

# An Experimental Investigation on Durability of GGBS Based Geopolymer Concrete

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**ABSTRACT:-** In the present days the cost of the construction is more and also the pollution in the environment is more from the construction activities. Hence to reduce the cost of construction and the pollution it is necessary to replace the conventional construction materials by any alternatives. For construction activity the major material is concrete. Concrete is the combination of cement, fine aggregates, coarse aggregates and water. In the production of the cement more than 70% of carbon dioxide and other harmful gases will produce and mixed with the atmosphere. This will damage the o'zone layer. Hence it is necessary to reduce the production and consumption of cement. Hence to avoid this problem the better alternative is geopolymer concrete.

## I. INTRODUCTION

India is one of the developing countries. The major activity in our country is construction work. The source of income is also more in this construction activity. But even though some developed countries and developing countries are facing the same problem that is the environmental pollution. This environment is polluted through various activities such as industries, vehicles, production of materials, through residences etc. The construction activity plays a major role in this environmental pollution. Every nation is facing the same problem. In the olden days the construction of a building can be done by using naturally available materials. Now a day it is replaced by artificial man made materials. This replacement creates the global warming problems. For the construction activity the major material is concrete. Concrete is the combination of cement, fine aggregates, coarse aggregates and water. The major problem is with the cement. In the production of the cement more that 70% of carbon dioxide and other harmful gases will produce and mixed with the atmosphere. This will damage the o'zone layer. Hence it is necessary to reduce the production and consumption of cement. For this new era it is necessary to go with alternative building materials which does not creates the problems in the environment. So many researchers have been done on many alternatives for cement, fine aggregates and coarse aggregates. By that research work now a day's cement is replaced by fly ash, rice husk ash, slag, baggase ash, eucalyptus ash, saw dust ash, waste sludge ash etc. by using this alternatives for cement the consumption of the cement will reduce and the production will definately reduces. So up to some extent it may solve the problems arising in the environmental pollution from construction activities.

## PROPERTIES OF GEOPOLYMER CONCRETE

- Usage of alkali activator solution, the properties of geopolymer concrete such as compressive strength, split tensile strength, durability, flexural strength may varies.
- Rate of water absorption and capillary pores are comparatively lesser than convention concrete.
- Geopolymer concrete sets quickly and it sets at room temperature.
- Bleeding of geopolymer concrete is less or completely nil.
- The strength of the geopolymer concrete is almost twice than the normal concrete.
- Geopolymer concrete is non-toxic and it does not affect the environment.

## OBJECTIVES

- The main objective is that to eliminate the OPC in the concrete by using slag waste.
- To study the strength properties of GGBS based geopolymer concrete.
- To know the durability of geopolymer concrete.

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- To achieve the optimum mix proportion for GGBS and fine aggregate.
- To find out the best alternative for fine aggregates

## II. MATERIALS AND METHODOLOGY

### MATERIALS

Generally concrete is the combination of cement, fine aggregates, coarse aggregates and water. Here to prepare geopolymer concrete we were taken materials such as GGBS, M-sand as fine aggregates, coarse aggregates and alkaline solution.

- **GROUND GRANULATED BLAST FURNACE SLAG (GGBS)**  
GGBS is the byproduct obtained from steel industry. In our work we were used this GGBS as binder material instead of OPC. This GGBS is white finely powdered material and it is finer than cement. GGBS is obtained from the blast furnace operation during the production of iron and steel.
- **FINE AGGREGATES**  
Fine aggregates are the materials used in concrete to fill the pores & to form dense concrete. These fine aggregates size should be less than 4.75mm. Here we had taken M-sand as fine aggregate.
- **COARSE AGGREGATES**  
Coarse aggregates plays major role in the concrete. It gives maximum strength to the concrete. Locally available crushed stones of 20mm down size are used as coarse aggregates.
- **ALKALINE SOLUTION**  
To prepare concrete, water is important. Here for GPC instead of water we will use this alkaline activator solution. To prepare this alkaline solution we had taken sodium hydroxide pellets and sodium silicate solution. NaOH are in the form of flakes/pellets & it should be dissolve in some calculated amount of water. So alkaline solution is made up of NaOH,  $\text{Na}_2\text{SiO}_3$  and water.



