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An Experimental Investigation on Physical Properties of GGBS Based Geopolymer Concrete

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ABSTRACT: Civil engineering is the fastest growing sector in developing countries. Due to high demand for construction activities, more and more cement is being produced. High rate of production of cement is exploiting the natural resources and also liberating enormous amount of heat to the atmosphere in the form of carbon di-oxide. This is leading to global warming which is serious issue causing lot of ill effects on living organisms. Thus it is a prime to think of an alternative which is environmental friendly and as well as a versatile material to replace cement and its products. This research is made on one of such alternative that is Geopolymer Concrete.

Geopolymer concrete is an upcoming trend in construction industry, which mainly make use of industrial waste such as fly ash or GGBS as binder cementacious material, even other materials such as kaolin, metakaolin etc,., are being used. But in this project we have used GGBS as binder material as it has more advantages over other alternatives. Main Advantage of GGBS based GPC is, it sets at room temperature and gains high strength in less time. In this research, Geopolymer concrete of 8, 10, 12 molarities are prepared and Checked for mechanical behaviors such as compressive strength, tensile strength with M-sand as fine aggregates. As there is shortage of river sand, it is the right time to think of alternatives for that also.

KEYWORDS: Na_2SiO_3,NaOH ,GGBS.

I. INTRODUCTION

Civil engineering is one of the fastest growing industries in this decade. Construction industry is the 2nd largest client of central excise and it is the main donor for the GDP. It is noteworthy that demand for cement in India is expected to develop at 10% yearly. Increase in cement production has also increased the amount of pollution which contributing indirectly to the increase of global warming. Cement industries liberated tons of carbon di oxide to atmosphere every year, which in turn increasing the earth's temperature.

Concrete is a complex mixture of water, cement, coarse aggregates and fine aggregates, which after hydration forms a hard solid material. Concrete is a versatile materials which reached many aspects in day today life such as from flower pots till precast materials for major construction.

GPC is a revolutionary idea. In which the usage of cement is nil. In GPC, constituents are cementacious material, fine aggregates, coarse aggregates and activator solution. Here cement is completely removed and alternatives such as fly ash, GGBS, metakaolin, kaolin are being used.

A French Professor 'Davidovits' gave the name "Geopolymer" in 1978. According to him, it represents an inorganic molecules network.

II. MATERIALS AND PROPERTIES

GPC is a type of concrete which has same constituents of conventional concrete except cement as binder material. Along with binder material, fine aggregate and coarse aggregate, it needs an activator solution instead of water. The constituents of GPC depend upon its availability, cost, type of application and finally according to the users requirements.

BINDER MATERIAL

GGBS is considered as the binder material in this work. Use of GGBS in GPC has main advantages such as rapid strength gain, bleed free and eco-friendly.

ACTIVATOR SOLUTION

Combination of Na_2SiO_3 and NaOH is used as activator solution. Na_2SiO_3 is commonly available in solution form and the Sodium Silicate solution used for research purpose had a chemical composition of Na_2O- 13.53%.SiO_2-

28.66% and water 49% by mass. Sodium hydroxide (NaOH) is commonly available in flakes form. In this research 97% pure sodium hydroxide pellets were used.

FINE AGGREGATES

For present study manufactured sand is used as fine aggregates.

COARSE AGGREGATES

20mm down size crushed stone aggregates are collected from a local quarry.

LABORATORY TESTS

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.

SL NO.	CHARECTERSTICS	RESULTS	STANDARDS [BS:6699]
1	Specific gravity	2.83	-
2	Passing through 90µ sieve	100%	MORE THAN 90%

Table 1: Properties of GGBS

MANUFACTURED 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^3	1860 kg/m3
4	Grading zone	II	II

Table 2: Properties of Manufactured Sand

COARSE AGGREGATES

20mm downsize crushed stone aggregates were procured from a local quarry.

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^3	-
5	Crushing value	22%	< 45 %
6	Maximum size	20mm	-

Table 3: Properties of Coarse Aggregate

IV. METHODOLOGY

PREPARATION OF ALKALINE ACTIVATOR SOLUTION

- Laboratory grade materials are procured and calculations are made for different molarities
- Portable water is measured for required quantity.
- Calculated amount of sodium hydroxide pellets is added to it based on its molarity.
- It has to be stirred effectively to avoid solidification at bottom of container.
- Now, sodium silicate solution is weighed and mixed to the sodium hydroxide solution and properly stirred.
- This is an exothermic reaction and generated heat more than 60-70 ^{0}C and thus this reaction has to complete before mixing with constituents of concrete, or else it will create thermal cracks in concrete.
- This alkali activator solution is chemically very active and this has to handle properly.
- This solution has to be kept for 24 hours so that, reaction will be complete and solution completely cools down.

PREPARATION OF GEOPOLYMER CONCRETE

The various constituents of GPC are weighed according to molarity.

