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EXPERIMENTAL RESEARCH ON GEO POLYMER CONCRETE WITH CONSTRUCTION DEMOLITION WASTE

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Abstract

Geo polymers are the materials based on pure aluminosilicate source materials such as fly ash, granulated blast furnace slag obtained from industrial, activated with an alkali metal hydroxide and silicate solution. Geopolymerisation is a complex multiphase exothermic process, involving a series of dissolution-reorientation-solidification reactions analogous to those observed in zeolite synthesis. High alkaline solutions are used to induce the silicon and aluminium atoms in the source material to dissolve and form Geopolymer gel. The sol gel formation (or polymerization) may be assisted by application of heat, followed by drying. The usage of ground granulated blast furnace slug made the geopolymer motor to cure at the room temperature. The Geopolymer gel binds the loose coarse aggregate, fine aggregate and un-reacted source material to form Geopolymer composites. The Portland cement free Geopolymer composites have many advantages like less curing time, earlier development of higher mechanical strength, very little drying shrinkage and very low creep, excellent resistance to sulphate attack, good acid resistance and resistance to high temperature. The strength development in Geopolymer composites depends on the chemical composition, morphology and reactivity of source materials, chemical composition of activating solution and curing process.
Keywords: *Compressive strength, Construction, Flexural strength, Geo polymer concrete, Fly ash, Rice husk ash*

1 INTRODUCTION

Geo polymers are the materials based on pure alumina-silicate source materials such as fly ash and rice husk ash obtained from industrial wastes or calcined clays like metakaolin, activated with an alkali metal hydroxide and silicate solution. The expression “Geopolymer “was proposed by Davidovits in the 1980’s due to their setting mechanism, a polycondensation process under alkaline conditions, similar to organic polymers.

Geopolymerisation is a complex multiphase exothermic process, involving a series of dissolution-reorientation-solidification reactions analogous to those observed in zeolite synthesis. High alkaline solutions are used to induce the silicon and aluminium atoms in the source material to dissolve and form Geopolymer gel. The sol gel formation (or polymerization) may be assisted by application of heat, followed by drying. The Geopolymer gel binds the loose coarse aggregate, fine aggregate and un-reacted source material to form Geopolymer composites. The Portland cement free Geopolymer

composites have many advantages like less curing time, earlier development of higher mechanical strength, very little drying shrinkage and very low creep, excellent resistance to sulfate attack, good acid resistance and resistance to high temperature. The strength development in Geopolymer composites depends on the chemical composition, morphology and reactivity of source materials, chemical composition of activating solution and curing process. These binders are currently attracting widespread attention due to their potential utilization as a high performance, environmental friendly and sustainable alternative to Portland cement.

2 OBJECTIVES OF THE EXPERIMENTAL WORK

This chapter presents the details of the preparations and the experimental investigations on geopolymer concrete with construction demolition waste conducted for studying the engineering properties of low calcium fly ash based geopolymer mortar. The main objectives of the experimental work are as under: 1) Preparation and characterization of geopolymer mortar using Indian Class F Fly ash blended with or without silica fume. Study on the effect of synthesizing parameters on the hardened properties of Geo polymer mortar i.e. Strength, Microstructure etc. Optimizing the rice husk ash as a partial replacement of fly ash. Effect of RHA to Fly ash ratio of Geopolymer Mix Composition. Bulk density and Water absorption. Test for strength and uniformity. Sulphate resistance and Acid resistance.

Initially, detailed description of the raw materials used and test procedures for characterization of geopolymers are presented in this chapter. The experimental methodology was divided in to two main parts: (1) Manufacturing of Geopolymers mortar and preparation of test specimen and (2) testing and characterization. The laboratory tests were conducted as per relevant Indian standard codes and in some special tests.

3RESULTS AND DISCUSSIONS

3.1 GENERAL

The concrete is tested to study their properties. The purpose of testing of hardened concrete is to confirm that the concrete used at site has developed the required strength. It also gives assurance of the concrete with regard to both strength and durability. The results obtained from each test are tabulated below.

3.2 PHYSICAL PROPERTIES OF MATERIALS

Experimental test were conducted to study the mechanical and physical properties of materials such as cement. Coarse aggregate, fine aggregate a fly ash, rice husk ash and results are tabulated.

