EXPERIMENTAL INVESTIGATION ON GEOPOLYMER MORTAR USING RHA AND GGBS

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ABSTRACT
The main objective of this project is to the compressive of strength of RHA and GGBS based Geopolymer mortar. The Geopolymer mortar is a mixture of Rice Husk Ash, Ground Granulated Blast-furnace Slag, and alkaline solution. The rice husk ash is replaced by Ground Granulated Blast-furnace Slagin different percentages such as 0% 10%, 20%, 30% and 40%. As an alkaline solution, sodium hydroxide – sodium silicate is used. Themolarity of alkaline solution is14M. Test specimens (mortar cubes) of various proportion of RHA and GGBS with alkaline solution were casted and tested for28 days compressive strength under both ambient and heat condition. For heat curing, specimens were kept at 70^{o} C for 1 day and kept at room temperature until testing. The test result indicates that the increase in molar concentration increases the compressive strength of Geopolymer mortar. Also the increase in the percentage of GGBS increases the compressive strength of Geopolymer mortar. Compressive strength of Geopolymer mortar made using Sodium activators. The maximum compressive strength of rice husk ash replacement as Ground Granulated Blast-furnace Slag is 45% than that of the normal specimen.

Keywords:*Rice Husk Ash (RHA), Ground Granulated Blast-furnace Slag (GGBS),Compressive strength, split tensile strength.*

1. INTRODUCTION

Waste materials such as industrial and agricultural wastes can be used in the production of concrete which eventually reduces the environmental impact due to its improper disposal[1].The production of Portland cement causes emission of greenhouse gas CO2 [2]. These Portland cement based conventional concretes are found to be less durable in severe environmental conditions [3]. The contribution of ordinary Portland cement production worldwide in the emission of greenhouse gas is approximately 7% to the total greenhouse gas emission to the atmosphere [4, 5]. Therefore, to preserve the global environment from the impact of cement production, it is essential to replace Portland cement with new binders.Similarly, the disposal of waste materials also poses another serious environmental problem [6]. Geopolymer is an inorganic alumino-silicate polymer, synthesized from predominantly silicon and aluminium material [7]. From a tonne of paddy, about 200 kg of rice husk can be obtained constituting about one fifth of the total rice produced. During the combustion, rice husk yields 22% of rice husk ash [8, 9]. Hence Rice Husk Ash can be referred as a cementitious material by using partial replacement of Ground Granulated Blast-furnace Slag [10, 11]. Thus, the addition of RHA as cementitious material is a promising solution to extenuate the environmental impacts due to cement manufacturing process [12]. The reaction of RHA with an aqueous solution containing alkaline activators in their mass ratio, results in a material with three-dimensional polymeric chain and ring structure bonds [13]. Water is not involved in the chemical reaction of Geopolymer mix and instead, water is expelled during curing and subsequent drying [14]. The commonly used alkaline liquids are Sodium hydroxide or Potassium hydroxide with Sodium silicate or Potassium silicate [15]. Thus, an alternative method is needed to reduce the emission of CO_2 and making the path for solid waste management system as well effect on the properties of the mortar [16]. The main objective of this study was

- Rapid development of mechanical strength.
- Shows high resistance to acid and other chemical attack.
- Excellent adherence to aggregates.
- Better ability to immobilize contaminants.
- Significantly reduced energy consumption and greenhouse gas emissions during production.
- Widespread availability of raw material inputs.

2. EXPERIMENTAL WORK

Ground Granulated Blast-furnace Slagis a by-product from the blast-furnaces used to make iron.The specific gravity of the GGBS is 2.55. The chemical composition of Ground Granulated Blast-furnace Slag is shown in table 2.1. M-sand is used in this project. Tine aggregate test as per IS 2386:1963. The physical properties of the M-sand are shown in table 2.2. The rice husk ash is used as binder material by replacing the Ground Granulated Blast-furnace Slag. The properties of Rice husk ash are shown in table 2.3. The Sodium silicate used in this experimental study.A53 commercial grade in the form of gel obtained from local. Thechemical composition is given in Table 2.4.

