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Experimental investigation and optimum utilization on fly Ash and GGBS based GEOPOLYMER concrete

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ABSTRACT

Concrete is the world most durable and reliable construction material which required large quantities of ordinary Portland cement. Ordinary Portland cement production is the major generator of carbon di oxide. . The production of ordinary Portland cement contributes 5-7% of total greenhouse gas emission and also demand of cement concrete is increasing day by day for satisfying the need of development of infrastructure facilities. Hence there is a need of using a alternate binder to make concrete which is eco- friendly and effort has been made to make new generation concrete called “Geopolymer Concrete” .Geopolymer concrete is an ecofriendly concrete in which ordinary Portland cement is replaced by mineral admixtures such as fly ash and GGBS which are the bi-products of thermal and steel plants. Geopolymer is a material resulting from there action of a source material that is rich in silica and alumina with alkaline solution. Geopolymer concrete is totally cement free concrete. In geopolymer fly ash and GGBS act as binder and alkaline solution act as an activator. Alkaline solution used for present study is combination of sodium hydroxide and sodium silicate. A grade chosen for the investigation were M30.The mix were designed for molarity of 13M based on sodium silicate.

Keywords: Geopolymer concrete, Fly ash, GGBS, Sodium hydroxide, Sodium silicate, Molarity, Curing, Strength.

INTRODUCTION

In our construction industry, cement is the main ingredient for the concrete production but the production of cement means the production of pollution because of the emission of CO2 during its production. On the other side the demand of concrete is increasing day by day for its ease of preparing and fabricating in all sorts of convenient shapes. So to overcome this problem, the concrete to be used should be environmental friendly. To produce environmental friendly concrete, we have to replace the cement with the industrial by products such as fly-ash and Ground granulated blast furnace slag therefore, it is essential to find alternatives to make the concrete environment friendly the fly ash and GGBS is the source materials for geopolymer binders, is available abundantly in India, but the utilization is limited. Hence it is essential to make the efforts to utilize this by-product in concrete manufacturing in order to make the concrete more environmental friendly. This paper describes the experimental work conducted by casting geopolymer concrete mixes to evaluate the effect of various parameter compressive strength of overall performance. Various parameters i.e. ratio of alkaline liquid to fly ash, GGBS, concentration of sodium hydroxide, ratio of sodium silicate, curing time, curing temperature, rest period and additional water content in the mix have been investigated.

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The test results show that compressive strength increases with increase in the curing time, curing temperature, rest period. The geopolymer concrete specimens were tested for their compressive strength at the ages of 7, 28 days [1].

LITERATURE REVIEW

1. J.Liyana, A.M.Mustafa al bakri, H.Kamarudin, C.M.Ruzaidi and A.R.Azura Geopolymer are member of the family of inorganic polymers. The geopolymerization process involves a fast chemical reaction under alkaline condition. The poly condensation of silica and alumina to attain structural strength.
2. Lohani T.K, S.Jena, K.P.Dash, M.PadhyAn approach on geopolymeric recycled concrete using partial replacement of industrial by product. The GPC advance technology by replacement of cement which can reduce the greenhouse gases alternative fly ash is used.
3. M.Talha Junaid, Obada Kayali, Amar Khennane, Jarvis Black The geopolymer concrete using fly ash by replacing cement. Alkaline solution is used to bind the aggregate and added to fly ash to form the GPC.
4. K.Ravishankara, N.Praveena, Prof.D.B.Raijiwala The fly ash and GGBS based geopolymer concrete using admixtures is the combination of NaoH and Na2Sio3 together to form a gel that binds the aggregate. The resultant gel is mixed with fly ash and GGBS to form geopolymer concrete.
5. J.Temuujin, A.Minjigmaa, U.Bayarzul, Ts. Zolzaya, B.Davaabal, The geopolymer is a new development in the world of concrete in which cement is totally replaced by material like fly ash, GGBS and activated by highly alkaline solution to act as a binder in the concrete mix. The geopolymer concrete to achieve desire strength at required workability. The mix design procedure is proposed on the basis quantity of fly ash, GGBS , water, aggregate.

