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EVALUATION OF STRENGTH PROPERTIES OF GGBS BASED GEOPOLYMER CONCRETE

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Abstract: Nowadays more cementitious waste material are produced by many industries like iron industries (GGBS), paper industries (paper ash) etc, But the cement production from the industries affects the environment to reduce CO2 emission and greenhouse effects through the greater use of substitute for Cement. The use of supplementary cementitious materials as partial replacements for the cement in concrete will play a significant role with respect to the environmental control global temperature reduction. The development of geopolymer concrete (GPC), processing of geopolymer using GGBS in combination with sodium hydroxide and sodium silicate solutions, offers a promising alternative to ordinary portland cement concrete. This study compares the differing the molarities of alkaline solutions which are 8M,10M,12M,14M and 16M and comparing the strengths of the above molarity and conducting the compressive strength, split tensile strength and flexural strength properties of GGBS based geopolymer concrete by conducting the test.

Index Terms **- Geo polymer concrete, GGBS, Strength properties.**

I. INTRODUCTION

The world's construction rate is increasing day to day life and the nation's economy is dependent on the construction industries. The waste disposal from the industries was also in a large scale. Utilization of these industrial wastes in a safe manner is required of these wastes in the construction field for cost reduction. Geopolymer concrete is made by GGBS with alkali activation and special concrete is prepared. The energy required for the manufacture of cement based concrete is very large than the geopolymer cement, this is effecting the environment. Where the concrete i.e. Ordinary Portland cement concrete with good durability aspect is preferred, such alternative concrete like geopolymer concrete is in needed. Where research works were carried out from several years to conform geopolymer concrete is a good material for construction purpose.

In India like country alternative concrete like geopolymer concrete have a great acceptance realizing the geopolymer concept CSIR-structural engineering research center carried on different parameters of geopolymer concrete is used and it is used and it is increasing slowly. In the year 1978 Davidovits proposed the binder can be obtained by using a alkaline solutions in the concrete the polymerization process will also occur in the concrete and it will creates a bond between the concrete and hence this concrete is also known as geopolymer concrete. In some countries like Australia and spain had done considerable amount of research these research have proposed some suitable materials for the preparation of geopolymer concrete and also mix design and durability aspects. Durability of geopolymer concrete is more because of inorganic binder with silica and alumina, like conventional concrete is reinforced geopolymer concrete should also reinforced for the structural applications.

In this project I have used the ratios of GGBS and aggregates is 30:70 in the replacement of cement. In present study on GPC are mainly focused on the Ground granulated blast furnace slag based geopolymer concrete and its strength properties.

II. MATERIALS

A. GROUND GRANULATED BLAST FRUNACE SLAG

GGBS is the byproduct of the blast furnace and which has been used for iron manufacturing, about 1500 degrees centigrade coke, iron ore and limestones are fed into the furnace. Where the iron ore becomes iron and the remaining materials forms like molten slag and that floats on top surface with the iron in the furnace and this slag is taken out from the furnace and rapid quenching with water after that it forms like granulated slag and this slag is grinded after this process GGBS is formed. Ground-granulated slag is synthesized through process of quenching. It is amorphous in nature and formed a result of slag quenching from blast furnace. It can also be seen as auxillary product during production of steel which can aid in concrete technology.

Table 1: Physical properties of GGBS

Specific Gravity	2.13
Colour	White
Fineness	4.3%

B.AGGREGATES

COARSE AGGREGATE:

Coarse aggregate is the predominant constituent of concrete. Hence, properties and characteristics fresh and hardened concrete are siginificantly affected by the properties coarse aggregate. Aggregates provide about 75% of the concrete volume making it a very important constituent. They should meet certain requirements with respect to grading, size, shape and strength. Of course, the characteristics of concrete are also affected by the properties of other constituent materials like cement, fine aggregate, chemical and mineral admixtures, SCM's etc. by viewing all these, concrete performance will also affected by the proportionating of constituent materials, method of mixing, transporting, placing, compaction and curing

Table 2: Physical properties of Coarse aggregate

Sl no	Properties	Values
1	Specific Gravity	2.80
2	Fineness Modulus	7.32
3	Bulk Density	1680(kg/m3)

C.FINE AGGREGATES:

Fine aggregates finer in the size less than 4.75mm. its size ranges from 4.75mm to 150 micron. The fraction of finer than 150 microns is considered as dust or it may be silt. Due to this development in construction and infrastructure, fine aggregates are available in various categories like manufactured sand similarly known as M-sand, natural or river sand etc. The fine aggregates are the particles which passes through 9.5mm sieve, almost entirely passing the 4.75mm sieve and predominantely retained on a 75micron sieve are called fine aggregates.