Table 2.2 chemical composition of GGBS

S.No	Compound	GGBS (wt %)
[1]	SiO_2	82.4
[2]	Al_2O_3	2.7
[3]	Fe_2O_3	1.8
[4]	CaO	3.5
[5]	MgO	1.8

Table 2.2 Properties of Fine aggregate

S.No	Properties	Value
1.	Specific Gravity	2.54
2.	Water Absorption	0.52%
3.	Fineness	3.362

Table 2.2 Properties of Rice Husk Ash

S.No	Properties	Value
1.	Specific Gravity	2.04
2.	Fineness	7%

Table 2.3 Chemical Composition of Sodium silicate

S.No	Oxides	% present
1.	SiO_2	29.4
2.	Na_2O	14.7
3.	Water	55.9

3.SPECIMEN PREPARATION

The alkaline solutions were prepared one day before casting. The addition of Sodium silicate to Sodium hydroxide solution forms the alkaline solution which enhances the reaction and bonding between the source materials. Geopolymer mortar was prepared in laboratory. For mortar, the dry materials were mixed together until homogeneity was obtained. Then alkaline solutions were added and mixed for 5 minutes. Added extra water was added if required. The mortar mixture was filled in mortar cube of size 100mm x 100mm x 100mm. The RA0 and RH0 signify that the normal specimen of rice husk ash . GA1,GA2, GA3, and GA4 and GH1, GH2, GH3, and GH4 signify the replacement of RHA with GGBS in 10%, 20%, 30% and 40%. For ambient curing, specimens were kept under room temperature for 7 days and 28 days. For heat curing, specimens were kept in heat curing chamber for 24 hours at 70^0 C for 7 days and 28 days.

4. RESULTS AND DISCUSSION

4.1 COMPRESSIVE STRENGTH TEST

The compression test was carried out as per IS: 516-1959. Mortar cubes of size 100mm x 100mm x 100mm were tested to determine the compressive strength of RHA and GGBS based Geopolymer mortar for both heat and ambient curing. The maximum compressive strength is achieved by GA 462.7% higher compressive strength than control specimen and a compressive strength of GH462% higher than the control specimen compressive strength. The compressive strength of the GA4 is 1.1% higher than that of the GH4. Figures 1 and 2 represent the compressive strength results.

