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EXPERIMENTAL INVESTIGATION ON STUDYING THE FLEXURAL BEHAVIOUR OF GEOPOLYMER CONCRETE BEAM UNDER FIXED BOUNDARY CONDITION

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ABSTRACT

Geo polymer concrete is one of the emerging construction material as a substitute for conventional cement concrete, eliminating the usage of OPC. This work is aimed to cast and testing of geo-polymer beam elements with restrained edge condition. The size of beam is 1m x 1m x 0.05 m. By using yield line theory, the moment of resistance and maximum deflection under flexural loading are calculated for the of GPC beam. Reinforcement details of these beam are calculated using ultimate load method as per IS code provisions. Geopolymer concrete is the greener concrete, which has the potential technology to reduce the carbon emission and lead to sustainable developments and growth of the concrete industry. During the manufacturing of ordinary Portland cement, large amount of carbon dioxide is released in the atmosphere causing not only air pollution but also highly responsible factor of global warming.

1. INTRODUCTION

The demand for concrete as a material of construction will increase as the demand for infrastructure development increases, especially in countries such as China and India. In order to meet this demand, the production of Portland cement must increase. However, the contribution of greenhouse gas emission from the Portland cement production is about 1.35 billion tons annually or about 7% of the total greenhouse gas emissions to the earth's atmosphere. Furthermore, Portland cement is also among the most energy-intensive construction materials, after aluminium and steel. Environmental issue has become a crucial issue in concrete industry. This is mostly because of the emission of greenhouse gasses from the production of Portland cement, a primary binder in making concrete. Many efforts have been made to reduce the use of Portland cement in concrete that in turn will reduce the greenhouse gas emission. Those efforts include use of supplementary cementing materials and finding alternatives for Portland cement. . Fly ash, a by product of coal obtained from the thermal power plant is plenty available worldwide. Fly ash is rich in silica and alumina reacted with alkaline solution produced alumina silicate gel that acted as the binding material for the concrete. It is an excellent alternative construction material to the existing plain cement concrete. Geopolymer concrete shall be

produced without using any amount of Ordinary Portland Cement. This work briefly reviews the constituents of geopolymer concrete, its strength and potential applications.

2. SCOPE AND OBJECTIVE

A. OBJECTIVE

There are three main objectives of this research.

1. To develop Geo-polymer concrete using Fly ash as a source material.
2. To calculate the density of Geo-polymer concrete.
3. To study the effect of sodium hydroxide concentration on strength and durability properties of fly ash and GGBS based Geo-polymer concrete.

B. SCOPE

To develop geo-polymer concrete of different grades using locally available fine and coarse aggregate using fly ash as a binder material. Commercially available chemicals will be used for preparing super plaster for activation of fly ash to act as binder material.

3. MATERIALS

1. Fly ash.
2. Ground granulated blast furnace slag.
3. Fine aggregate.
4. Coarse aggregate.
5. Superplasticizer.
6. Alkaline Solution.

A. FLY ASH

Fly ash is a by-product of coal fired electric generating plant. Fly ash can be used in Portland cement concrete to enhance the performance of the concrete. Fly ash is an artificial pozzolana produced from coal fired thermal power plants and for every 300 MW of power generated, about 500 Kg of fly ash is produced. The annual production of fly ash in India is about 75 million tons. In India, there are more than 50 thermal power plants.

Table 1 Properties of Fly Ash

S.No	Test Particulars	Result
1	Specific gravity	2.0
2	Bulk density	1500 (kg/m^3)
3	Colour	Grey
4	Bulk density	Powder

B. GROUND GRANULATED BLAST FURNACE SLAG (GGBS)

GGBS-Ground Granulated Blast Furnace Slag which is a by-product of steel manufacturing industry is an accepted mineral admixture for use in concrete. This granulated material when further ground to less than 45micron is called Ground Granulated Blast Furnace Slag.

Table 2 Physical Properties of GGBS

S.NO	Property	Value
1	Normal consistency	30%
2	Initial setting time in min	55minutes
3	Final setting time in min	9hours
4	Specific gravity	2.98
5	Fineness of cement by sieve	8%

Table 3 Chemical Properties of GGBS

Material	SiO2	Al2O3	Fe2O3	CaO	MgO	SO3	K2O	Na2O	LOI
GGBS	33.46	(SiO2+ Al2O3+ Fe2O3) = 48.63		25.02	7.97	0.85	1.28	1.32	13.61

C. FINE AGGREGATE

Sand is primarily filler for the voids in concrete. Increasing the proportion of sand in the total mix increases cement demand because of the relatively very large surface area that needs to be coated by cement paste. Flat elongated and angular shaped sand such as products from crushed sand, also require more water to produce workable concrete. Hence, cement demand is increased to maintain the same W/C Ratio.