Table 3: Physical properties of Fine aggregate

Sl no	Properties	Values
1	Specific Gravity	2.63
2	Fineness Modulus	2.51
3	Bulk Density	1564(kg/m3)

D.ACTIVATOR SOLUTIONS:

Alkaline solution was the combination of the sodium silicate and sodium hydroxide with the water which forms the alkali solution.The different concentration of NaOH solution were prepared in the lab. Sodium silicate of 40% concentration and required grade was added to sodium hydroxide solution and the alkali solution will be prepared. A compound sodium metasilicate will be the common name for sodium silicate(Na_2SiO_3). It was handy in the form of liquid and solid. Sodium silicate solution is used in manufacturing of cement and automobile. Silicon dioxide and sodium carbonate which reacts in molten state to the sodium silicate and the carbon dioxide.

III. METHODOLOGY

The GGBS based geopolymer concrete specimens (GPC) were prepared with alkaline solution ratio (sodium silicate to sodium aluminate) of 2.5 by its mass, hence the strength was maximum where the ratio is kept as 2.5. The grade of concrete chosen based on the IS 456-2000. The cubes were casted in size of 150*150*150mm and the molarity is taken as 6M,8M,10M,12M and 14M with a ratio of 30:70 of GGBS and aggregates and further the aggregates are differentiated in to 35:65 i.e., fine aggregates: coarse aggregates. After casting the specimens it will be cured in an ambient condition for 3days and 7days. The specimens were tested for compressive, split tensile strength and flexural strength test. Then this will be compared to OPC concrete.

IV. DESIGN MIX

Aggregates are taken in the saturated surface dry conditions. The binder to aggregate proportion are taken as 30:70Further the aggregates has been proportioned as 35:65 i.e., fine aggregate to coarse aggregate.

V. RESULTS AND DISCUSSION

a) COMPRESSIVE STRENGTH:

The compression test were carried out by the 150*150*150mm size cube specimen at which the results of 3days and 7days. All the moulds were tested by using CTM of 2000KN capacity undergoes uniform rate of loading until failure occur and also the final loading in failure was taken for the calculation of compressive strength.

Table 4: Average results of compressive strength

CONCENTRATIO	COMPRESSION STRENGTH	
	3DAYS	7DAYS
6M	35.28	35.02
8M	45.11	44.8
10M	35.15	34.9
12M	35.2	35.37
14M	34.8	34.75
16M	36.8	36.62

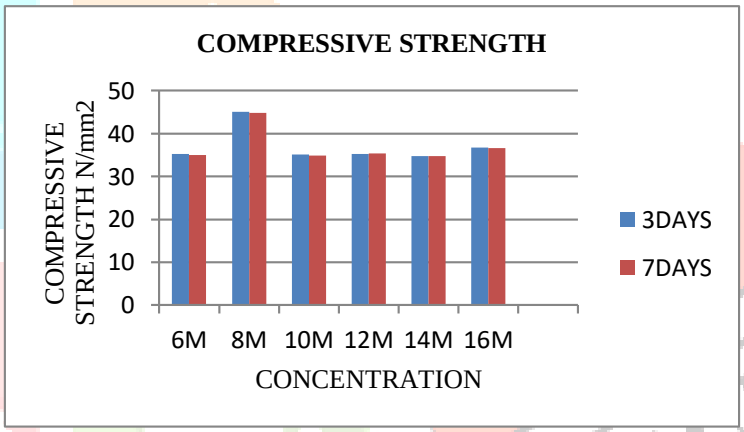

Fig 1: Comparison graph for compressive strength for 3days and 7days

Figure 1 shows the comparison of compressive strength of 6M,8M,10M,12M and 14M concentration of NaOH geopolymer cubes in which the 8M concentration geopolymer concrete cubes shows the high strength and for further studies 8M ratio will be taken for GPC.

b) SPLIT TENSILE STRENGTH

To compute the split tensile strength of GPC, cylindrical moulds (150*300mm) were used and the specimens are cured in sunlight for 3days and 7days respectively. The geopolymer concrete mix is carried through 8 molarities of 3days and 7days strength, and the specimens were tested for their split tensile strength using UTM