3.2.1 Properties of Fly ash

The experiments were conducted to study the physical properties of as per IS code. Table 3.1 shows the properties of cement which are tabulated below.

Physical properties	**Values**
Specific gravity	2.3
Fineness modulus	7.86

Table 3.1 Properties of fly ash

3.2.2 Properties of Fine Aggregate

The experiments were conducted to study the physical properties of fine aggregate as per IS code. Table 3.2 reveals the properties of fine aggregate which are tabulated below.

Sl No	**Property**	**Value**
1	Specific gravity	2.62
2	Fineness value	3.63

Table 3.2 Properties of fine aggregate

3.2.3 Properties of Coarse Aggregate

The experiments were conducted to study the physical properties of coarse aggregate as per IS code. Table 3.3 shows the properties of coarse aggregate which are tabulated below.

Table 3.3 Properties of coarse aggregate

3.2.4 Properties of Rice husk ash

The experiments were conducted to study the physical properties of rice husk ash as per IS code. Table 3.4 shows the properties of Rice husk ash which are tabulated below.

Sr.No.	Particulars	Properties
1	Colour	Gray
2	Shape Texture	Irregular
3	Mineralogy	Non Crystalline
4	Particle size	<45 micron
5	Odour	Odourless
6	Specific gravity	2.3
7	Appearance	Very fine

Table 3.4 Properties of Rice husk ash

3.3 TESTING OF HARDENED CONCRETE

In present study cube compression test of normal concrete and Geo polymer concrete are carried out. After that comparing these value of load with percentage of Rice husk ash and construction demolition waste. The experimental results and discussions results for various tests are described below.

3.3.1 COMPRESSIVE STRENGTH CUBE SPECIMENS WITH 10 MOLARITY

The result of the tested cube specimen is tabulated with respect to the percentage of RHA and RCA add to the Geo Polymer concrete with 10 molarity of Alkaline solution. The table should contains the result of compressive strength value of the cube for 7th day and 28th day of the curing in which the molarity of Alkaline solution as 10. The compressive strength are calculated with the various value of percentage of RHA and RCA like 0%, 10%, 15%, and 25% for both 7th and 28th day of curing with the molarity of Alkaline solution as 10 should be in N/mm2

3.3.2 Compressive Strength Test

The result of the tested cube specimen is tabulated with respect to the percentage of RHA and RCA add to the Geo Polymer concrete. The table should contain the result of compressive strength value of the cube for 7th day and 28th day of the curing. The compressive strength are calculated with the various value of percentage of RHA and RCA like
0%, 10%, 15%,25% of RHA and 30% of RCA for both 7th and 28th day of curing in N/mm2 .

Cube specimens	**Compressive strength N/mm^2**	
	7^{th} day	28^{th} day
Cube specimens with 0% of RHA and 30% of RCA	16.46	25.46
Cube specimens with 10 % of RHA 30% of RCA	16.44	24.44
Cube specimens with 15% of RHA and 30% of RCA	12.04	20.9
Cube specimens with 25% of RHA and 30% of RCA	4.54	15.3

Table.3.5 Compressive Strength cube specimens

The graph is plotted with respect to the compressive strength of the cube. The X axis of the graph contains the compressive strength value and the Y axis of the graph contains the percentage of the RHA added to the Geo Polymer Concrete. The compressive strength value of both 7^{th} and 28^{th} days curing is plotted with respect to the percentage of RHA and RCA. By using the graph the compressive strength of the Geo Polymer Concrete is easily studied.

