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Recycling Of Ggbs into Geopolymer Concrete and Creating Eco-Friendly Cement Product

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ABSTRACT: Concrete industry is one of the crucial supporters of the emanation of nursery gasses. That is concrete creation expends huge measure of virgin materials in environment, which is one of reason for an Earth-wide temperature boost. Likewise, in India in excess of 100 million tons of fly ash is delivered every year. Fly ash was picked as the essential material to be actuated by the Geopolymerisation procedure to be the solid cover, to thoroughly supplant the utilization of Portland concrete. For the polymerization the sodium hydroxide and potassium hydroxide were utilized in three blend process. The some boundary expected as fixed with past writing audit. The other boundary like temperature, restoring time and testing age were break down with various sort of the activator. The activators were utilized like sodium hydroxide, potassium hydroxide and half of sodium hydroxide, 50 % of potassium hydroxide. The compressive quality test utilized for the improvement of temperature and restoring time of geopolymer concrete. In this examination answer for fly ash proportion of 0.45 with 10 Mole concentrated sodium hydroxide arrangement and potassium hydroxide is utilized and grade picked for examination was M30.All the examples were restored in broiler at 800 C for 24 hours length. All tests were led by Indian standard code technique. Test results for compressive quality, split rigidity and flexure strengthare arranged and talked about in subtleties and some significant ends are made.
This research paper is about to control the engine valves of an one cylinder 4-stroke engine with a computer controlled electromagnetic actuator. There are many possibilities in electromagnetic devices. We chose a push solenoid to actuate the engine valve. For controlling the solenoid, we chose a user interface with control options. The user interface communicates serially with a microprocessor. The microprocessor monitors and reports the engine's performance and control the opening/closing of the engine valves. The ultimate goal is improved efficiency, decrease pollutants, and produce maximum power throughout the RPM range with a camless engine.

KEYWORDS: Fly Ash, GGBS, Geopolymer Concrete, Cement Product, OPC.

I. INTRODUCTION

Mostly worldwide use of concrete is secondthe pollution due to factory smoke or other materials. Basically in civil construction concrete is an important parameter and cement is a main key factor of concrete material. One tone of cement manufacture produced one tone carbon dioxide. The carbon dioxide affects human health and surrounding environment. It is responsible for many serious problems. Now the world is focusing on eco-friendly materialand products. In this project, attempts are made to replace cement by GGBS and FA which is an industrial waste material. There is also problemof disposal of this material. An expressive use of GGBS and FA in GPC material. Geopolymer concrete has excellent properties, as aresearcher has already studied. The cement consumption has risen nearly more than 1.3 billion tons per annum.CO2 is emitted during the calcination of limestone, resulting in an approximately 1 ton of CO2 for every ton of OPC produced. So to reduce the Greenhouse gas, we need to control the emission of CO2Therefore its need of the time to not only introduces such materials and technologies for an alternative to the cement but also to use it more and more. Replacing 15% of cement worldwide by other cementations material will reduce CO2 emission by 250 million tons and if it's replaced by 50 %, emission is reduced by 800 million tonnes Our Project Aim is to completely replace the cement by fly ash which is used as a binder in Geopolymer Concrete At present nearly 170 million tonnes of fly ash is being generated in India and its utilization is only 25 million tonnes. So the disposal of fly ash and GGBS is also a major issue.

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1.1. Geopolymerization Starts with Oligomers:

Geopolymerization is the process of combining many small molecules known as oligomers into a covalently bonded network. The geo-chemical syntheses are carried out through oligomers which provide the actual unit structures of the three dimensional macromolecular edifice. In 2000, T.W. Swaddle and his team proved the existence of soluble isolated alumino-silicate molecules in solution in relatively high concentrations and high pH. One major improvement in their research was that their study was carried out at very low temperatures, as low as 9 °C. Indeed, it was discovered that the polymerization at room temperature of oligo-sialates was taking place on a time scale of around 100 milliseconds, i.e. 100 to 1000 times faster than the polymerization of ortho-silicate, oligo-siloxo units. At room temperature or higher, the reaction is so fast that it cannot be detected with conventional analytical equipment.