Fig 1: GGBS



Fig 2: M-sand



Fig 3: Coarse aggregate



Fig 4: NaOH



Fig 5:  $\text{Na}_2\text{SiO}_3$

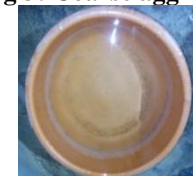


Fig 6: Water

### LABORATORY TEST RESULTS

#### ➤ GGBS

The physical properties and test result of the GGBS is mentioned in the below table. There is no proper specifications and standards for GGBS in India.

Serial no	Properties	Test result	Standards (BS-6699)
1	Specific gravity	2.83	-
2	% particles retained on 90 $\mu$ sieve	100%	More than 90%

Table 1: Physical properties of GGBS

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➤ **M-SAND**

Serial no	Properties	Test result	Standards [IS: 383-1970]
1	Specific gravity	2.66	2.65
2	Fineness modulus	3.24	2.7-4.4
3	Bulk density	1810 kg/m <sup>3</sup>	1860 kg/m <sup>3</sup>
4	Grading zone	II	II

**Table 2: Physical properties of M-sand**

➤ **COARSE AGGREGATE**

Serial no	Properties	Test result	Standards [IS 383-1970]
1	Type	Crushed	Crushed
2	Specific gravity	2.71	2.6-2.9
3	Fineness modulus	4.43	4-6.5
4	Bulk density	1630 kg/m <sup>3</sup>	-
5	Crushing value	22%	< 45 %
6	Maximum size	20mm	-

**Table 3: Physical properties of Coarse aggregate**

**PREPARATION OF ALKALINE SOLUTION:-**To prepare the alkaline solution, sodium hydroxide flakes, sodium silicate solution and distilled water is required. This alkaline solution should prepare 24 hours before casting the concrete. The heat liberation and reaction will be more when the NaOH flakes dissolved in water. Hence it should be prepared 24 hours before casting. According to the molarities this solution should be prepared. The quantity of materials will vary for different molarities. We were taken 3 different molarities i.e. 8M, 10M & 12M. Initially the proper calculated amount of NaOH flakes should be dissolved in required quantity of distilled water. After complete dissolving of flakes calculated amount of Na<sub>2</sub>SiO<sub>3</sub> solution should be added and stirred it properly and keep it for 24hours. During this time around 60-70 °C heat will liberate. In this way we can prepare the alkaline solution. Here we have taken the ratio of sodium silicate to the sodium hydroxide as 1:2.5 throughout our work. The preparation of alkaline solution is shown in below figure.



**Fig 7: Preparation of alkaline solution**

**PREPARATION OF GPC BLOCKS:-**To prepare this GPC blocks we have taken GGBS as binder material, M-sand as fine aggregate, 20mm down size coarse aggregates & alkaline liquid. Before preparing or casting the blocks alkaline solution should be prepared. Later the GGBS, FA & CA should be mixed in a dry condition according to the mix proportions until the uniformity occurs. Later the prepared alkaline solution should be added to that dry mix & mixed it thoroughly for 3-5 minutes. After mixing, it should be poured or placed in the mould which should be oiled before. Then compaction should be done to get dense concrete. Here we have mixed the concrete in drum mixer and compacted with the help of tamping rod. In this way we can prepare the blocks. The preparation of GPC blocks were shown in below figure.