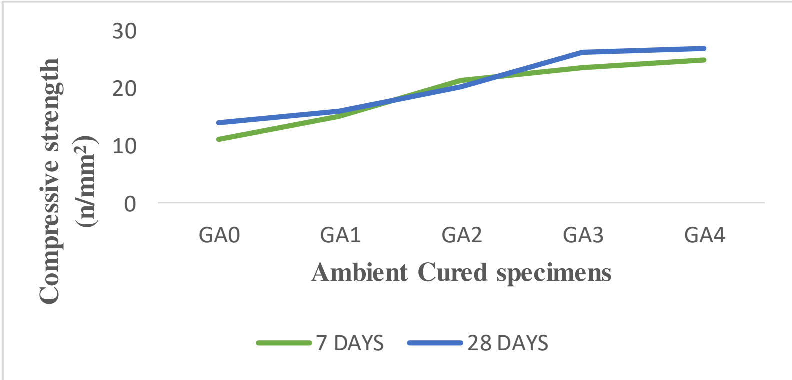

Fig.1 Compressive strength for ambient curing

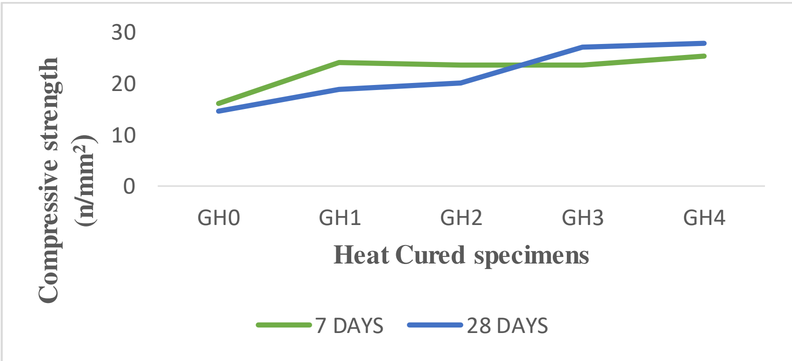

Fig.2 Compressive strength for heat curing

4.2 SPLIT TENSILE STRENGTH

The split tensile strength of mortar test conducted as per code IS 5816:1999. The test is conducted by using the cylindrical specimen diameter size of 100 mm and height of 200 mm. The maximum split tensile strength is achieved by GA4 44.8% higher compressive strength than control specimen and a compressive strength of GH4 37.2% higher than the control specimen compressive strength. The compressive strength of the GA4 is 18.6% higher than that of the GH4. Figures 3 and 4 represent the tensile strength results.

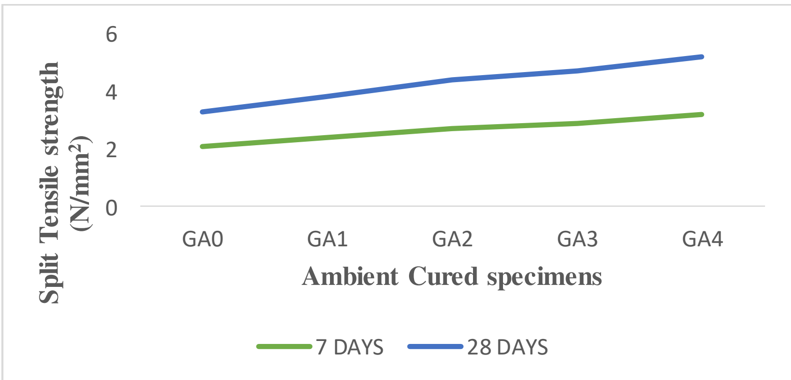

Fig.3 Split Tensile strength for ambient curing

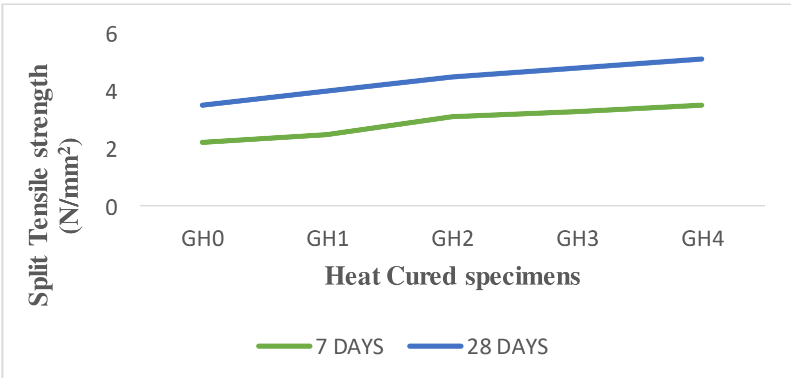

Fig.4 Split Tensile strength for heat curing

4.3 WATER ABSORBTION

Water absorption test is a measure of the capillary forces exerted by the pore structure causingfluid to be drawn into the body of the material. The water absorption percentage of mix GH4, which is 41.6% lower than control specimen, and the water absorption percentage of mix GA4, which is 26.6% lower than control. GA4 has 43% less water absorption than the GH4.Figures 5 and 6 represent the water absorption results.