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GEOPOLYMER

India also is facing the problem of depletion on natural resources such as limestone which is the most important ingredient to produce cement and in turn the concrete in India. In this situation, geopolymer concrete which is the concrete with zero cement in concrete naturally becomes very important. Therefore, an attempt has been made in the present investigation by casting geopolymer concrete mixes with 100% replacement of OPC with processed fly ash and GGBS in each concrete. Geo polymer demonstrate improved strength and chemical properties in addition to many other characteristics which are potentially valuable. Depending on the selected raw material and processing conditions, geopolymer concrete exhibit a variety of diverse properties, including high compressive strength, low shrinkage, fast or slow setting, acid resistance, fire resistance and low thermal conductivity. The manufacture of geopolymer concrete is carried out using the usual concrete technology methods. Compressive strength of Geopolymer concrete is very high compared to the ordinary Portland cement concrete. Geopolymer concrete also showed very high early strength. The compressive strength of Geopolymer concrete is about 1.5 times more than that of the compressive strength with the ordinary Portland cement concrete. Similarly the Geopolymer Concrete showed good workability as of the ordinary Portland Cement Concrete [2-5].

NECESSITY OF GEOPOLYMER CONCRETE

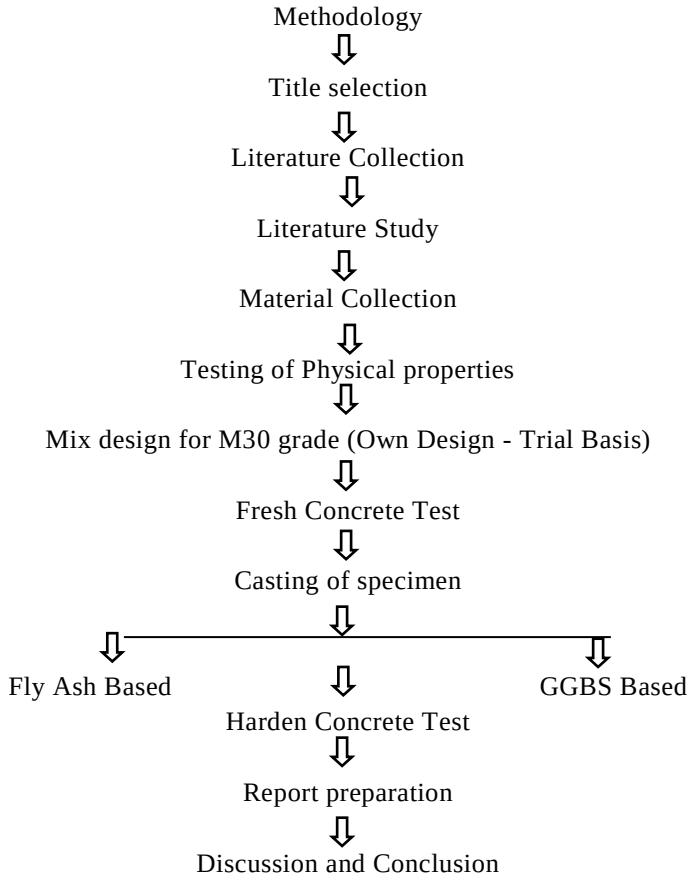
The production of one ton of cement, approximately one ton of carbon di oxide will be emitted to the atmosphere, which is a major threat for the environment. In addition to the above huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder. The Cement production generated carbon di oxide, which pollutes the atmosphere. To produce environmental friendly concrete, we have to replace the cement with the industrial byproducts such as fly-ash, GGBS which is simply dumped on the earth, occupies larges areas. In Geopolymer concrete doesn't use any

cement, the production of cement shall be reduced and hence the pollution of atmosphere by the emission of carbon di oxide shall also be minimized [6-8].

OBJECTIVE

- Study and evaluation of chemical composition and effects of sodium hydroxide and sodium silicate on fly ash and GGBS.
- Study of polymerization process in Fly ash and GGBS, sodium hydroxide and sodium silicate of the composition that is geopolymer.
- Testing of geopolymer by using universal testing machine.
- Analysis of geopolymer testing & comparison [9].