1.2. Research Significance:

In this research, an effort has made to understand the properties of geopolymer concrete and cement replaced by GGBS and Fly Ash at a different percentage. Focus is on mixing design of Geopolymer concrete and curing type and temperature.Alsoeffects on the properties of GPC. To find out the compression and tensile strength of the concrete.

1.3. Objectives:

1. To examine the properties of GGBS and Fly Ash as the alternative material of OPC.
2. To find the economical, technical, and environmental limits of GGBS and Fly Ash over OPC.
3. To determine compressive strength of Geopolymer concrete and compare between 3 alkaline solutions.
4. To write a conclusion on Geopolymer concrete whether good alternative material of conventional Portland cement.

II. LITERATURE REVIEW

Joseph Davidovits (1994) studied of properties geopolymer cement carried out by the author. Researcher focused on excellent properties of geopolymer and its use regardingrehabilitation of retrofitting of structures after a disaster. The geopolymer is the best material for retrofitting regarding the environmental and construction usages.

Lyon E et al (1996) studied that geopolymer is noncombustible and fire resistive structural materials. Which are suitable for infrastructure where a high degree of fire resistance is needed at low to moderate cost. The main conclusion was entered that load bearing capability increases with increasing fire up to 100^0C temperature might be reached.

Balaguru. P (1997) from this paper it is being concluded that study has been done with the help of geopolymer concrete for repair and rehabilitation RCC beam. The first objective of this paper was to know whether geopolymer can be used or not for repair of the concrete structure. It has been also concluded that geopolymer concrete has the strongest bond with carbon fabrics.

VijayaRangan B (2004) carried out a study on durability of geopolymer concrete by considering the environmental protection. This paper described the results by conducting the test by large scale reinforced geopolymer concrete member and also give the application of geopolymer concrete in the constructionindustry. The test gave the results regarding excellent to resistance to sulfate attack and fire undergoes low creep was noted the based benefit of geopolymer concrete

VijayaRangan et al (2006) studied the behavior of fly ash based Geopolymer concrete and informed that the geopolymer concrete had an excellent compressive strength and is suitable for the structural applications. The elastic properties of the hardened concrete, as well as the behavior and strength of the reinforced structural members, were similar to those of Portland cement concrete. Therefore, the design provisions present in the current standards and codes can be used to design the reinforced fly ash-based geopolymer concrete structural members.

Sumajouw D.M.J et al (2006) Studied of thebehavior of fly ash and slender reinforced columns. They studied analysis of the behavior and the strength of reinforced geopolymer concrete slender columns. The low calcium fly ash based geopolymer concrete reinforced columns had excellent potential in the precast industry.

Bhikshma et al. (2010) In this paper author investigated that flexural behavior of high strength manufacture sand concrete. The researcher observes the workability of M50 grade investigated sand concrete is supposed to be 30% less compared to ordinary concrete and compressive strength of M50 grade concrete having varying percentages that are 0%, 25%, 50%, 75%, 100%. Manufacture concrete improves the strengths by 6.89%, 10.76%, 20.68% respectively and the outcome was while comparing to ordinary concrete the load carrying and moment carrying capacity of reinforced concrete beam was 3 to 12 % higher.

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Vijai et al (2010) informed that geopolymer concrete had an excellent compressive strength and it is more suitable for the structural application. The elastic as well as behavior and strength properties of reinforced structure members here similar to those of portland cement concrete. Hence the design provisions according to the current codes and standards can be used to design the reinforced fly ash-based geopolymer concrete member structure.

III. METHODOLOGY

3.1. Introduction

This section includes planning of project work and step by step all detail explanations about work which as follows.

