EFFECT OF CHEMICAL COMPOSITION OF REACTION GENERATING LIQUID ON THE STRENGTH CHARACTERICTCS OF HIGH VOLUME FLYASH BASED GEOPOLYMER CONCRETE MIX

Aswathy sugu
Department of civil engineering
Mangalam College of Engineering
Kottayam
Emailid: aswathysuguengg@gmail.com

Dr. N P Rajamane
Head CACR
SRM Institute of Science and Technology
Kattankulathur, Tamilnadu

Abstract— *Geopolymer is a class of aluminosilicate binding materials synthesized by thermal activation of solid aluminosilicate base materials such as fly ash, GGBS etc with an alkali metal hydroxide and silicate solution. The present program investigates the impact of sodium oxides and silicate di oxide content of alkaline activated solution on the cs of high volume fly ash based geopolymer concrete. The solutions 1:2:7, 1:4:5 and 1:7:2 were prepared and used for casting of standard cubes of size 100X100mm and cylinders of size 100X200mm. The result shows that as the sodium oxide and silicate dioxide content increases the rate of reaction also increases and the compressive strength of geopolymer concrete is correspondingly increasing. Also it is found that, the geopolymers that are cured at a high temperature of 80⁰C possess high compressive strength than the room temperature curing*

Keywords— Geopolymer, reaction generating liquid, silicatedioxide, sodium oxide

1. INTRODUCTION

Cement is used as the binding agent of concrete in world wide. But the manufacturing of cement will result in the emission of CO_2 resulting from the calcinations of lime stone in to the atmosphere which will result in to serious environmental issues. In such regard, geopolymer concrete can be considered as potential applicant material. The name geopolymer was the first time coined by Devidovits[1]. In geopolymer concrete, cement is replaced by fly ash and ground- granulated blast furnace (GGBS) and an reaction generating liquid (RGL) which is a mixture of sodium hydroxide and sodium silicate will replace the water. This reaction generating liquid is prepared by mixing sodium oxides, silicate di oxide and water with certain proportion. This paper investigates about this proportion of RGL and the effect of sodium oxides and silicate di oxide in geopolymer concrete with 80% fly ash and 20% GGBS.

2. SCOPE OF THE PRESENT STUDY

The geopolymer mix is mainly consisted to four ingredients

1) Geopolymer Source Material (GSM)

Powderly ingredient of the mix such as fly ash, GGBS etc

2) Fine Aggregate in the form of M Sand
3) Coarse Aggregate
4) The liquid component known as the Reaction Generating Liquid (RGL)

The geopolymer source material (GSM) of the concrete mix was prepared by mixing fly ash and GGBS in the ratio of 4:1. Thus the binder portion is having 80% fly ash and 20% GGBS. This proportion are based on the extensive work on geopolymer at SRM university at ambient temperature curing, thereby avoiding the necessity fact keeping the moulds of GPC mix in the oven as reported by many research works in the literature[2].

The three numbers of RGL prepared with varying chemical composition. The rate of RGL used RGL/GSM ie, liquid/binder was arrived 0.65 based on the trial mixes to achieve the satisfactory workability of the mixes.

The compressive strength was required at 7 and 14 days using the cubes of size 100 X100mm and the split tensile strength were measured using cylinders of size 100 X 200mm. The test data was analysed understanding the chemical composition of RGL and the strength characteristics.

3. LITERATURE REVIEW

GajjalaRamya, D SVSMRK Chekravarthy[3]: In this study, the development of geopolymer concrete was carried by using fly ash and GGBS river sand and

quartz sand in equal proportions the mix design adopted was aimed for high 50MPa the mechanical properties like compressive strength, rupture strength, split tensile strength was focused which has exhibited good in increase in its characteristics. It is found that the use of binder's fly ash and GGBS in equal ratio had shown standard increase in compressive split tensile and flexural strength geopolymer concrete.
Increases in compressive strength and tensile strength of concrete with FA as SRM were reported by Bakoshi et al.[4]
The source materials may be industry throw away products such as Fly ash, slag, red mud, ash and silica fume may be used amalgamation of geopolymers. The alkaline liquids are strenuous aqueous alkali hydroxide with soluble alkali metals, usually sodium-(Na) or potas-sium-(K) based. The earlier in-vestigators have discussed the development and properties of low-calcium FA based GPCs[5].
They have described the development, the blend proportions and the short-term properties of low-calcium FA based GPC concrete. It was concluded that low-calcium FA-based GPCs had brilliant CS, suffer very little drying shrinkage and low creep, had excellent opposition to sul-phate attack, and good acid resistance. The research report describes the structural behavior of GPCs beams and columns.