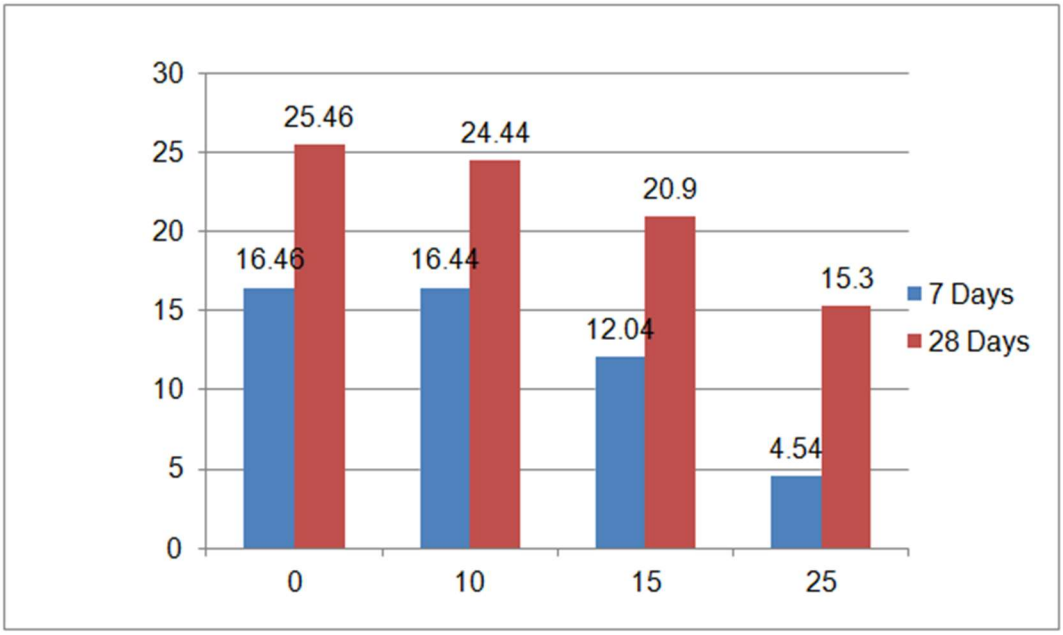


Fig 1: Compressive Strength cube specimens

3.3.3 SPLIT TENSILE STRENGTH OF SPECIMENS

The result of the tested cylinder specimen is tabulated with respect to the percentage of RHA and RCA add to the Geo Polymer concrete. The table should contains the result of split tensile strength value of the cube for 7^{th} day and 28^{th} day of the curing. The split tensile strength are calculated with the various value of percentage of RHA and RCA like 0%, 10%, 15%, and 25% for both 7^{th} and 28th day of curing in N/mm^2.

Cylinder specimens	**Split tensile strength N/mm^2**	
	7^{th} days	**28^{th} days**
Cylinder specimens with 0% of RHA and 30% of RCA	1.4	2.12
Cylinder specimens with 10% of RHA and 30% of RCA	1.34	2.1
Cylinder specimens with 15% of RHA and 30% of RCA	0.99	1.6
Cylinder specimens with 25% of RHA and 30% of RCA	0.63	1.27

Table.3.6 Split Tensile Strength of specimens

The graph is plotted with respect to the split tensile strength of the cylinder. The X axis of the graph contains the split tensile strength value and the Y axis of the graph contains the percentage of the RHA and RCA added to the Geo Polymer Concrete. The split tensile strength value of both 7^{th} and 28^{th} days curing is plotted with respect to the percentage of RHA and RCA. By using the graph the split tensile strength of the Geo Polymer Concrete is easily studied.

