Sio_3 and NaOH)
   a) Concentration of sodium hydroxide in terms of molarity :12M and 16M
   b) Concentration of sodium silicate solution :48.19% solid content
6. Solution-to-fly ash ratio by mass : 0.38

7. Sodium silicate-to-sodium hydroxide ratio by mass :2.0

   c) Water content : nil

8. Fine aggregate

   a) Type : Natural river sand confirming to grading zone-ii as per IS383-1970,

      F.M. = 2.65

   b) Water absorption : 3.67

9. Coarse aggregate

   a) Type : crushed /angular

   b) Maximum size: 20 mm

   c) Water absorption: 0.89%

   d) Moisture content: Nil

3.4.3.6 Preparations of specimen

For the preparation of specimen, following procedure is adopted for strict quality control.

3.4.3.6.1 Measurement of ingredients

All fly ash, sand and coarse aggregate 20 mm respectively are measured with digital balance. The water is measured with measuring cylinder of capacity 1 liter and measuring jars of capacity 1000ml and 2000 ml are measured with digital balance of accuracy 1mg.

Table no.3.13 schedule of specimen preparation

TRIAL	MOLARITY OF NaOH	% OF FLY ASH	% OF GGBS	COMPRESION OF STRENGTH (MPA)			FLEXURAL TEST	SPLIT TENSILE TEST
DAYS ⟹				3	7	28	28	28
1	12	85	15	3	3	3	3	3
2	14	85	15	3	3	3	3	3
3	16	85	15	3	3	3	3	3
4	12	70	30	3	3	3	3	3
5	14	70	30	3	3	3	3	3
6	16	70	30	3	3	3	3	3
7	12	50	50	3	3	3	3	3
8	14	50	50	3	3	3	3	3

9	**16**	**50**	**50**	**3**	**3**	**3**	**3**	**3**
GRAND TOTAL				**24**	**24**	**24**	**24**	**24**

3.5 Testing of specimens

There are many tests which are conducted to check the quality of concrete. These tests are basically divided into two categories i.e. Fresh concrete test and hardened concrete test.

3.5.1 Fresh Concrete Test

Fresh concrete tests are conducted immediately after mixing of concrete. These are the tests used to check the workability of concrete. Various tests such as slump cone, vee bee, compaction factor and flow table test are generally conducted. In the present study, due to polymerization process there is continuous expulsion of water so flow table test is recommended.

3.5.1.1 Flow table test (IS: 1199- 1959)

The flow of the concrete shall be recorded as the percentage increase in diameter of the spread concrete over the base diameter of the moulded concrete, calculated from the following formula.

$$\text{Flow, percent} = \frac{\text{Spread diameter in cm} - 25}{25} \times 100$$

3.5.2 Hardened Concrete Test

Testing of hardened concrete plays an important role in controlling and material used and greater assurance of performance of concrete. In the present study test conducted on harden concrete were carried out by using Compressive Testing Machine(CTM) of capacity 2000 kN and Universal Testing Machine (UTM) of capacity 200 KN as per IS 516:1959.

3.5.2.1 Compressive Strength Test: (IS 516:1959)

3.5.2.3 Split tensile test: (IS 5816:1999)

RESULT

TRIAL	MOLARITY	FLYASH	GGBS	FLEXURE STRENTGH AT 28 DAYS IN MPa	SPLIT TENSILE STRENGTH AT 28 DAYS IN MPa
1	12M	100	0	8.11	8.11
2	16M	100	0	10.30	10.30
3	12M	80	20	10.26	10.26
4	16M	80	20	10.56	10.56
5	12M	60	40	12.85	12.85
6	16M	60	40	12.90	12.90
7	12M	50	50	12.38	12.38
8	16M	50	50	12.34	12.34

CONCLUSIONS

It is observed from the previous study that;

1. As there is CaO content in GGBS based geo polymer concrete the curing temperature required for Fly ash based geo polymer concrete is 60^0C but it can be reduced by addition of GGBS to the fly ash based geo polymer concrete up to 45^0C.

2. In case of fly ash based geo polymer concrete as there is no CaO content, curing of fly ash based geo polymer concrete takes place due to polymerization process but with the addition of GGBS to the fly ash based geo polymer concrete, the curing temperature due to combined effect of polymerization as well as heat of hydration due to presence of alkaline solution and CaO respectively.

3. Workability of Geo polymer concrete was found to be very stiff before addition of extra water.

4. As conventional concrete requires external curing due to heat of hydration reaction but there is expulsion of water in the polymerization process of Geopolymer concrete so no extra curing is required.

5. Compressive strength of geo polymer concrete increases with increase in percentage of replacement of fly ash with GGBS. Fly ash was replaced by GGBS up to 40%, beyond that fast setting was observed.

6. Molarity of sodium hydroxide is major parameter which affects the mechanical strength of geo polymer concrete.

REFERENCES

1. Sundeep and Megha Sharma (2016)," Ground Granulated Blast Furnace Slag (GGBS) and Rice Husk Ash (RHA) Uses in the Production of Geo polymer Concrete", Dept. of Civil Engineering, The Univ. of Texas at El Paso, El Paso, TX 79902.

2. Patankar Subhash V., Ghugal Yuwaraj M and Jamkar Sanjay S. (2015) "Mix Design of Fly Ash Based Geo polymer Concrete" Springer India.

3. Naidu Ganapati. Prasad A.S.S. N, Adiseshu S., Satayanarayana P.V.V (July 2014), "A study on strength properties of geo polymer concrete with addition of G.G.B.S" International journal of engineering research and development, volume 2, Page No. 19-28.

4. Anuradha R., Sreevidya V., Venkatasubramani R., and Rangan B.V. (2012), "Modified guidelines for geo polymer concrete mix design using Indian standards," Asian journal of Civil Engineering, vol. 13, pp. 353–364.

5. Joseph, B., and Mathew, G. (2012). "Influence of aggregate content on the behaviour of fly ash based geo polymer concrete." Sci. Iran., 19(5), 1188–1194.

6. Patankar S. V., Jamkar S. S., and Ghugal Y. M. (2012), "The effect of partial replacement and full replacement of cement by low calcium fly ash," Journal of structural Engineering, vol. 39, no. 1, pp. 7–12.