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

Arjun Subhash Ghodake[1], Prof. Nikhil H. Pitale[2]
[1, 2] Department Of Civil Engineering
[1, 2] G.H.Raisoni College of Engineering, Hingana Road, Nagpur

Abstract- *as we know the world is facing pollution problem. The global use of concrete is second only to water. The cement consumption has risen nearly more than 1.3 billion tonnes per annum.CO_2 is emitted during the calcinations of limestone, resulting an approximately 1 tonne of CO_2 for every tonne of OPC produced. So to reduce the Greenhouse gas, we need to control the emission of CO_2Therefore 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 CO_2 emission by 250 million tons and if its replaced by 50 %, emission is reduced by 800 million tonnes Our Project Aim is to completely replace the cement by low calcium fly ash which is used as a binder material 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 major issue. So all the researchers have put full efforts in geopolymer concrete. This GPC concrete requires oven curing in different temperature for a time period one day to four day.*

We are noticed that with variation in materials such as molarity, polymer Activator, catalyst activator, GGBS, Fly ash, curing time and temperature makes the difference in the strength. Lot of information on geopolymer concrete and we are focusing on gap of research. In this research solution to GGBS and Fly ash ratio is 0.45 with 10 Molarity Concentrated Potassium hydroxide is used and grade chosen for investigation was M30. All tests were conducted according to Indian standard code procedure. Test results are represent in tabulated and graphical form in below and conclusion are made.

Keywords- GGBS, Fly ash, Catalyst Activator, Polymer Activator, Compressive Strength, Split tensile strength, Molarity, Curing Temperature and time.

I. INTRODUCTION

As we know the world is facing pollution problem. The 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 material and products. In this project, attempts are made to replace cement by granulated blast furnace slag (GGBS) and fly ash (FA) which is an industrial waste material. There is also problem of disposal of this material. An expressive use of granulated blast furnace slag (GGBS) and fly ash (FA) in Geopolymer concrete. Geopolymer concrete has excellent properties, as a researcher has already studied. The main strength of geopolymer concrete depends on the source of materials, chemical structure, and polymer and catalyst activator solution, the ratio of solution to fly ash, base period, curing type and curing temperature.

As per IS code the cement is replaced by fly ash with 35% weight of cementations material, and it is easily available in the industry. Fly ash is industrial waste material and it is to maintain great mechanical properties with whole durability performance. Another by-product is used such as rice husk, fly ash etc. In this material, there is presence of aluminium (Al) and silicate (si).Another industrial material is GGBS which is made from iron ore or slag. This material helps to increase the strength of geopolymer concrete. The chemical and physical properties are mention below the point and also the factors that effect on geopolymer concrete cube such as material source, workability, curing period and curing type that is discussed in the paper.

1. 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. how to effect on the properties of Geopolymer concrete. To find out the compressive and splitting tensile strength of the concrete.

2. Outline of Project

This project has included materials, test methods to find out the strength of geopolymer concrete blocks such as compression, tensile strength, result, discussion and conclusion.

II. LITERATURE REVIEW

1. Fly Ash (FA)

In this research, Class - F low calcium fly ash produced from the thermal power plant, MIDC, Aurangabad, 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. The physical and chemical properties are mention Table 2.

Table 2. Physical and chemical properties of Fly ash

Sr.No.	**Parameter**	**Low Calcium Fly Ash (%)**
1	Silicon dioxide (SiO_2)	19 – 59
2	Aluminum oxide (Al_2O_3)	4 – 34
3	Iron oxide (Fe_2O_3)	11 – 41
4	Calcium oxide (CaO)	0 – 6
5	Loss of ignition	0 – 16

2. Coarse aggregate

Crushed granite stones of size 20mm and 10mm are used aggregate. As per IS:2386 (part 3)-1963[8], the bulk specific dry condition and water absorption of coarse aggregate are 2.78 and 0.32% respectively [8]. The fineness of modulus of 20mm and 10mm coarse aggregates are 2.95 and 1.75.

3. Fine Aggregate

Natural river sand is used as fine aggregate. As per IS: 2386 (Part 3)-1963 [8], the bulk specific gravity in oven dry condition and water absorption of the sand are 2.65 and 1% respectively [8].

4. Alkaline Liquid

The alkaline liquid used was combination of potassium silicate and potassium hydroxide solution. The potassium silicate solution (K2SiO3) and Potassium hydroxide (KOH) in flakes or pellets from 97%-98% purity and it was purchased from chemicals, Pune.

5. 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 15000 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 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. $\frac{CaO+MgO+1/3Al2O3}{SiO2+2/3Al2O3}$	1.07	≥ 1.0	Major Oxide should be Satisfy at least one
B	2. $\frac{CaO+MgO+Al2O3}{SiO2}$	1.60	≥ 1.0	

6. Mixture Proportions

Based on previous past research on GPC (Hardjito & Rangan, 2005), the following proportions were selected for the constituents of the mixtures. In the design of geopolymer concrete mix, we are total cement replaced by waste material GGBS and fly ash with different percentage of mixing. The density of GPC is near about similar to conventional concrete as 2400 kg/m3. The fly ash and GGBS taken 70-30% and the molarity of potassium hydroxide solution was kept at 10M, the details of mix design and its proportion for different mixes of GPC are given in table 3.