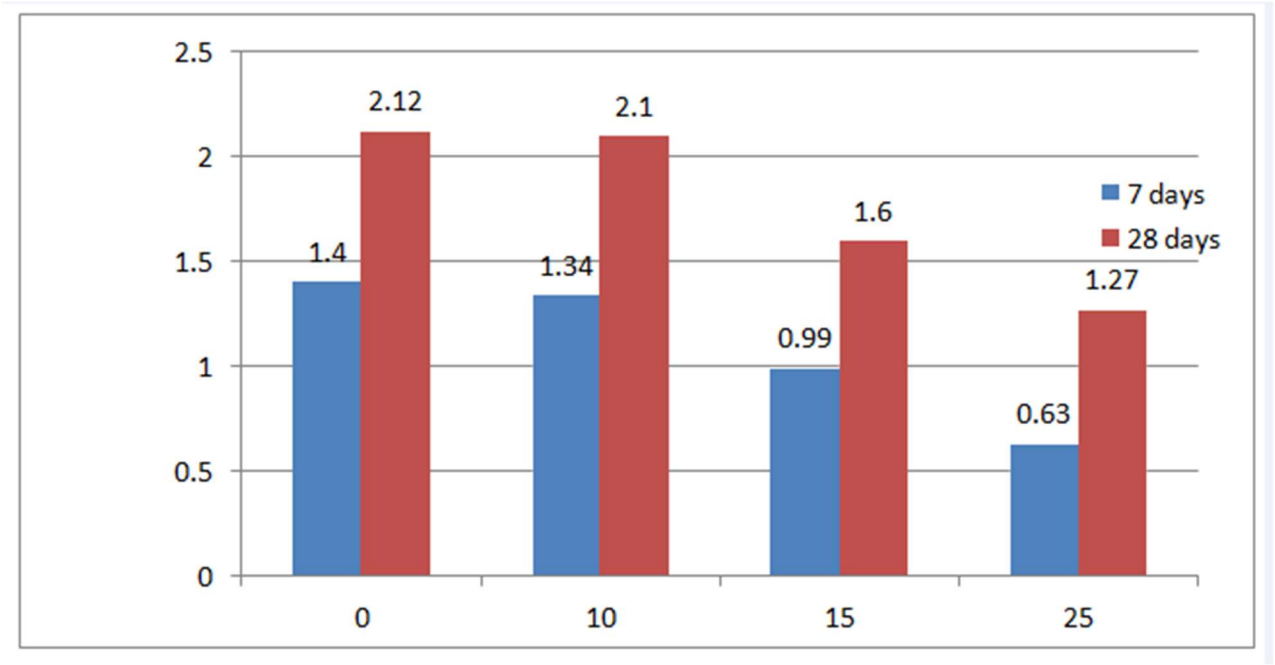


Fig 2: Split Tensile Strength of specimens

3.3.4 Flexural Strength Test

All the beams are casted and out of which control beam is tested under simply supported end conditions. Mainly two types of loading conditions are used in this thesis, static loading and cyclic loading. In static loading two-point loading is adopted for testing. Spacing between two concentrated loads for flexural strengthening is given on the one third of the span. In cyclic loading midpoint loading with two fixed end condition will be provided. The testing of beams is done with the help of loading frame having capacity 200T.

The load is applied to the beam with the help of loading frame and the data is recorded from the data acquisition system, Two LVDTs (Linearly variable differential transducer) were used to measure the lateral and longitudinal deflections. The load was increased in stages till the failure of the specimen in the case of monotonic loading. At each stage of loading, following measurements are made.

1. Deflection at mid span using a LVDT
2. First crack load

3. The load at which beam yields.
4. Ultimate load of beam
5. Crack widths after first crack load using a microscope of 25X magnification.

The beams are stressed up to 70% of the ultimate load. Then the beams are tested under static and cyclic loading.

3.4 Testing of beam

The reinforced beam of specific dimension is made and allowed to cure at room temperature. After the cure period of 28 days is completed the beam is tested in the loading frame in the laboratory for the different loading at constant interval. The strength and various other properties are calculated and it is tabulated and plotted in graph.

Fig 3: Loading Frame

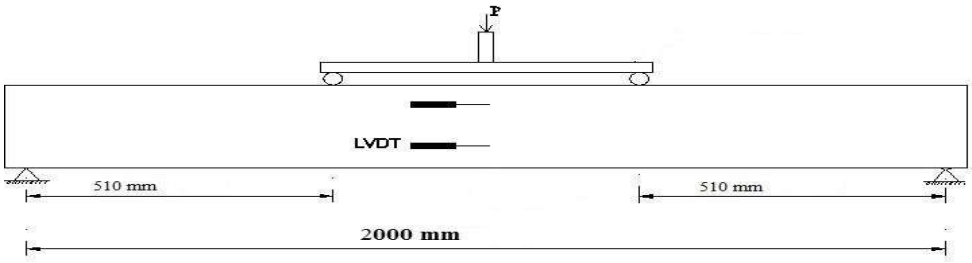


Fig 4: Schematic diagram of test setup.

