Mechanical Strength Properties of Geopolycrete with GGBS for Composite Construction

P.T.Ayswariya Lakshmi, S.Maragatham

Abstract: Concrete which is at high necessity is both economically and environmentally facing contradictions. Invoking this issue as the need of time, Geopolymer has made its existence into construction. But in further stage cement and river sand are both causing depletion to natural resource. The hybrid geopolycretesi is eco-friendly, non-corrosive and good durability. Substantial research papers has reported the studies on GGBS & Geopolymer. Composite construction involves the technique in which material efficiency of two different materials go hand in hand. This paper explains the mechanical behavior of GGBS blended Geopolymer Concrete and the results are discussed for its application in composite slab. The hybrid geopolycrete of M25 grade is tested for strength and durability properties by casting test specimens. The design for the slab is performed manually.

Keywords: Composite slab, Decking sheet, Geopolymer concrete, GGBS, Fly ash.

I. INTRODUCTION

An alternative eco-friendly concrete binder called “GEOPOLYMER” is developed, an aluminosilicate material. Fly ash (also known as flue-ash) is a residue generated by combustion of coal which is rich in alumina and silica. Geopolymer reduces about 80% of emission CO2. Geopolymer was synthesized with fly ash, GGBS, alkaline solution, M-sand. Geopolymer concrete is ambient cured and requires no water curing[1].

Geopolymer is an inorganic alumino-silicate compound, synthesized from materials of geological origin or from by-product materials such as fly ash, rice husk ash, etc., which are rich in silicon and aluminum.[2]. Fly ash is one of the residues generated from the combustion of coal, generally captured from the chimneys of coal-fired power plants. The important strategy in making materials more environmental friendly is consumption of fly ash in manufacture of Geopolymer. Based on this reason, in order to utilize this industrial waste in a better way fly ash is used as the base material in this project.

Accordingly, the present project aims in replacing the cement with fly ash using Geopolymer concrete. Hence CO2 and consumption of OPC is reduced. The obtained result is being applied on the emerging construction technology.[5]

GGBS comprises of CaO, aluminum oxide, magnesium oxide, silicon di-oxide. Its possible when the GGBS is added in Geopolymer concrete will boost the strength of the concrete and curing is done at normal room temperature. The chemical content of ground granulated blast furnace slag remains the same as in normal PPC cement but different in proportion.[6]

II. OBJECTIVE

1. To study the material properties of raw material and incorporate in the mix design.
2. To compare the mechanical strength properties of the test specimens for various percentage of GGBS from 0% - 30%.[3]
3. Achieve ambient curing of the specimens.
4. To design the specification of composite slabs.

III. METHODOLOGY

Fly ash:
Fly ash of class F from Mettur Thermal Plant (MTPP) was used. Fly ash used are conforming to IS 3812-1981.
Fine aggregate:
Clean and dry M-sand was used. Sand passing through IS 4.75mm Sieve was used for casting all the specimens. Fine aggregate used are conforming to IS 383-1970.
Coarse aggregate:
Coarse aggregate is a board category of coarse particulate material used in the construction, including gravel, crushed stone, slag, recycled concrete and geosynthetic aggregate.
Water:
Castings of specimens were done with the portable water.
Alkaline solution:
Sodium Hydroxide and Sodium Silicate are used to prepare the Geopolymer mortar.

Keywords: Composite slab, Composite construction, Geopolymer concrete, GGBS, Fly ash.

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Mix design[7]

a.) Design stipulation for proportioning:
Grade designation = M25
Size of coarse aggregate = 20 mm
Specific gravity of fly ash = 2.02
Specific gravity of Coarse aggregate = 2.78
Specific gravity of FA (M-Sand) = 2.72
Sand confirming = Zone II
Specific gravity of NaOH = 1.47
Specific gravity of Na2SiO3 = 1.6

b.) Mix Design
i) Selection of fly ash to comp. Ratio = 540 Kg/m3
Alkaline liquid = 255 Kg/m3
Na2SiO3 = 2.5 NaOH

NaOH = 75 Kg/m3
Na2SiO3 = 150 Kg/m3

iii.) Volume of Concrete = 1 m3

iv) Determine of aggregate content

\[ V = \left( \frac{S_o + S_f + f + p \cdot S_o}{S_{fa}} \right) \times \frac{1}{1000} \]

\[ V = \left( \frac{S_o + S_f + f + p \cdot S_{fa}}{S_{so}} \right) \times \frac{1}{1000} \]

V = [ 100-2 ] % = 0.98

S_o = NaOH in Kg/m3
S_o = Specific gravity of NaOH
S = Na2SiO3 in Kg/m3
S_f = Specific gravity of Na2SiO3
F = Fly ash in Kg/m3
C_a = CA in Kg/m3
S_a = Specific gravity of CA