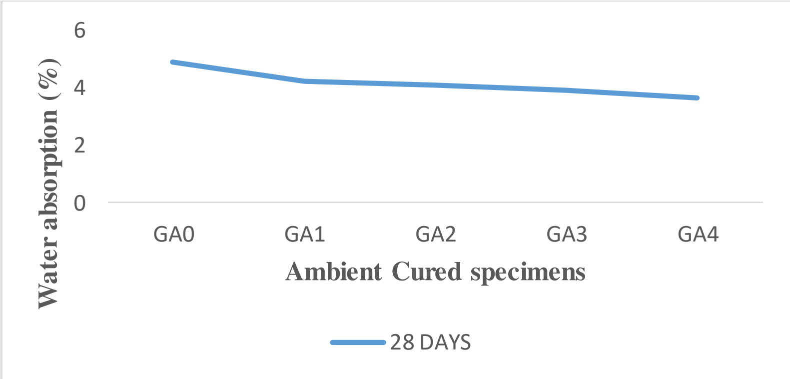

Fig.5 Water absorption for ambient curing

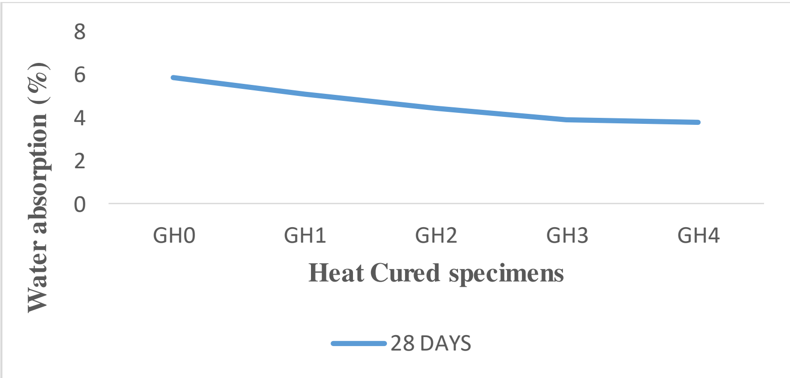

Fig.6 Water absorption for heat curing

4.4 RELATION SHIP BETWEEN MECHANICAL PROPERTIES OF GEO POLYMER MORTAR

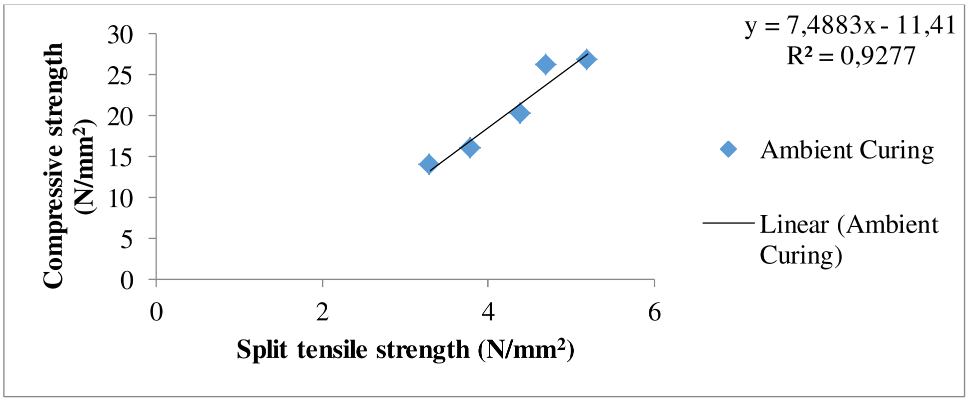

Fig.7 Relationship between Compressive strength and split tensile for ambient curing

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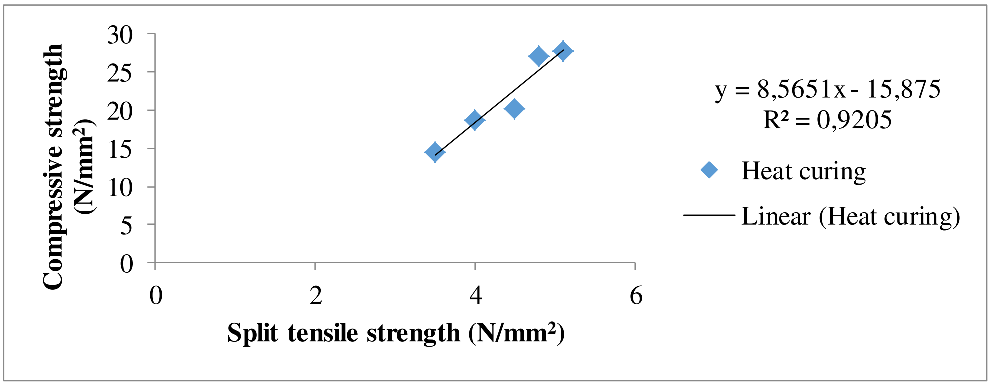