4. MATERIALS

4.1 FLYASH

Fly ash is a product of which the coal is combusted and that is composed of the particles that are driven out of coal- fired boilers together with the tube gases. The properties of fly ash is cited in table [1]

4.2 GGBS

Ground granulated blast furnace slag is produced in thermal industries obtained by extinguish molten iron slag (a byproduct of iron and steel making) from a blast kiln in water or steam, to produce a glassy, grainy product called GGBS. The properties of GGBS are cited in table [1]

Table 1: properties of fly ash and GGBS

Property	**Fly ash**	**GGBS**
Specific Gravity	2.2	2.8
Appearance	grey	Greyish white
Particle Size	30 microns	25 microns

4.3 REACTION GENERATING LIQUID (RGL)

This is the alkaline solution commonly referred as Alkaline Activator Solution (AAS) in the literatures. The word alkalinity refers to chemical nature of the liquid having higher amount of OH ions however measured commonly by pH value using pH meter. Our observation shows that the alkalinity level on the geopolymer concrete and the conventional cement concrete mixes in fresh state was having the pH level in the order of 12 – 13. Thus we feel like the term alkaline to the solution can be avoided and since the liquid generates the chemical reaction in the alumina and silica containing Powderly (eg: Fly ash, GGBS etc) of the GPC mix. Therefore in this paper the term AAS is replaced by "RGL".
The RGL is generally prepared by mixing the laboratory available sodium hydroxide solution with commercially available silicate solution. We may note that, here the RGL is thus a sodium silicate solution having the weight ratio (SiO_2/Na_2O) less than sodium silicate solution which is commercially available.
As in the case of sodium silicate solution, the RGL is also characterized by the content of % Na_2O, %SiO_2 and % H_2O in the solution. Using this approach three RGL were prepared by different amalgamation of sodium hydroxide and sodium silicate solutions and the compound characterizes of this is described in table [2]

Table 2: Chemical characteristics of RGL

RGL	**S(%)**	**N(%)**	**H(%)**	**S/N**	**S+N (%)**
A	6	10	84	0.6	18
B	12	14	75	0.85	26
C	21	18	61	1.14	39

The table shows that (1) the RGL A, B, C having gradually increasing contains of sodium oxides (Na_2O), silicate dioxide (SiO_2) and the weight ratio (SiO_2/NaO_2), (2) The water content of the RGL is gradually reduced. It was noted that the viscosity of RGL is more that of water.

4.4 FINE AGGREGATE

This was a M sand having fineness modulus 2.9 m^2/kg, specific gravity of 2.25 and the bulk density of 1620 kg/m^3.

The M sand was found to be actually crushed stone having similar hardness and crushing strength to that of coarse aggregate which are also basically crushed stone.

4.5 COARSE AGGREGATE

The coarse aggregate with specific gravity 2.6, and bulk density of 1580 was used. The coarse aggregate is the main major component in adding the strength to geopolymer concrete nearly 65% of the geopolymer concrete mix the size of coarse aggregate used is 10mm.

5. PREPARATION OF TEST SPECIMEN

The units contains of ingredients of the GPC mixes are given in the table [3]

Table 3: Contains of GPC mixes

Contains	**Kg/m^3**
Flyash	300
GGBS	70
Fine aggregate	848
Coarse aggregate	1180
RGL	239

The liquid/ solid ratio or liquid/ binder ratio is 0.65. for each batch of mixing in pan mixer, a total of 35kg of materials was used. The fresh concrete mix is found to possess satisfactory workability for compaction by vibration. The casting of cubes is shown in figure 1. And the casting of cylinders is shown in figure 2.