Table 4 Properties of Fine Aggregate

S.NO	PROPERTY	VALUE
1.	Specific gravity	2.65
2.	Fineness modulus	5.2
3.	Water absorption	7.0%
4.	Surface texture	Smooth

D. COARSE AGGREGATE

The coarse aggregate properties are shown in below table. Beyond this, a smaller sized aggregate may have strength advantages in that internal weak planes may be less likely to exist or would be smaller and discontinuous. A rough angular surface such as in crushed aggregates will increased for a given slump, the water and cement content per cubic meter of concrete are decreased. Coarse aggregate having bulk density 1691 kg/m^3. Coarse aggregate is sieved to 20 mm and the passed out is used.

Table 5 Properties of Coarse Aggregate

S.NO	PROPERTY	VALUE
1.	Specific gravity	2.68
2.	Fineness modulus	6.75
3.	Water absorption	2.5%
4.	Flakiness Index	14.13 %
5.	Elongation Index	21.29 %
6.	Crushing value	21.33 %
7.	Impact Value	15.40 %

E. SUPER PLASTICIZER

Conplast SP430 is used as the admixture. It is high performance super plasticizing admixture which has the appearance of Brown liquid having the specific gravity of 1.18 in which alkali content is typically less than 55g.

F. ALKALINE SOLUTION

Combination of sodium hydroxide (NaoH) and sodium silicate are used in the preparation of GPC mix. NaoH is readily available in pellets. Sodium silicate is easily available in the market of proportions is SiO2= 30.24%, Na2O = 15.7% and H_2o – 54.06%by weight. The sodium hydroxide solution is mixed with sodium silicate solution to get the desired alkaline solution one day before making the geo-polymer concrete.

4. MIX DESIGN

From the literature survey it is understood that as there is no code available for Mix design of Geopolymer Concrete.
Fly ash= 142 kg/m3.
GGBS= 172 kg/m3.
Water (Net Mixing) = 155 kg/m3.
Fine Aggregate= 770 kg/m3.
Coarse Aggregate= 1146 kg/m3.
Chemical Admixture= 4.74 kg/m3.

5. TESTING OF SPECIMENS

The following tests are conducted to the concrete specimes.

A. COMPRESSIVE STRENGTH TEST

Compressive strength and density tests were performed on both normal and common effluent treatment waste sludge blocks. Compressive strength test was carried out to determine the load bearing capacity of the blocks. The blocks that have attained the ripe ages for compressive strength test of 7, 14, and28 days were taken from the curing or stacking area to the laboratory, two hours before the test was conducted, to normalize the temperature and to make the block relatively dry or free from moisture. The weight of each block was taken before being placed on the compression-testing machine in between metal plates. The block was then crushed and the corresponding failure load was recorded. The crushing force was divided by the sectional area of the block to give the compressive strength. The density of the block was determined by dividing the weight of the block prior to crushing, with the net volume. The compressive strength for 7, 14, and 28 days are calculated and tabulated for various samples. Manufacturing of solid blocks by adding sludge has a good compressive strength compared to the normal block. It has more than 19N/mm2 and also the water absorption is very less in sludge added block. It has more amount of lime component so the additive strength also gets increased for block.

Fig 1 Compressive Strength

B. SPLIT TENSILE STRENGTH TEST

The tensile strength of concrete is approximately 10% of its compressive strength. After curing of 7 and 28 days the specimens were tested for splitting tensile strength using a calibrated compression testing machine of 2000 KN capacity.

Fig 2 Split Tensile Test of Cylinder

C. FLEXURAL STRENGTH TEST

The tests on beams were carried out on Flexural testing machine of 100kN capacity under two point loading system. The average value of 3 specimens for each category at the age of 28 days is tabulated in the Table 3.The increase in strength of various concrete mixtures over the plain concrete is also tabulated in the Table. There is considerable increase in the flexural strength of concrete with the inclusion and increase in the percentage of waste foundry sand up to 50%. However after 50% there was decrease in the strength compared to normal concrete mixture.

Fig 3 Flexural Strength Test Of Beam

6. RESULTS AND DISCUSSIONS

RATIOS FOR SPECIAL CONCRETE

Cement Replacing 50 % of Fly Ash
Cement Replacing 50 % of GGBS
Super Plasticizer 430 – 0.3% Adding.