3.2. Experiment Procedure:

Before starting the project work study of many research papers which give me basic of carrying out my experiment work. After referring various papers material finalization done and following project work was followed.

- Selection of material like Coarse aggregate, fine aggregate, Fly Ash, GGBS, Polymer and catalyst
- Laboratory test on were performed on Coarse Aggregate, Fine Aggregate, GGBS, Fly Ash, Catalyst Activator, Polymer Activator
- Mix Design was done for M30 Grade of Concrete.
- Cement is replaced in various proportions by Fly Ash and GGBS.
- Workability of concrete was checked.
- Determining the compressive strength,split tensile strength,and flexural strength of concrete of different mix.
- 24 hours steam curing has been given.
- Flexural strength of concrete is determined by the flexural testing machine.
- Test results were compared.

3.3. Material:

3.3.1 Ground Granulated Blast Furnace Slag (GGBS)

It is the by-product from the blast-furnaces used to make iron, blast furnaces are fed with a controlled mixture of iron ore, coke, and limestone, and operated at a temperature of about 1500^0 C. when these materials are melt then there is two by-products are formed molten slag and iron. This slag is very light in weight than the cement particle and it is floated on top of the molten iron. This slag is nothing but alumina and silicates from the real iron ore, including with oxides from limestone. The manufacturing process of slag to implicate at maximum water pressure jets. The slag particle size is not greater than 5 mm. Further, this is used in process for drying and then grinding in a mill to very thin powder, which is known as GGBS.

Table 3.1: physical and chemical properties of GGBS

Sr.No.	Particulars	GGBS (In %)	As per IS : 12089-1987 (Reaffirmed 2008)	
1	Calcium Oxide (Cao)	37.34	-----	
2	Aluminum Oxide ($Al_2O_{3)}$	14.42	-----	
3	Iron Oxide ($Fe_2O_{3)}$	1.11	-----	
4	Silicate Oxide (SiO_{30}	37.73	-----	
5	Magnesium Oxide (MgO)	8.71	Max. 17.0%	
6	Manganese Oxide (MnO)	0.02	Max. 5.5%	
7	Sulphate Sulphur	0.39	Max. 2.0%	
8	Loss of Ignition	1.41	----	
9	Insoluble Residue	1.59	Max. 5%	
10	Glass Content	92	Min. 85%	
A	Chemical Moduli: 1. $\frac{CaO+}{SiO}$	1.07	≥ 1.0	Major Oxide should be Satisfy at least one
B	2. $\frac{CaO+}{}$	1.60	≥ 1.0	

3.3.2 Fly Ash (FA)

In this research, Class - F low calcium fly ash produced from the thermal power plant, MIDC, Satara, MH is used. As per IS 456-2000 Cement is replaced by 35 % of fly ash by weight of cementations material. The specific gravity of fly ash is 2.24.

3.4 Mix Design of Geopolymer Concrete

Design of Geopolymer Concrete is based on as per IS 10262:2009, IS 456:2000 and Previous Research Paper is as follows.

Mix Design for Grade M 30:

Characteristics Strength required at 28 days = 30 Mpa
Fly ash grade = Pozzolana 63
Max size of Aggregate = 20 mm
Degree of quality control = Good
Type of exposure = sever.

Procedure of Mix Design

Step 1:

Target mean strength, fck = fck + t x S
Where, t = a statistical value depending on expected proportion of low result t = 1.65 &
S = Standard deviation from Table 3.6
For M40 grade concrete & good quality control,
S = 5
Target mean strength = 30 + (1.65 x 5) = 38.25 Mpa

Step 2:

To decide water /cement ratio, this will give 38.25 Mpa
Select water /cement ratio (w/c) = 0.45; this is lesser than 0.5 prescribed in
I.S 456-2000[20] for sever condition for reinforced concrete (Table 3.7).