Table 5: Results of split tensile strength for 8M concentration

CONCENTRATION	SPLIT TENSILE STRENGTH	
	3DAYS	7DAYS
8M	2.8	2.71
8M	2.85	2.82
8M	2.91	2.4

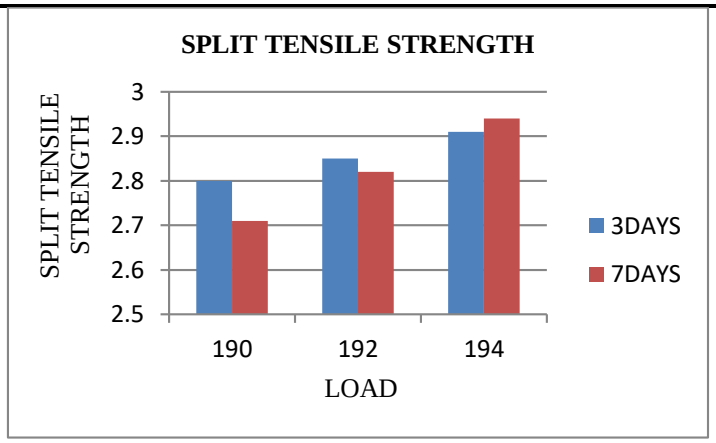

Fig 2: Comparison graph for split tensile strength for 3days and 7days

The figure 2 shows the comparison of 3days and days strength, the split tensile strength for 8M geopolymer concrete which has been kept in sunlight for 3days and 7days and the cylindrical moulds are tested in a universal testing machine, the strength gained 2.83KN/mm^2 and 2.85KN/mm^2.

c) FLEXURAL STRENGTH

The flexural quality GPC by the utilization of straightforward bar or crystal with 3 point stacking, this method is generally referred to a modulus of crack. By which decide the flexural strength of GPC, prism moulds are (50*10*10)were used and the specimens are taken for 8 molarities and those specimens underwent sunlight curing for 3days and 7days and those specimens underwent sunlight.

Table 6: Results of Flexural strength for 8M concentration

CONCENTRATION	FLEXURAL STRENGTH	
	3DAYS	7DAYS
8M	5.13	5.75
8M	5.69	6.56
8M	5.54	6.82

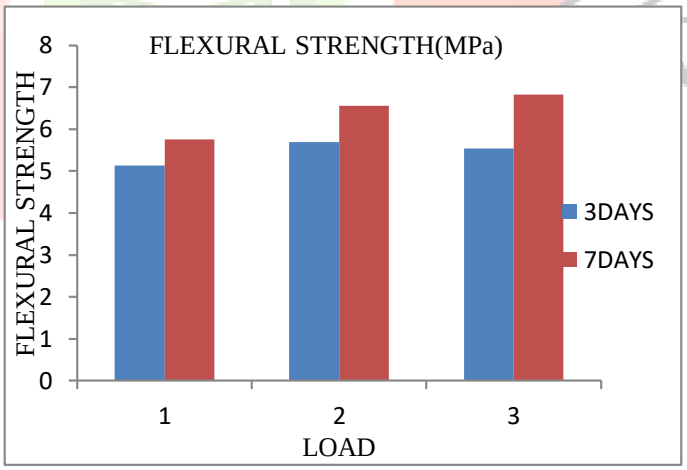

Fig 3: Comparison graph for Flexural strength for 3days and 7days

The flexural strength for 8M geopolymer concrete which has been kept in sunlight for 3days 5.45MPa and for 7 days strength is 6.37MPa and the figure 3 clearly shows that the 7days strength of GPC is more compare to 3days.

d) CONCLUSIONS

- With the conducted experiments based on the different methods and the interpretation of the acquired results, it was noted that the use of GGBS as replacement for cement, it enhanced the property of the concrete in related to stability and service life of the obtained product.
- The use of GGBS also enhanced the Moisture resistant characteristic of the mix which can be used in Marine Construction, the less reactive property obtained by the use of alkali solution led to increase in stable chemical mix, that further aided in less reactive nature with the salts and other minerals present in sea, thus increasing the service life of the structure.
- With the use of GGBS the service life of the concrete was increased to 40% on average, and with reduction in 30% cost as compared to the normal concrete made entirely with cement, was found to be more economically suitable which had better desirable property.
- With the increase in the load characteristic, and better resistant to external force, the service cost in service life of the structure can be reduced.
- The Compressive Strength properties of geopolymer concrete shows that, 3days strength for 8M of GPC gives a better result compare to 7days strength. Hence for further studies 8M concentration is taken.
- The Split Tensile Strength properties shows that the 8M concentration of GPC gives higher strength in 7days test compare to 3days.
- The Flexural Strength properties shows that the 8M concentration of GPC gives higher strength in 7days test as compare to 3days.
- With the extensive use of GGBS in construction aids in balancing the environment by reducing the pollution caused by the disposal of the residue of the furnace.
- With the addressed Pro's of the project it can be concluded that the concrete structure made by GGBS geopolymer provided better results as compared to the normal concrete structure.

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