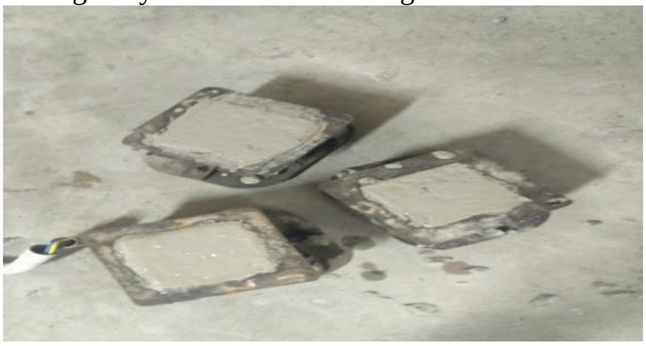

Fig 1: Casting of cubes

The de moulding operation is easily done after 24 hours of casting. The specimens are stored in open area in the laboratory for effective curing under ambient condition of temperature. The general temperature was around 30ºC.

Fig 2: casting of cylinder

6. TEST RESULT AND DISCUSSION

6.1 RGL COMPOSITION

The commercially available Sodium Silicate Solution (SSS) of weight ratio (SiO_2/Na_2O) is 2 was reduced to 0.6,0.85 and 1.14 for the RGL A, B and C respectively by adding stoichiometrically calculated sodium hydroxide solution.

As the water content of RGL 84% in A and 61% in RGL C, it is observed also the change in the viscosity. The viscosity of the RGL A was the lowest and that of C was the highest. This should be attributed to increase the concentration of the solution which was varied from 16% to 39% in RGL A and C respectively. The testing of cubes in compression testing machine is shown in fig 3

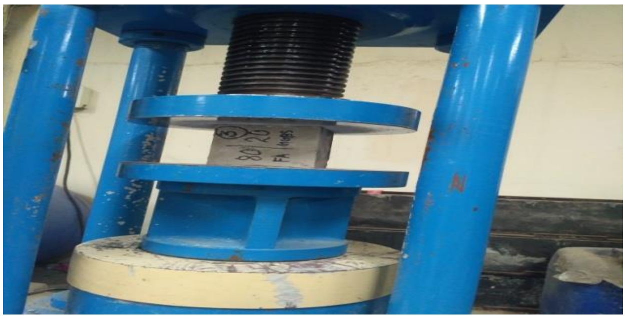

Fig 3: Testing of cubes

6.2 COMPRESSIVE STRENGTH

There is a marginal difference between 7 day and 14 day compressive strength. The compressive strength of cubes at 7 days and 14th days are shown in fig 4.

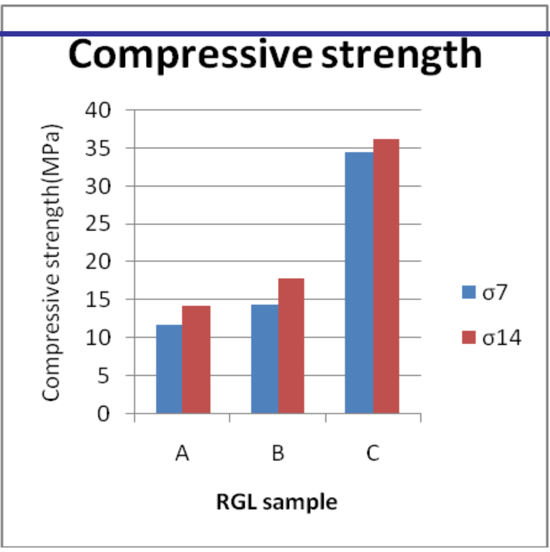

Fig 4: Compressive strength of cubes

The RGL C contributed to achieving maximum 7day compressive strength of 34.5MPa which gets marginally increased by 36.22 at 14 days. This level of strength is sufficient for most of the structural constructions.
The least 14 day compressive strength in the present study was obtained as 14.4MPa for RGL A. This level of strength to be used for many building blocks and pavement applications.