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Fig 8: Dry mixing



Fig 9 :Mixing in drum mixer



Fig 10 :After mixing



Fig 11 :compacting the cubes



Fig 12 :casted cubes

### III. TESTS ON GEOPOLYMER CONCRETE

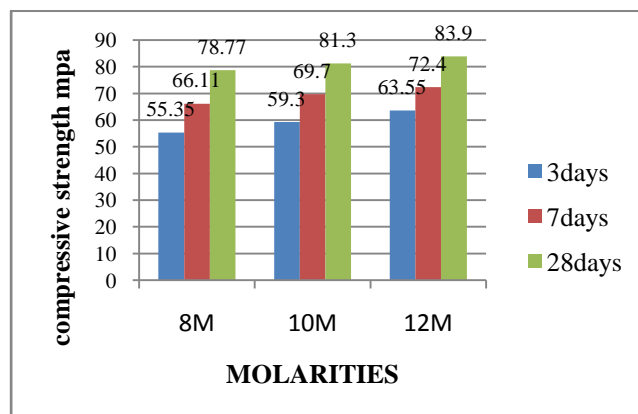
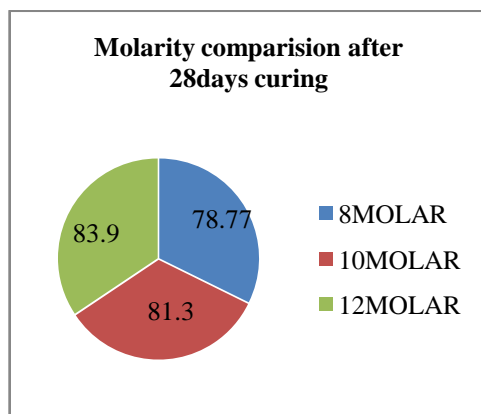
The various tests were conducted to know the durability of the geopolymer concrete like

- Compressive strength test
- Acid resistivity test
- Accelerated corrosion test

#### Compressive strength test:-

Compressive strength in N/mm <sup>2</sup>	Age(Days)		
	3	7	28
8M	55.35	66.11	78.77
10M	59.30	69.70	81.30
12M	63.55	72.40	83.90

Table 4 :- compression test values for m-sand



**Acid resistivity test:-** This test is conducted to know the resistance of GPC against acidic condition. To conduct this test normal concrete cube of size 150X150X150mm should be casted and curing should be done for 28 days. After curing the dry weight of the cubes were noted down. Later the cubes were placed in acid bath tub prepared initially by dissolving 50gms of concentrated sulphuric acid for each liter of water. Note down the pH of the diluted acid. We have maintained the pH of 1.0 throughout our work by using pH tablets. Then the cubes were placed in the acid for 10days, 20days &30days. After 30days the cubes were taken out and dried it completely. Note down the final weights of the cubes and note down its compressive strength. The weight difference shows the resistance of the concrete to the acid.

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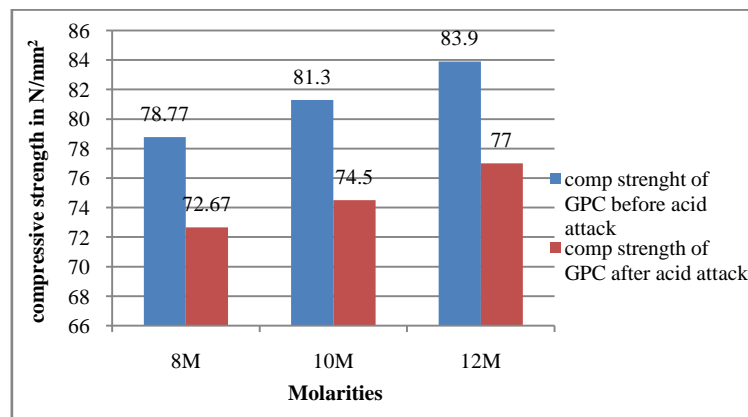
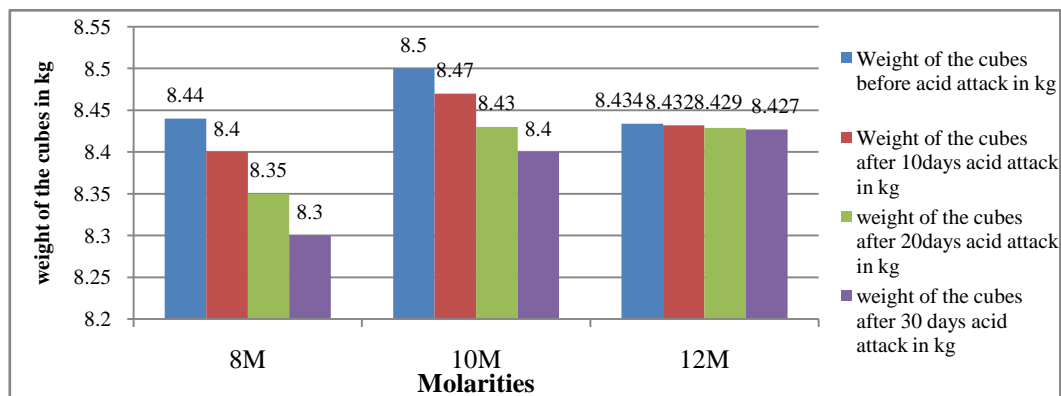
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molarities	Initial weight of the cubes before acid attack in kgs	Weight of the cubes after 10days acid attack in kgs	Weight of the cubes after 20days acid attack in kgs	Weight of the cubes after 30days acid attack in kgs	Compressive strength of the cubes after acid attack in N/mm <sup>2</sup>
8M	8.44	8.40	8.35	8.30	72.67
10M	8.50	8.47	8.43	8.40	74.50
12M	8.434	8.432	8.429	8.427	77.00