Displacement (mm)

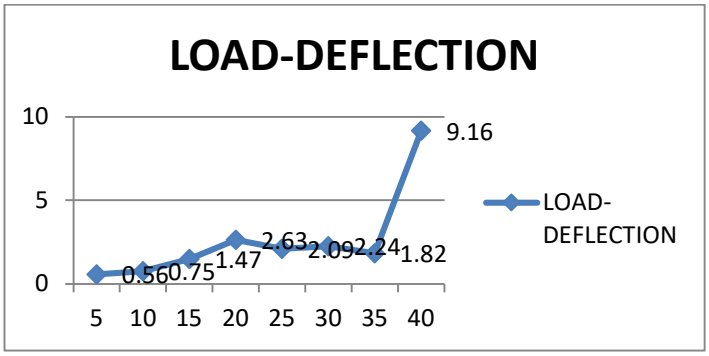
The graph is plotted with respect to the flexural strength of the beam. The X axis of the graph contains the load value and the Y axis of the graph contains the deflection values. The flexural strength value of both 7^{th} and 28^{th} days curing is plotted with respect to the load-deflection. By using the graph the flexural strength of the Geo Polymer Concrete is easily studied.

Beam 2: Specimens with 10% of RHA and 30% of RCA at 28 days of Curing

LOAD (kN)	LEFT LVDT 1	CENTRE LVDT 2	RIGHT LVDT 3
	DEFLECTION (mm)		
0	0	0	0
5	0.54	0.60	0.55
10	0.73	0.81	0.71
15	1.71	1.52	1.20
20	2.47	3.42	2.01
25	2.01	1.98	2.29
30	1.98	2.29	2.47
35	1.87	1.60	2.01
40	9.29	10.28	7.91

Table 3.8: load-deflection for beam specimens

Beam specimens with 10% RHA and 30% of RCA

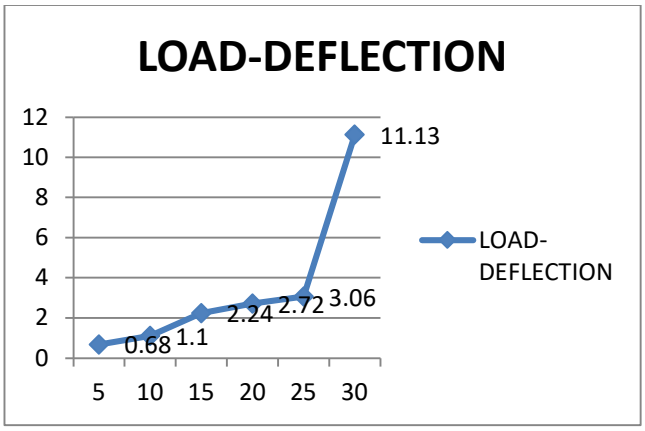


Beam 3: Specimens with 15% of RHA and 30% of RCA at 28 days of Curing

LOAD (kN)	LEFT LVDT 1	CENTRE LVDT 2	RIGHT LVDT 3
	DEFLECTION (mm)		
0	0	0	0
5	0.69	0.73	0.63
10	1.02	1.08	1.20
15	2.01	2.29	2.42
20	2.94	2.42	2.80
25	3.25	2.75	3.19
30	11.28	12.25	9.88

Table 3.9: load-deflection for beam specimens

Beam specimens with 15% RHA and 30% of RCA



Displacement (mm)

4.CONCLUSION

Based upon the results of experimental and analytical study are carried out the following conclusions can be drawn:

- The control specimen where tested under the two-point loading and the results were satisfactory.
- Experimental results shows that as the percentages of rice husk ash increases then compressive strength decreases
- Up to 10 and 15 % of fly ash can be replaced with rice husk ash, beyond that the bonding in between alkaline liquids, rice husk ash and fine aggregates is not so strong. Strength obtained with no replacement of fly ash is nearly equal to 10% replacement with rice husk ash, that implies rice husk ash can also be used a alternate binder in geo polymer concrete As the molarity concentration increases, compressive strength also increases, not only on molarity but also on temperature and number of days of curing.
- Compressive strength is directly proportional to temperature. The strength of the Geo Polymer concrete increase as the molarity of Alkaline solution in the concrete increase.
- The uniformity of the Geo Polymer concrete is higher as compare to the normal concrete. Geo Polymer concrete are Eco Friendly and also utilize the waste protect like Fly ash and waste chemical, construction demolition waste.
- The water absorption of recycled aggregates is higher than the natural aggregates. The aggregate crushing and impact values of recycled aggregates are higher than the natural aggregates. This is because the recycled aggregates have already been subjected to fatigue once during the previous use.