METHODOLOGY



MATERIALS USED

Fly ash, GGBS, Sodium hydroxide, Sodium silicate, Fine aggregate, coarse aggregate, water.

MATERIAL DETAILS

Fly ash

Fly ash plays the role of an artificial pozzalano. The fly ash often helps to improve the workability of the fresh concrete, while its small particle size also plays as filler of voids in the concrete, hence to produce dense and durable concrete. An important achievement in the use of fly ash in concrete is the development of high volume fly ash concrete that successfully replaces the use of OPC in concrete upto 100% [10].

GGBS

Ground granulated blast furnace slag is obtained by quenching molten iron slag a by-product of iron and steel-making, to produce a glassy granular product that is then dried and ground into a fine powder. Slag is grinded to get a fine powder form of GGBS.

Fine Aggregate

Sand is a granular material made of finely isolated rock and mineral particles. It is characterized by size, being better than rock. Sand utilize up to a level of 20% substitution of sand gives a decent compressive quality. The river sand, passing through a 4.75 mm sieve and retained on 600µm sieve, conforming to Zone-II.

Coarse Aggregate

The crushed coarse aggregate of 20 mm and 10 mm size from the local crushing plants was used. The locally available crushed granite stone is used as coarse aggregate.

Sodium Silicate

The sodium silicate solution is used as alkaline activator. Sodium silicate solution is available in liquid form. As per the manufactured, silicate were supplied to detergent company and textile industry as bonding agent, the same sodium silicate is used for making of geopolymer concrete, which we brought from local supplier.

Sodium Hydroxide

The sodium hydroxide are available in the form of solid state pellets. The sodium hydroxide is used as lowest cost upto 94% to 96% purity. The sodium hydroxide solids were dissolved in water to make the solution.

Water

Water is an important ingredient the chemical reaction with sodium hydroxide pellets. The water is helps to from the strength giving binder gel.

MIX DESIGN

Fine aggregate (Kg/m^3)	Coarse aggregate (Kg/m^3)	Flyash/GGBS (Kg/m^3)	Na_2Sio_3:NaoH
683	1268	405	75:25
683	1268	405	65:35
683	1268	405	60:40
683	1268	405	50:50

ANALYSIS OF TEST RESULT

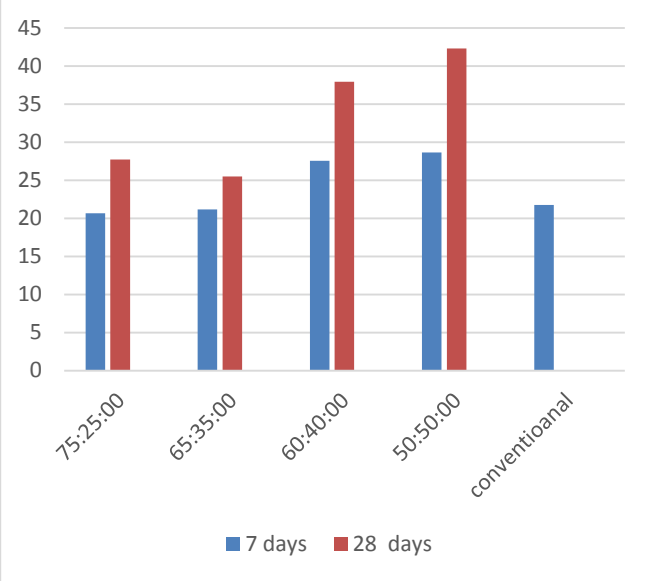
Compressive Strength

The optimum mix of material is taken is fly ash and GGBS based geopolymer concrete and by varying the molarity of alkaline solution. Compression strength is presented for the 7 days and 28 days.