6.3 SPLIT TENSILE STRENGTH
The split tensile strength of cylinders which are casted using RGL A, B and C were tested for 7day and 14 day. The results obtained as

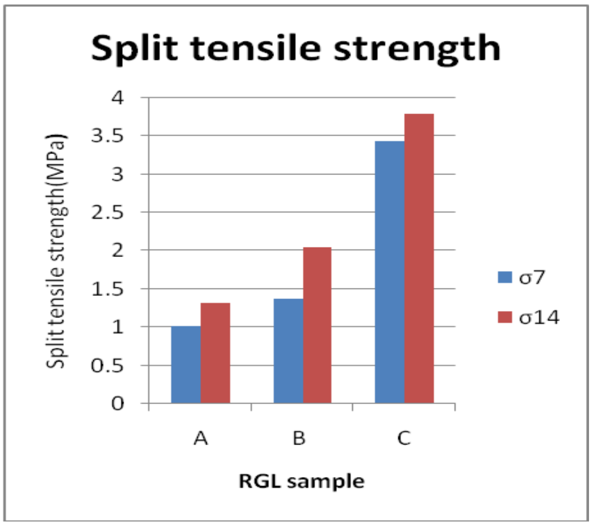

Fig 5: Split tensile strength of cylinders

7. CONCLUSION

1. Compressive strength of geopolymer concrete investigated is increased
   - The sodium oxide content increases
   - Silicate dioxide content increases
   - Solid content of RGL (N+S) increases
   - Weight ratio (SiO_2/Na_2O) increases
2. 20% addition of GGBS was found to provide sufficient reactivity for strength gain at initial stages for enabling the de moulding operation within 24 hrs of casting without any need for high temperature curing as mentioned in many literatures for geopolymer mixes.
3. The strength level obtained in the present study can be considered sufficient for structural applications especially RGL B and C.

8. REFERENCE

[1] C. K. Madheswaran, J. K. Dattatreya, and P. S. Ambily, "Investigation on behaviour of reinforced geopolymer concrete slab under repeated low," vol. 3, no. 3, pp. 10775–10786, 2014.
[2] N. P. Rajamane, J. A. Peter, and P. S. Ambily, "Prediction of compressive strength of concrete with fly ash as sand replacement material," vol. 29, pp. 218–223, 2007.
[3] P. Visintin, M. S. M. Ali, M. Albitar, and W. Lucas, "Shear behaviour of geopolymer concrete beams without stirrups," *Constr. Build. Mater.*, vol. 148, pp. 10–21, 2017.
[4] S. M. G. P. Aggarwal , Y. Aggarwal, "Effect of Bottom Ash As Replacement of Fine Aggregates in Concrete," *Asian J. Civ. Eng. (Building Housing)* , vol. 8, no. 1, pp. 49–62, 2007.
[5] C. A. Jeyasehar and R. Balamuralikrishnan, "Strengthening of structures by HPFRCC laminates," *Asian J. Civ. Eng.*, vol. 13, no. 4, pp. 557–570, 2012.
[6] IS: 383-1970.Specifications for coarse and fine aggregates from natural sources for concrete, Bureau of Indian Standards, New Delhi, India.
[7] IS: 10262-1982. Recommended guidelines for concrete mix design, Bureau of Indian Standards, New Delhi, India.
[8] IS: 1199-1959.Indian Standards methods of sampling and analysis of concrete, Bureau of Indian Standards, New Delhi, India.
[9] IS: 516-1959.Indian standard code of practice methods of test for strength of concrete, Bureau of Indian Standards, New Delhi, India.
[10] Okoronkwo, M. U.; Balonis, M.; Katz, L.; Juenger, M.;

Sant, G. A thermodynamics-based approach for examining the suitability of cementitious formulations for solidifying and stabilizing coalcombustion wastes. J. Environ. Manage. 2018, 217, 278−287

[11] Adewuyi, Y. G.; Khan, N. E. Modeling the ultrasonic cavitationenhanced removal of nitrogen oxide in a bubble column reactor. AIChE J. 2012, 58, 2397−2411

[12] M.F. Nuruddin, A.B. Malkawi, A. Fauzi, B.S. Mohammed, H.M Almattarneh, Geopolymer concrete for structural use: Recent findings and limitations, IOP Conference Series: Materials Science and Engineering. 2016. IOP Publishing

[13 D. Khale, R. Chaudhary, Mechanism of geopolymerization and factors influencing its development: a review, Journal of Materials Science, 42 (2007) 729-746.