P = ratio of FA to total aggregate by absolute volume of 20mm aggregate (35%)

Fa = 583.29 kg/m3  Ca = 1107.5 Kg/m3

Decreases in sand content = 0% for zone II
Total aggregate by absolute volume = 35

Preparation of Alkaline Liquid

Sodium hydroxide pellets are generally used to prepare alkaline liquid.
In this research NaOH solution of 16 Molar concentrations were used per litre.[4]
To make the solution, a mass of 444 grams of NaOH solids are measured and dissolved in 556 ml of water.
Once the pellets gets dissolved sodium silicate solution of 2.5times of NaOH solution is mixed to prepare the alkaline liquid.
It is to be noted that the solution is prepared at least one day prior to casting.

Preparation of Specimens

• For the study of compressive strength, split tensile strength, flexural test and for which cube, cylinder and prism specimens were casted.
• Cube size of 150 mm x150 mm x 150 mm
• Cylinder size of 100mm dia x 200mm
• Prism size of 700 mm x 150 mm x 150 mm.

Tests Performed:

a. Compressive Strength Test

Mix Proportions
Fly ash = 590 Kg / m3
Na2SiO3 = 257.15 Kg / m3
NaOH = 102.85 Kg/ m3
Alkaline liquid ratio = 0.61
FA = 420 Kg / m3
CA = 846.8 Kg / m3
b. **Split Tensile Strength Test**

![Fig.4 Split Tensile Strength Test](image)

![Fig.6 Slab-Beam Panel](image)

![Fig.7 Design Section View](image)

![Fig.8 Design Data](image)

*Note: Only the slab specimens are considered for the study.*

**IV. RESULT AND DISCUSSION**

**a. Compressive Strength Test**

**Table.1 Compressive Strength Result**

<table>
<thead>
<tr>
<th>Mix no.</th>
<th>% of Fly ash</th>
<th>% of GGBS</th>
<th>Compressive strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>90</td>
<td>10</td>
<td>24.4</td>
</tr>
<tr>
<td>M2</td>
<td>80</td>
<td>20</td>
<td>25.5</td>
</tr>
<tr>
<td>M3</td>
<td>70</td>
<td>30</td>
<td>27.5</td>
</tr>
<tr>
<td>M4</td>
<td>60</td>
<td>40</td>
<td>26.7</td>
</tr>
</tbody>
</table>

**b. Split Tensile Strength Test**

**Table.2 Split Tensile Strength Result**

<table>
<thead>
<tr>
<th>Mix no.</th>
<th>% of Fly ash</th>
<th>% of GGBS</th>
<th>Split-tensile strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>90</td>
<td>10</td>
<td>2.54</td>
</tr>
<tr>
<td>M2</td>
<td>80</td>
<td>20</td>
<td>2.65</td>
</tr>
<tr>
<td>M3</td>
<td>70</td>
<td>30</td>
<td>2.86</td>
</tr>
<tr>
<td>M4</td>
<td>60</td>
<td>40</td>
<td>2.77</td>
</tr>
</tbody>
</table>

**c. Flexural Strength Test**

**Table.3 Flexural Strength Result**

<table>
<thead>
<tr>
<th>Mix no.</th>
<th>% of Fly ash</th>
<th>% of GGBS</th>
<th>Flexural strength (N/mm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>90</td>
<td>10</td>
<td>3.45</td>
</tr>
<tr>
<td>M2</td>
<td>80</td>
<td>20</td>
<td>3.53</td>
</tr>
<tr>
<td>M3</td>
<td>70</td>
<td>30</td>
<td>3.67</td>
</tr>
<tr>
<td>M4</td>
<td>60</td>
<td>40</td>
<td>3.61</td>
</tr>
</tbody>
</table>

1) The working ease of the geopolymer concrete prepared by blending GGBS with fly ash was found to be good.
2) Geopolymer concrete blended GGBS gave better performance in split tensile strength and flexural strength.
3) With reference to IS 5816:1997, the value must range between 1/8-1/10th of the fck of geopolymer concrete for split tensile strength.
4) Addition of GGBS accelerated the earlier setting time and ambient curing helps in practical applications.
V. CONCLUSION

1) The working ease of the geopolymer concrete prepared by blending GGBS with fly ash was found to be good.

2) Geopolymer concrete blended 30% of GGBS gives better performance in split tensile strength and flexural strength.

3) With reference to IS 5816:1997, the value must range between 1/8-1/10th of the fck of geopolymer concrete for split tensile strength.

4) Addition of GGBS accelerated the earlier setting time and ambient curing helps in practical applications.

5) This technique is an excellent alternative solution to the CO2 producing Portland cement concrete.

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REFERENCES


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