7. Preparation of test specimen

The potassium hydroxide flakes or pellets were dissolved in water to make solution with a desired concentration at least one day prior to use. The mixture of GGBS, Fly ash , fine aggregate and coarse aggregate were mixed together 2-3 min. After that potassium silicate and potassium hydroxide were mixed together with super plasticizer and the extra water and then added to the dry materials and mixed for few minutes. After mixing the GPC was cast in mould. The specimen was compacted with three layers of placing and tamping using a rod. This was followed by an additional vibration of 10 sec. using a vibrating table. After that the specimen were stored for 24 hrs, then demoulded and kept in open until the day of testing

Table 3. GPC Mix Proportions (Kg/m3)

Material		A	B	C
Coarse aggregate	20mm	715.8	708.4	702.6
	10mm	477.2	472.4	468.4
Fine aggregate	Sand	642.2	635	630.5
Fly Ash		384	360	336
GGBS		96	120	144
Potassium Silicate Solution		86.4	109.5	129.6
Potassium Hydroxide (10M)		57.6	72.96	86.4
Extra Water		16	8	2
Alkaline solution/(FA+GGBS)		0.3	0.38	0.45
Water/ GPC solids		0.29	0.29	0.29
Density (Kg/m^3)		2475	2479	2497

8. Test methods

The mechanical properties of geopolymer concrete are evaluated by using compressive strength test, flexural test and split tensile test. These samples were tested at 7, 14 and 28 days of curing at 800 C temperatures.

III. RESULTS AND DISCUSSIONS

1. Compressive Strength

Compressive strength values of GPC mixes at different curing periods are shown in table and figure.

Table 4. Mechanical Properties of GPC (Compressive Strength)

Sr.No.	Molarity	Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Average (N/mm²)
1	10	80°C	24	7	22.207
2	10	80°C	24	14	41.879
3	10	80°C	24	28	56.29

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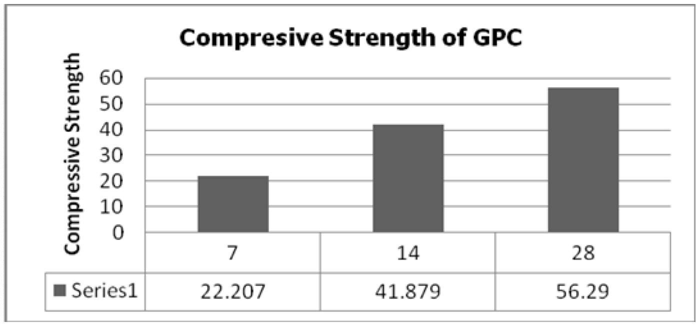

Figure 1.

From the results, it is seen that compressive strength values of GPC mixes were increased increasing the time period.

2. Split tensile strength

Split tensile strength values of GPC mixes at different curing periods are shown in table and figure.

Table4. Mechanical Properties of GPC (Tensile Strength)

Sr.No.	Molarity	Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Average (N/mm²)
1	10	80°C	24	7	1.968
2	10	80°C	24	14	2.253
3	10	80°C	24	28	3.296

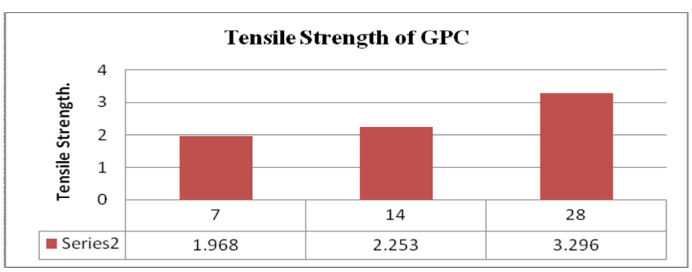

Figure 2.

From the results, it is seen that compressive strength values of GPC mixes were increased increasing the time period.

3. Flexural Strength

Flexural strength values of GPC mixes at different curing periods are shown in table and figure.

Table4. Mechanical Properties of GPC (Flexural Strength)

Sr.No.	Molarity	Temperature (°C)	Curing Time (Hrs)	Rest Period (Days)	Average (N/mm²)
1	10	80°C	24	7	4.334
2	10	80°C	24	14	5.23
3	10	80°C	24	28	6.67

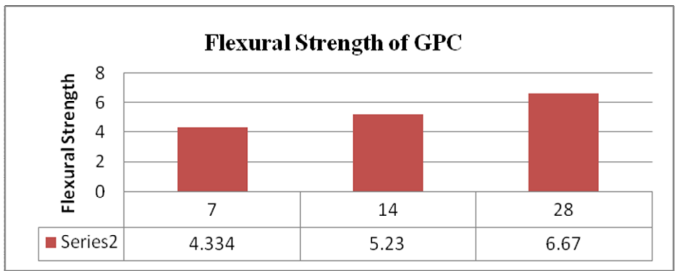

Figure 3.

From the results, it is seen that compressive strength values of GPC mixes were increased increasing the time period.

IV. DISCUSSION

Studied above research paper Geopolymer is made of GGBS, Fly ash, Polymer Activator, Catalyst Activator. The chemical reacts with the Binding material gets Geopolymerisation Process starts. So, it can be directly affected on strength of material. The different curing temperature conditions are more effective and workable for all atmospheric conditions.

V. CONCLUSION

- The rate of gain of strength is slow at 600C but high in 1000C and reduce at 1400C. For Geopolymer concrete the curing time and temperature variation play important role for polymerization.
- The rate of gain of strength is slow at 600C but high in 1000C and reduce at 1400C.
- The sodium hydroxide is cheaper than the potassium hydroxide shows near about same mechanical properties of geopolymer concrete.
- Longer curing time improved the polymerization process resulting in higher compressive strength of geopolymer concrete for optimized temperature.
- The price of fly ash-based geopolymer concrete is estimated to be about 10 to 20 percent cheaper than that of conventional concrete.

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