- From the compressive strength results of recycled aggregate concrete it can be concluded that the recycled aggregate concrete though have slower strength development than the conventional concrete, it can still be used in construction by electing the optimum replacement ratio. In this investigation it is found that up to 30% replacement of natural coarse aggregates by recycled aggregates can be done and used as up to his replacement level, further it can also be concluded that the split tensile strength also follows the same trend of reduction in strength with increased replacement to be used in structural concrete and hence are satisfactory.
- From the above investigations it can be hence concluded that the optimum replacement for this particular mix for high strength concrete is 30% up to this replacement good compressive strength can be achieved using recycled aggregates Hence the use of Geo Polymer concrete with RHA and RCA is more efficient as that of normal concrete. Form the experimental analysis of three beam there was not much variation in the total deformation and ultimate load.

5.References

- G Nanda kishore,BGayathri(2017) "experimental study on RHA and flyash based geopolymer concrete using msand"
- R.Anuradha,V.Sreevidya,R.Venkatasubramani and B.V Rangan "Modified guidelines for geopolymer concrete mix design using indian standards"(2012).
- M.I Abdul aleem and P.D Arumairaj (2012) "optimum mix for the geopolymer concrete"
- K.Arulpriya "strength and durability studies of Msand and flyash based geopolymer concrete"(2016).
- Yun yongkim,byung-jae lee "strength and durability performance of alkali-activated RHA geopolymer mortar"(2014).
- S.Nagajothi and S.Elavenil "strength assessment of geopolymer concrete using Msand"(2016).
- DR.S.M.Naik "use of demolished concrete waste as a coarse aggregates in high strength concrete production"
- Anaghakalpavalli and Dr.s.Naik "use of demolished concrete wastes as a coarse aggregate in high strength concrete production"(2015).
- Nik.D.Oikonomou "Recycled concrete aggregates"(2005).
- Azizulislam,U.JohnsonAlengaram, "The development of compressive strength of GGBS-palm oil fuel ash-fly ash based geopolymer mortar"(2014).
- TawatchaiTho-in,Vanchaisata,Prinyachindaprasirt"pervious high-calciumflyash geopolymer concrete"(2012).
- Susan Bernal,Ruby De Gutierrez "Performance of an alkali-activated slag concrete reinforced with steel fibers"(2010).
- SudiptaNaskar,ArunkumarChakraborty "Effect of nano materials in geopolymer concrete"(2016).
- M.Ezzat,H.M.Khater,Abdeen M.EINagar"Enhanced characteristics of alkali activated slag/grog geopolymer bricks"(2016).

- G.Saravanan,C.A.Jeyasehar and S.Kandasamy “Flyash based Geopolymer concrete”(2013).
- R.Anuradha,V.Sreevidya,S.Balaji and R.Venkatasubramani “Analysis of Eco friendly geopolymer concrete beams using sand and M-sand”(2012).
- Dr.AbdulAleem M.I and Dr.Arumairaj P.D “Analytical modeling of geopolymer concrete with M-sand using Ansys”(2016).
- M.LeninSundar,Sherine raj “Study on characteristics of geopolymer concrete with Ewaste”(2017).
- Pradeepkumar.B,Prabhakar.K,PraveenRaj.S,Pravinkumar.B,Srihari.M “Study of strength devolepment of geopolymer concrete using M-sand as Fine aggregate”(2017).
- T.S.B.Damu,J.Thaarrini,Dr.R.Venkatasubramani “Strength studies on geopolymer concrete using steel and polypropylene fibres”(2015).
- Joni M,RexinC,FrankStephen,Adalmengesha “Shear behaviour of M-sand based geopolymer concrete”(2018).
- Mahantesh NB, Amarnath.K, Raghuprasad.BK “Flexural behavior of flyash-slag based reinforced geo polymer concrete slabs cured at room temperature”(2017).
- MorufOlalekanyusuf,MegatAzmiMegatjohari,ZainalArifinAhamed,MohammadMasleh uddin “Evolution of alkaline activated GGBS-Ultrafine palm oil fuel ash based concrete”(2014)