A. COMPRESSIVE STRENGTH TEST

Mix Design	% Of Replacement	Compressive Strength (N/mm²)		
		7days	14 Days	28days
M_{30}	CC	25.6	30.6	38.32
	50% FA	26.2	31.2	39.8
	50% GGBS	26.90	32.0	41.50
	50% FA + 50% GGBS	27.6	32.6	42.33

Table 6 Compressive Strength Test Result

CALCULATION

STRENGTH $= \frac{Load}{Area}$ N/mm²

$= \frac{576000}{150\ x\ 150}$

= 25.6 N/mm²

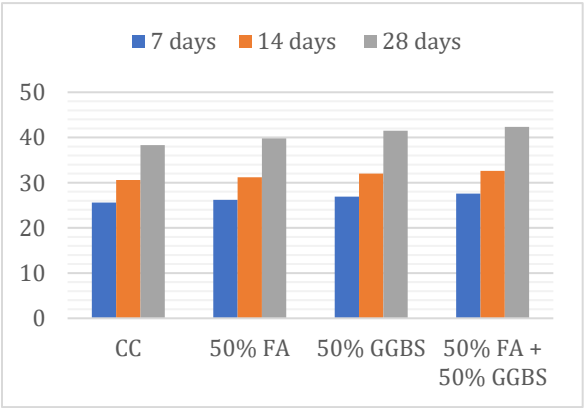

Fig 4 Compression Test Graph Result

B. SPLIT TENSILE STRENGTH TEST

Mix Design	% Of Replace-ment	Split Tensile Test (N/mm²)		
		7 Days	14 Days	28 Days
M_{30}	CC	1.68	2.1	2.99
	50% FA	1.70	2.18	3.02
	50% GGBS	1.75	2.25	3.06
	50% FA + 50% GGBS	1.82	2.32	3.1

Table 7 Split Tensile Test Result

CALCULATION

STRENGTH $= \frac{2P}{\pi dl} N/mm^2$

$= \frac{2\ x\ 118752.20}{\pi\ x\ 150\ x\ 300}$

$= 1.68\ N/mm^2$

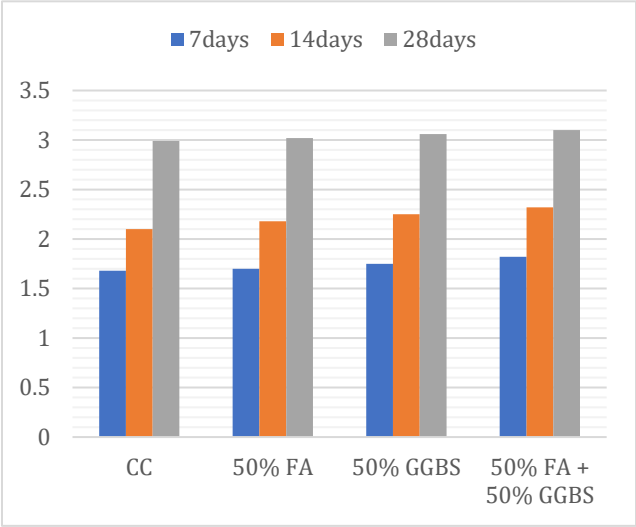

Fig 5 Split Tensile Graph Result

C. FLEXURAL STRENGTH TEST

Mix Design	% Of Replacement	Flexural Strength Test (N/mm²)		
		7 Days	14 Days	28 Days
M_{30}	CC	2.21	3.93	5.87
	50% FA	2.25	4.0	5.89
	50% GGBS	2.30	4.05	5.91
	50% FA + 50% GGBS	2.34	4.12	5.93

Table 8 Flexural Strength Test Result

CALCULATION

Flexural strength R $= Pl/bd^2$

$= 10125 \times 700/150 \times 150^2$

$= 2.21\ N/mm^2$

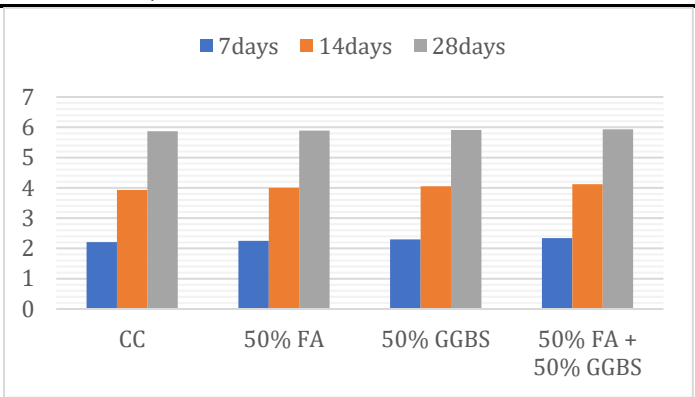

Fig 6 Flexural Strength Graph Result

7. SUMMARY AND CONCLUSION

Based on the results obtained in the experimental investigation, the following conclusions are drawn.

It was observed that Compressive strength was found maximum for complete replacement of (50% Flyash + 50% GGBS) Cement. The compressive strength increased.

The increase of GGBS in the flyash based mix increases the workability characteristics.

It was observed that Split tensile strength was found maximum for complete replacement of Cement by Flyash & GGBS. The split tensile strength increased as 3.1N/mm^2 at 28 days.

The strength of geopolymer concrete was increased with increase in percentage of Flyash &GGBS in a mix.

CONFLICT OF INTERESTS

None.

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None.

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