Fig.8 Relationship between Compressive strength and split tensile for heat curing

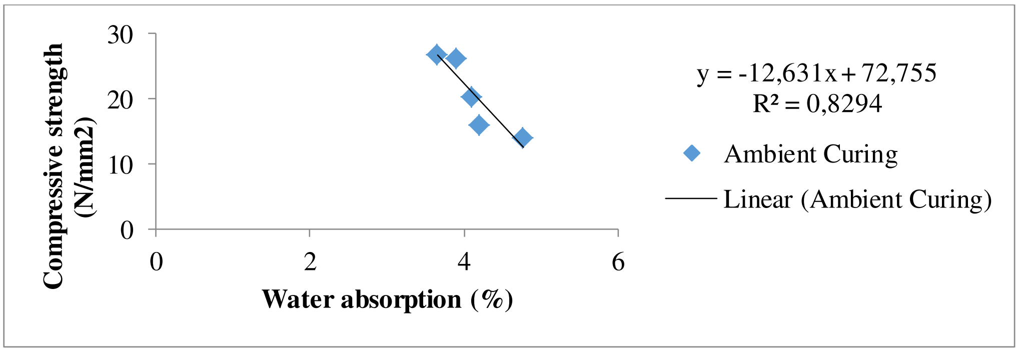

Fig.9 Relationship between Compressive strength and water absorption for ambient curing

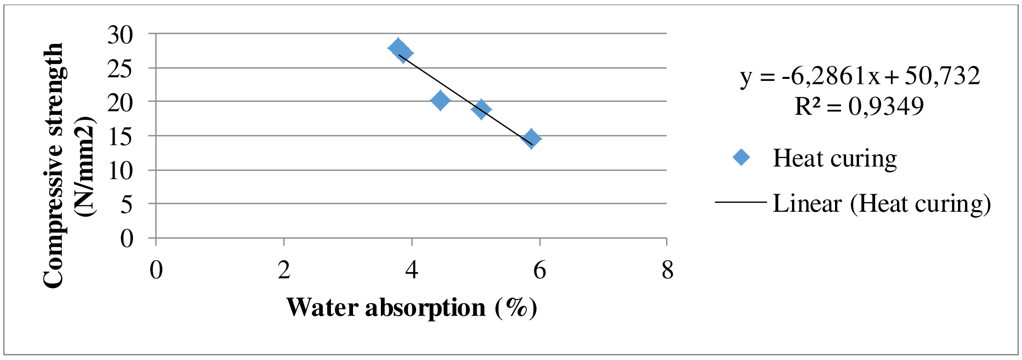

Fig.10 Relationship between Compressive strength and water absorption for heat curing

From fig. 7 and Fig. 8, it was observed that the compressive strength and tensile strength are closely related for the ambient and heat cured specimens. From fig. 9 and Fig. 10, it was observed that the compressive strength and tensile strength are closely related for the ambient and heat cured specimens. The relation is

The Linear equation of ACS

$$Y = 7.4883x - 11.41 \quad (4.1)$$
$$R^2 = 0.9277$$

The Linear equation of HCS

$$Y = 8.5651x - 15.875 \quad (4.2)$$
$$R^2 = 0.9205$$

The Linear equation of ACW

$$Y = -12.631x + 72.755 \quad (4.3)$$
$$R^2 = 0.8294$$

The Linear equation of HCW

$$Y = -6.2861x + 50.732 \quad (4.4)$$
$$R^2 = 0.9349$$

5. CONCLUSION

Addition of RHA increases the requirement of water in the mix proportion.The strength of the mortar cube increases with the increase in the percentage of GGBS replacement.

The compressive strength of the mortar increases with increase in the molar concentration of NaOH.The compressive strength of mortar is higher at 40% GGBS replacement with RHA.