Compressive Strength Testing - Fly Ash Based

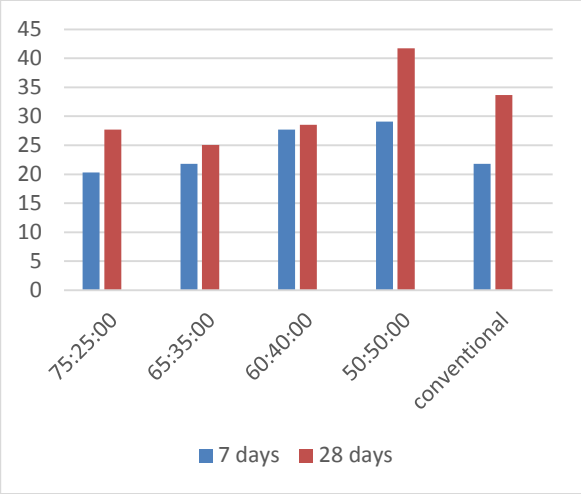
S.No	Specimen Specification (Na_2Sio_3:NaoH)	Compressive Strength (N/mm^2)	
		7 Days	28 Days
1.	75:25	20.00	27.11
2.		20.66	27.55
3.		21.33	28.44
4.	65:35	19.11	24.44
5.		21.77	25.33
6.		22.66	26.66

7.	60:40		26.88	36.88
8.			27.55	37.77
9.			28.22	39.11
10.	50:50		28.00	41.77
11.			28.44	42.44
12.			29.55	42.66
13.	Conventional	concrete	21.33	32.88
14.			22.22	33.77
15.			21.78	34.44



Compressive Strength Testing – GGBS Based

S.No	Specimen Specification (Na_2Sio_3:NaoH)		Compressive Strength (N/mm^2)	
			7 Days	**7 Days**
1.	75:25		19.55	27.11
2.			20.44	27.55
3.			20.88	28.44
4.	65:35		21.11	24
5.			21.77	24.88
6.			22.22	26.22
7.	60:40		27.11	27.55
8.			27.55	28.44
9.			28.44	29.55
10.	50:50		28.66	41.33
11.			28.88	42.22
12.			29.77	42.66
13.	Conventional	concrete	21.33	32.88
14.			22.22	33.77
15.			21.78	34.44

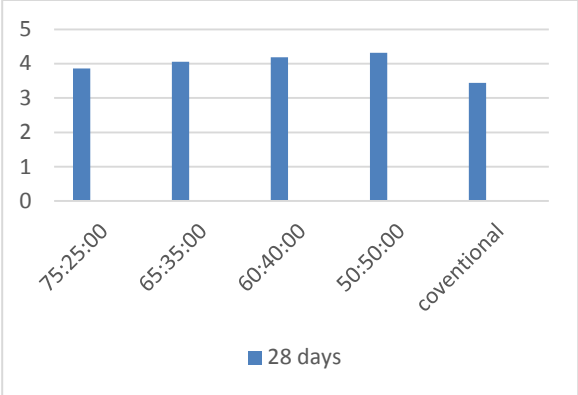


SPLIT TENSILE STRENGTH

The optimum mix of material is taken is fly ash and GGBS based geopolymer concrete and by varying the molarity of alkaline solution. Split tensile strength is presented only for 28 days.

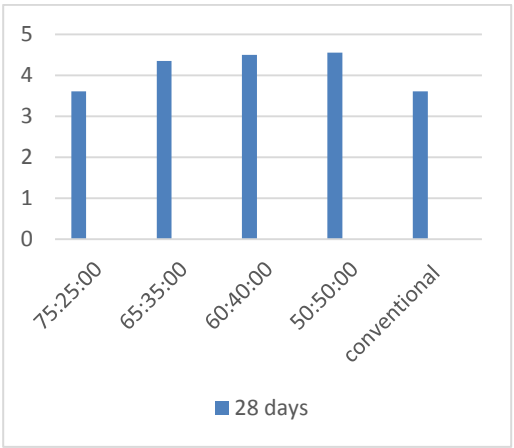
Split Tensile Strength-Fly Ash Based

S.No	Specimen Specification (Na_2Sio_3:NaoH)	Split Tensile Strength (N/mm^2) 28 Days
1.	75:25	3.15
2.		4.20
3.		4.25
4.	65:35	4.00
5.		4.05
6.		4.13
7.	60:40	4.16
8.		4.18
9.		4.25
10.	50:50	4.28
11.		4.33
12.		4.37
13.	Conventional concrete	3.28
14.		3.45
15.		3.60