Step 3:

Selection of water content: from Table 3.9
For 20 mm size of aggregate use maximum water content 186 lit.
For 100 mm slump = 186 + (6/100) ×186 = 197

Step 4:

Calculation of cement content:
Cement content: 197/0.45 = 437.78 kg/m^3
Replaced cement by Fly Ash (75 %) and GGBS (25%)
Fly Ash = 328.5 kg/m^3 and GGBS 109.5 kg/m^3
437.785 kg/m^3 > 320 kg/m^3

Step 5:

Volume of C.A. and F.A.:
Table 3.10, Volume of C.A. corresponding to 20 mm size of aggregate and F.A. zoneII for W/C ratio = 0.45
Therefore,
Volume of C.A. = 0.6 and Volume of F.A. = 0.4.

Step 6:

Mix calculation:

i. Volume of concrete = 1 m^3

ii. Volume of fly ash = (Mass of fly ash/ Specific gravity of fly ash) × (1/1000)
= (328.5/2.3) × (1/1000)
= 0.1428 m^3

iii. Volume of GGBS = (Mass of GGBS/ Specific gravity of GGBS) × (1/1000)
= (109.5 / 2.85) x (1/1000)
= 0.03842 m^3

iv. Volume of water = (water/ Specific gravity of water)× (1/1000)
= (197/ 1) × (1/1000)
= 0.197 m^3

v. Volume of all aggregate = i- (ii + iii + iv)
=1- (0.1428+0.03842+0.197)
= 0.62177 m^3

vi. Mass of C.A. = v × volume of C.A. × Specific gravity of C.A. × 1000
= 0.62177 x 0.6 x 2.67 x1000
= 996.0898 kg.

vii. Mass of F.A. = v × volume of F.A. × Specific gravity of F.A. × 1000
= 0.62177 x 0.4 x 2.57 x 1000
= 639.179 kg.

[Note: 1. Replace cement by fly ash by 75% and GGBS 25%
2. Replace water by alkaline solution such as sodium silicate and sodium hydroxide by 100%.]

IV.RESULT AND DISCUSSION

4.1. General

The tests on geopolymer concrete are carried out according to relevant standards wherever applicable. Various tables presented in this section show the results obtained from the test on geopolymer concrete. The geopolymer concrete were casted with three type of combination sodium hydroxide and sodium silicate, potassium hydroxide and potassium silicate and 50 % of sodium silicate and 50% of potassium silicate with same quantity of respective silicate.

4.2 Slump Flow Test

Slump Flow test is carried out according procedure of IS 516 - 1959 Guidelines and test results obtained from M30 grades of Geopolymer concrete, results are presented in table

Table2: Slump flow test for geopolymer concrete.

Sr. No.	Mix of concrete	Solution/ fly ash ratio	Slump Flow for Geopolymer concrete (mm)
01.	M30	0.45	125

The Slump flow is carried out as per IS 516 - 1959 and test readings are present in above table 4.1. It can be seen that the workability of Geopolymer concrete is more than that of Normal concrete.

4.3. Geopolymer Concrete Test Results

Testing of geopolymer concrete is an important role in controlling and confirming the quality of cement concrete work. Tests are made by casting cubes, beams, and cylinder from the actual concrete. The effect of compressive strength, flexural strength, split tensile strength, geopolymer concrete were studied for constant 10 molarity,Steam curing period of 24 hours and temperature of 80^0 c.

4.4. Effect of molarity of Sodium hydroxide solution and Sodium Silicate.

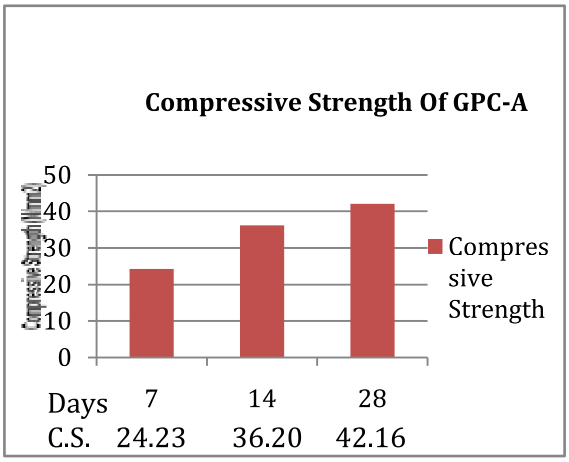
The molarity variation tested by using compressive strength with respect to curing temperature, curing time and testing age of concrete (days).