**Table 5 : Acid attack test values for M- sand**



**Accelerated corrosion test:-**The accelerated corrosion test can be done to know the amount of corrosion of reinforcement in the concrete. This corrosion will occur mainly due to carbonation. To conduct the accelerated corrosion test cylinders of 150mm dia & 300mm length should be casted. We have conducted this test for 3 different molarities. We have taken 12mm diabars. During the casting of cylinders the reinforcement should be placed inside the concrete. Before placing the bars into the concrete the initial weight of that bar should be noted down. After 28 days curing the cylinders should be placed in the tub which contains 3.5% NaCl solution and current is passed through the reinforcement from the 12volt battery by making reinforcement as positive and copper plates immersed in tub are used as negative. This test is also conducted for 10days & 20days. After 20days the cylinders are placed in CTM & by applying the load can find out the split tensile strength & remove that bars from the cylinders & cleaned it thoroughly & note down its weight. The loss of weight gives the rate of corrosion of rebars in concrete.

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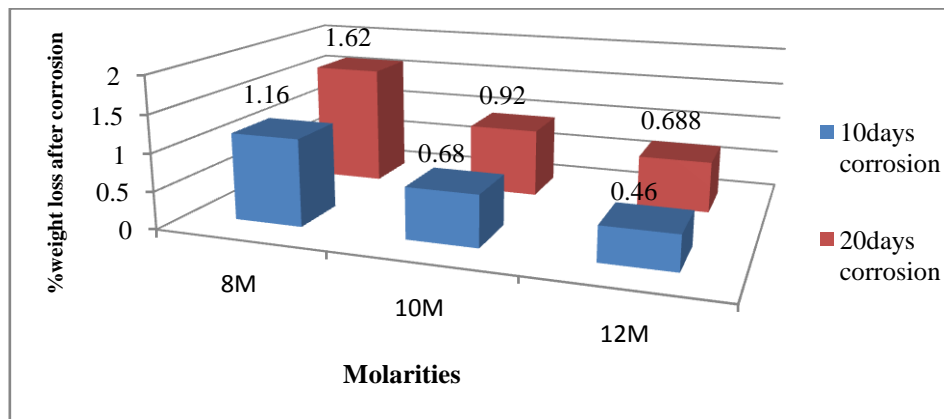
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Molarities	No of days	Weight of reinforcement before corrosion $W_i$ in gm	Weight of reinforcement after corrosion $W_f$ in gm	%weight loss(P) $P = \frac{(W_i - W_f) \times 100}{W_i}$	Split tensile strength in $N/mm^2$
8M	10	430	425	1.16	3.13
	20	432	425	1.62	2.99
10M	10	442	439	0.68	3.90
	20	434	430	0.92	3.50
12M	10	436	434	0.46	4.25
	20	436	433	0.688	4.00

**Table 6: Accelerated corrosion result of GPC**



#### IV. CONCLUSION

Following broad conclusions can be made from my experimental study on ambient cured geopolymers concrete

- Compressive strength of the cubes increases with increasing the molarities i.e. compressive strength is maximum for 12molar GPC compared to 8molar.
- In the present study, it can be observed that acid attack and accelerated corrosion is more for 8molar compared to 12molar GPC.
- Depth of carbonation is also more for 8molar GPC.
- Sorptivity is also more for 8molar GPC.
- The cubes prepared with M-sand of 12 molar were very strong enough to resist the acid, corrosion, carbonation and sorptivity.
- GPC can be prepared by eliminating the cement and hence it becomes Eco-friendly.
- Usage of M-sand gives good results and hence we can easily go for M-sand instead of river sand.

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