The maximum compressive strength is achieved by GH4 62.7% higher compressive strength than control specimen. The maximum split tensile strength is achieved by GH4 44.8% higher compressive strength than control specimen. The water absorption percentage of the mix GH4 is 41.6% lower than that of the control specimen.

REFERENCES

[1] Azizul Islam, U. Johnson Alengaram, MohdZaminJumaat, IftekhairIbnul Bashar, "The development of compressive strength of ground granulated blast furnace slag-palm oil fuel ash-fly ash based geopolymer mortar", Elsevier – Materials and Design (2013).
[2] C.D. Budh, N.R. Warhade, "Effect of Molarity on Compressive Strength of Geopolymer Mortar", International Journal of Civil Engineering Research, Volume 5, Number 1 (2014).
[3] GokhanGorhan, GokhanKurklu, "The influence of the NaOH solution on the properties of the fly ash-based geopolymer mortar cured at different temperatures", Elsevier – Composites: Part B (2013).
[4] Hai Yan Zhang, VenkateshKodur, Bo Wua, Liang Cao, Fan Wanga, "Thermal behavior and mechanical properties of geopolymer mortar after exposure to elevated temperatures", Elsevier – Construction and Building Materials (2016).
[5] Mandeep Kaur, Jaspal Singh, Manpreet Kaur, "Synthesis of Fly ash based Geopolymer Mortar considering different concentrations and combinations of Alkaline Activator Solution", Ceramics International (2017).
[6] A.M.Mustafa Al Bakri, H,Kamarudin, M.BnhussainmA.R.Rafiza, Y.Zarina, "Effect of NaOH/Na2SiO3 ratios on NaOH molarities on compressive strength of flyash based geopolymers" ACI Materials Journal (September 2012).
[7] Bhalchandra S A, et al., (2013), Properties of Glass Fiber Reinforced Geopolymer Concrete, International Journal of Modern Engineering Research, 3(4), 2007-2010.
[8] A.Alekhya, et al., Experimental Investigations on Properties of Glass Fiber Reinforced Geopolymer Concrete Composites, IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 14, Issue 6 Ver. III (Nov. - Dec. 2017).
[9] V. Kishore Kumar et al, Experimental Evaluation of Glass Fibre reinforced Geopolymer Concrete (GFGPC), International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES), Volume 3, Issue 11, November-2017.
[10] G. Ramkumar et al, Development of Steel Fiber Reinforced Geopolymer Concrete, International Journal of Advance Research In Science And Engineering, IJARSE, Vol. No.4, Special Issue (01), March 2015.
[11] Meor Ahmad Faris et al, Performance of steel wool fiber reinforced geopolymer concrete, American Institute of Physics, 1885, 020041 (2017).
[12] Tadepalli Naga Srinu et al, Mechanical Properties of Steel Fiber Reinforced Geopolymer Concrete Incorporated With Fly-Ash & GGBS, International Journal of Civil Engineering and Technology (IJCIET) Volume 9, Issue 3, March 2018.
[13] SofiYasir and Gull Iftekar, "Study of Properties of Fly Ash Based Geopolymer Concrete" International Journal of Engineering Research, Vol. 3, Issue 1, ISSN: 2321-7758,January 29, 2015.
[14] Aryaaravind and Mathews M paul, "Study of Mechanical Properties of Geopolymer Concrete Reinforced with Steel Fiber"International Journal of Engineering Researchand Technology,Vol.3,Issue9,ISSN:2278-0181,24September 2014.
[15] C. Kamlesh. Shah, A. R. Parikh and K. J. Parmar, "Study of Strength Parameters and durability of Fly ash based Geopolymer Concrete" Indian Journal of Research,Vol.3, Issue 7, ISSN - 2250-1991, July 2014.
[16] Jaydeep, SandB.J.Chakravarthy,"StudyOnFlyAshBased Geopolymer Concrete Using Admixtures" International JournalofEngineeringTrendsandTechnology,Vol.4,Issue 10, pp: 2231-5381, ISSN: 2231-5381, Oct2013.