4.4.1Compressive Strength of GPC.

Compressive test was carried out as per I.S. 516-1959, for that test 150 x 150 x 150 mm cube were used. For compressive test, used compression testing machine of capacity 3000 KN. Compressive test were taken for constant 10 molarity,curing temperature of 80^0 c and curing time of 24 hours.

Table 4.1: Effect of constant molarity and temperature on compressive strength of GPC.

Sr No.	Sample No	Rest Period (Days)	Load (KN)	Comp Strength (N/mm²)	Average (N/mm²)
1	A1	7	566	25.15	24.23
	A2		522	23.20	
	A3		548	24.35	
2	A4	14	790	35.11	36.20
	A5		821	36.48	
	A6		833	37.02	
3	A7	28	978	43.46	42.16
	A8		923	41.02	
	A9		945	42	



Graph 4.1: Effect of constant molarity on compressive strength.

4.5 Effect of molarity of Potassium hydroxide solution and Potassium Silicate.

The molarity variation tested by using compressive strength with respect to curing temperature, curing time and testing age of concrete (days).

4.5.1 Compressive Strength of GPC.

The results of compressive strength which are obtained from temperature variation of 80°C oven cured concrete for 24 hours. Compressive test was carried out as per I.S. 516-1959, for that test 150 x 150 x 150 mm cube were used.10M solution used.

Table 4.2: Constant temperature and KOH Solution effect on Compressive strength of GPC

Sr. No.	Sample No.	Rest Period (Days)	Load (KN)	Compressive Strength (N/mm²)
1	B1	7	608	27.02
	B2		580	25.77
	B3		603	26.80
2	B4	14	900	40.00
	B5		866	38.48
	B6		832.5	37.00
3	B7	28	1028	45.68
	B8		1039.6	46.20
	B9		965.5	42.91

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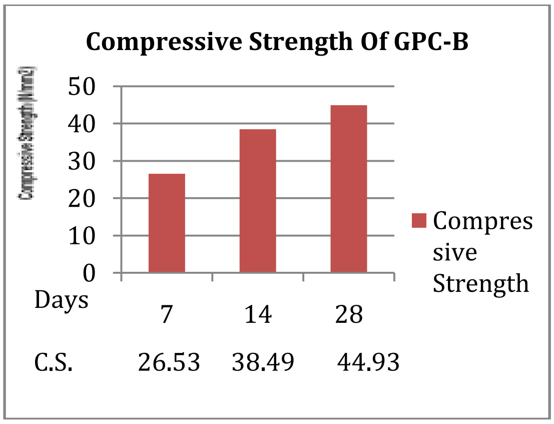


Graph 4.2: Constant molarity and Temperature on Compressive strength.

4.6 50-50 % of Sodium hydroxide solution and Potassium Hydroxide Solution

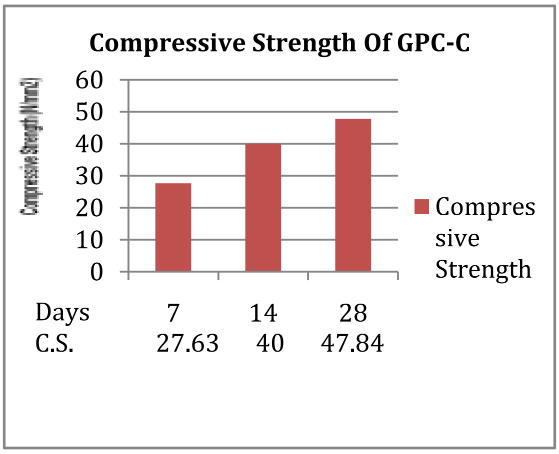
The 50-50 % Sodium And Potassium Hydroxide solution variation tested by using compressive strength, Split Tensile and Flexural Strength with respect to curing temperature, curing time and testing age of concrete (days).