- Initially coarse aggregates, fine aggregates and binder materials are mixed well and a good dry mix is prepared.
- Prepared activator solution, cooled for 24 hours is poured to dry mix and mixed effectively.
- Uniform mix is obtained after 2 to 3 minutes of effective mixing.
- The GPC mix is now filled to moulds (cubes of 150X150X150mm, cylinders of 150mm diameter and 300mm height) in 3 layers with good compaction methods.
- Hand compaction can be adopted to achieve the compaction of GPC

The prepared GPC can be demoulded after setting and kept for ambient curing.

V. RESULTS AND DISCUSSIONS

The test results cover the effect of age on the compressive strength, tensile strength and flexural strength. The test specimens are made with differing molarities of 8M, 10M and 12M for the Manufacture sand. Each test result plotted in the Figures or given in the Tables is the mean value of results obtained from at least three specimens.

TESTS CONDUCTED ON CONCRETE

The following test were conducted

A) Compression Test
B) Split Tensile Test

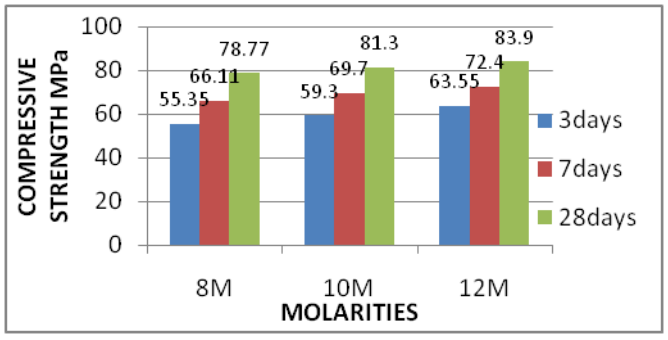
COMPRESSION TEST

Figure 1: Compression Test

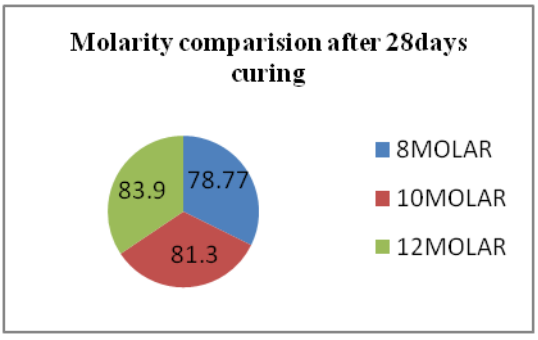
Compressive strength in N/mm^2	Age(Days)		
	3	7	28
8M	55.35	66.11	78.77
10M	59.30	69.70	81.30
12M	63.55	72.40	83.90

Table 4: Compressive strength of GPC

Compressive strength or stress = [Load /Area] N/mm^2



Graph 1: Compressive Strength of GPC



Graph 2: Pie chart comparison of Compressive strength of GPC

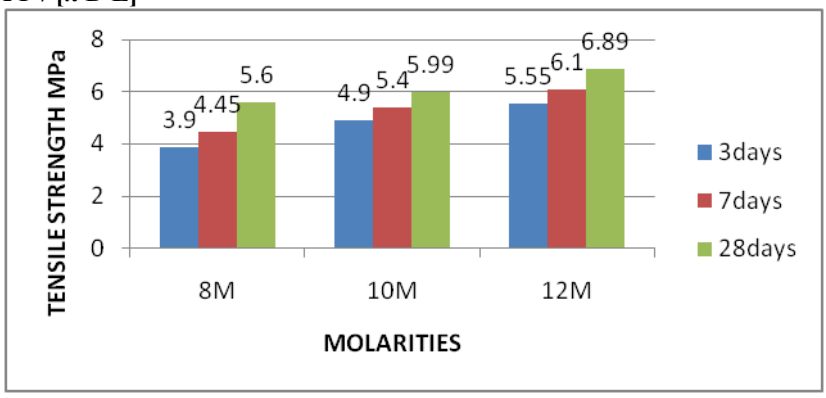
SPLIT TENSILE TEST

Figure 2: Split Tensile Test

Tensile strength in N/mm^2	Age(Days)		
	3	7	28
8M	3.90	4.45	5.60
10M	4.90	5.40	5.99
12M	5.55	6.10	6.89

Table 5: Split tensile strength of GPC

Split tensile test= 2 X P / [π D L]



Graph 3: Tensile strength of GPC with M-sand

VI. CONCLUSIONS

The following broad conclusions can be drawn from the limited experimental study on the ambient cured GGBS based GPC;

- Compressive strength of cubes increases with increase in molarity that is strength of 12M is the highest and 8M is the lowest.
- GPC made with manufactured sand attains more strength.
- In places where workability is more important than strength, river sand can be used as fine aggregate.
- Due to short supply of river sand, manufactured sand can be effectively replaced.
- As slag is a byproduct of iron and steel industry it gives better tensile strength to GPC.
- As OPC concrete will lead to environmental depletion, hence GPC can be the best alternative.
- Percentage water absorption is more for 8molar compared to 10M and 12M.

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