Split tensile strength GGBS based

S.No	Specimen Specification (Na_2Sio_3:NaoH)	Split Tensile Strength (N/mm^2) 28 Days
1.	75:25	3.25
2.		3.70
3.		3.90
4.	65:35	4.10
5.		4.30
6.		4.65
7.	60:40	4.90
8.		4.27
9.		4.35
10.	50:50	4.40
11.		4.50
12.		4.75
13.	Conventional concrete	3.45
14.		3.60
15.		3.80

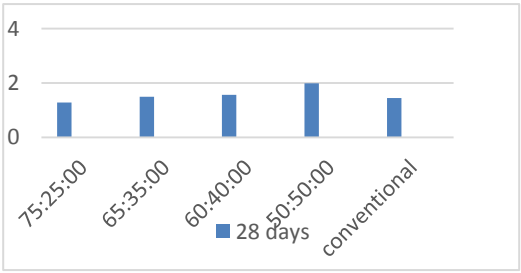


FLEXURAL STRENGTH

The optimum mix of material is taken is fly ash and GGBS based geopolymer concrete and by varying the molarity of alkaline solution. Flexural strength is presented only for 28 days.

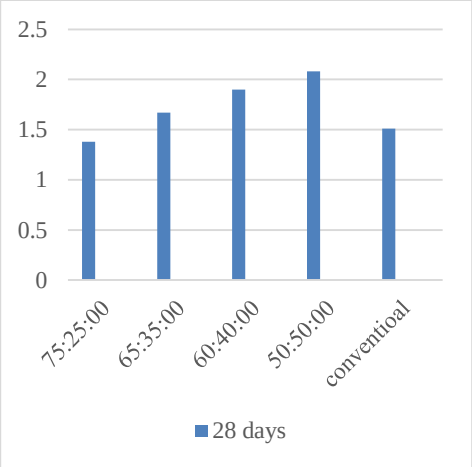
Flexural Strength - Fly Ash Based

S.No	Specimen Specification (Na_2Sio_3:NaoH)	Flexural Strength (N/mm^2) 28 Days
1.	75:25	1.2
2.		1.28
3.		1.38
4.	65:35	1.52
5.		1.56
6.		1.44
7.	60:40	1.62
8.		1.66
9.		1.7
10.	50:50	1.88
11.		1.94
12.		2.16
13.	Conventional concrete	1.38
14.		1.44
15.		1.54



Flexural Strength- GGBS Based

S.No	Specimen Specification (Na_2Sio_3:NaoH)	Flexural Strength (N/mm^2) 28 Days
1.	75:25	1.30
2.		1.40
3.		1.46
4.	65:35	1.60
5.		1.68
6.		1.74
7.	60:40	1.80
8.		1.92
9.		1.98
10.	50:50	2.00
11.		2.10
12.		2.16
13.	Conventional concrete	1.42
14.		1.52
15.		1.60



CONCLUSION

The compressive strength attained by GGBS and fly ash based Geopolymer concrete. The reaction of GGBS and fly ash in geopolymer concrete with alkaline solution attains higher strength. Based on the molar concentration of sodium silicate the grades of concrete can be designed and implemented in construction. The geopolymer concrete can be innovative supplementary to OPC in construction material. The compressive strength of the geopolymer concrete increases with increase in the curing time. The workability of the geopolymer concrete in fresh state increases with the increase of extra water added to the mix. With increase in the curing temperature the compressive strength of the geopolymer concrete also increases. The construction industry is in demand of ecofriendly which are durable. As compared to the existing concrete materials GGBS and fly ash is advantageous but its uses as tested against strength & durability needs to be confirmed. The present project work on the research & development activity in construction materials using fly ash and GGBS with geo polymers. The project preparation of test samples of fly ash and with geo polymers of different molarity of sodium silicate solution .The samples are prepared with the different molarities such as 13M Tests for compressive strength, split tensile strength, flexural strength are carried out for 7& 28 days, as per standards of respective properties. The optimum strength attained in the ratio of 60:40 and 50:50 for fly ash and GGBS.

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