4.6.1Compressive Strength of GPC.

The one ratio for the hydroxide and silicate also used. The 50% of NAOH and 50% of KOH used in this test for Geopolymerization. The results of compressive strength which are obtained from temperature variation of 80°C oven cured concrete for 24 hour . Compressive test was carried out as per I.S. 516-1959, for that test 150 x 150 x 150 mm cube were used. The potassium hydroxide solution and sodium hydroxide having concentration of 10M were used.

Table 4.3: 50-50% NaOH and KOH Solution effect on Compressive strength of GPC.

Sr. No.	Sample No.	Rest Period (Days)	Load (KN)	Compressive Strength (N/mm²)	Average (N/mm²)
1	C1	7	665	29.55	27.63
	C2		615.5	27.35	
	C3		535	26	
2	C4	14	855	38.00	40
	C5		925.5	41.13	
	C6		920	40.88	
3	C7	28	1100	48.88	47.84
	C8		1046	46.48	
	C9		1084	48.17	

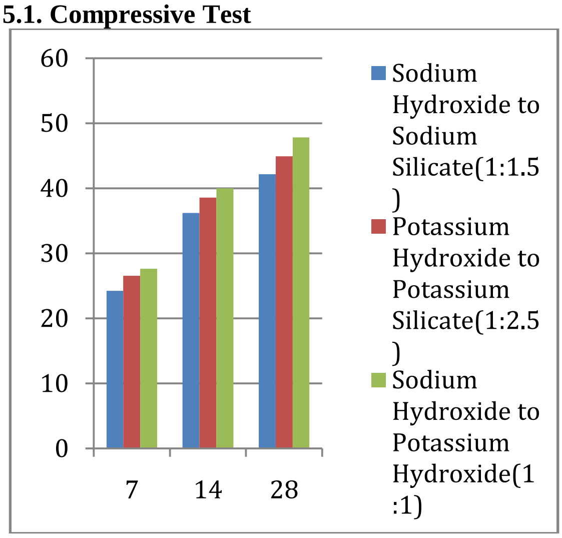


Graph 4.3: 50-50% NaOH and KOH Solution effect on Compressive strength of GPC.

V.COMPARISON

Comparison between compressive test of 3 alkaline solutions used in geopolymer concrete and ggbs shown below by graphs:

5.1. Compressive Test



Graph 5.1:Compressive Test of 3 Alkaline Solutions

VI. CONCLUSION

Following conclusions are drawn after casting and testing the fly ash based geopolymer concrete for workability and compressive strength:

1. For Geopolymer concrete the curing time and temperature variation play important role for polymerization.
2. The 24 hours of curing time shows the significant result.
3. The potassium hydroxide to sodium hydroxide ratio 1 shows the significant properties of geopolymer concrete.
4. Sodium Hydroxides to Potassium Hydroxide ratio 1 has highest strengths among 3 alkaline solutions.
5. It has 11.8% and 6.09% greater compressive strength than Sodium hydroxide and potassium hydroxide solution.
6. Steam curing results in high early compressive strength i.e almost 80-90% of characteristic strength so thus it can be used in precast concrete units.
7. The sodium hydroxide is cheaper than the potassium hydroxide shows near about same ssmechanical properties of geopolymer concrete.
8. Longer curing time improved the polymerization process resulting in higher compressive strength of Geopolymer concrete for optimized temperature.
9. Geopolymer concrete is more environmental friendly.
10. It has the potential to replace cement from concrete in many applications such as pre-cast units.

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