GGBS & Fly ash Based Geo-Polymer Concrete

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Abstract: Utilisation of fly ash and Ground granulated Blast furnace slag as an alternate material in concrete reduces the employment of OPC in concrete. Evolution of geopolymer concrete cured at ambient temperature broadens its suitability and relevance to concrete structures. This paper discusses the effect of mix proportions and its outcome as experimental study on the density and compressive strength of geopolymer concrete. GGBS was used as a base material that was made to react with sodium hydroxide and sodium silicate to act as a binder for fine and coarse aggregate. Ground granulated Blast slag was replaced in several proportions to fly ash to boost properties of concrete. The concrete was subjected to hardening at ambient temperature. Supported by the study applied, replacement of GGBS in fly ash up to 50% resulted in satisfactory mechanical properties

INTRODUCTION
Geo-polymers are formed by the alkaline activation of aluminosilicate materials like fly ash, blast furnace slag etc [i]. Low-calcium fly ash-based Geo-polymer concrete has been attributed to possess wonderful compressive strength, sufficient acid resistance and resistance to sulphate attack [ii]. Geo-polymer concrete not requires any water for matrix bonding, instead of the alkaline solution to react with silicon and aluminium contained in fly ash. Geo-polymer is synthesized by combining aluminosilicate-reactive material with high basicity alkali solutions, like sodium hydroxide (NaOH), potassium hydroxide (KOH), sodium-silicate or potassium silicate. The mixture may be cured at ambient temperature or higher temperature cured. Highly common varieties of Geo-Polymer are the polysialate Al−O−Si chain, polysialate silixo Al−O−Si−Si chain and polysialate disilixo Al−O−Si−Si−Si chain. In the synthesis of Geo-polymer, NaOH was found having an effect on both the compressive strength and structure of Geo-polymer. The NaOH concentration within the liquid part of the Geo-polymer system acts on the dissolution method, furthermore as on the bonding of solid particles in final structure [iii]. It was however found that prime hydrogen ion concentration (pH=14) was the optimum condition for Geo-polymerization. The impact of composition and temperature on the properties of fly ash- and kaolinte-based Geo-polymer was studied, and it absolutely was concluded that the water content, the fly ash/kaolinte magnitude relation, additionally because the type of metal silicate used had a considerable impact on the ultimate properties of Geo-polymer [iv]. The {polymerization action} process is mostly accelerated within the higher temperature than ambient. Fly ash based Geo-polymer created in ambient temperature achieves lower strength in the early stage as compared to heat cured, however in ambient curing the compressive strength will increase as the age of concrete increases from seven days to twenty-eight days. The compressive strength of temperature cured ash based mostly Geo-polymer concrete doesn't increase considerably after seven days [v]. The tensile strength of the geopolymer concrete will increase with increase in the total aggregate content [vi]. In terms of application it's vital to cure at ambient temperature. hence this study aimed to provide Geo-polymer concrete based on ash and ground granulated blast slag with improved engineering properties

EXPERIMENTAL DETAILS
A. Materials
Fly ash used for Geo-polymer concrete was low Ca fly ash (ASTM class F) that was obtained from Thermal powerhouse. Ground granulated blast slag was collected from nearest steel mill. The chemical composition of fly ash and GGBS was shown in Table one. The fine FA used was natural sand (river sand) and was sieved with four.75mm sieve to eliminate larger particles. The coarse CA used was a HBG metal that was obtainable from native crusher with nominal max size of ten, twelve and 20mm that met the Indian Standard specifications. NaOH was obtained in form pellets and is dissolved to solution with water. Sodium Silicate was obtained as gel that was with sodium hydroxide. The sodium silicate solution with a ratio of SiO2 to Na2O is 2.0 was used.

B. Preparation of solution for Geo-Polymer concrete
Sodium hydroxide was obtained as pellets, was dissolved in tap water to a solution of water. Based on the previous works the Molarity for sodium hydroxide was set to 14M [ix]. In preparation of sodium hydroxide solution of Molarity 14M, 560 grams of Sodium hydroxide pellets was dissolved in one litre of water. Dissolving of sodium hydroxide with water liberates heat. Sodium Silicate gel was added to the solution of Sodium Hydroxide after 15 minutes

I. Mix Proportioning
Based on the previous works the concrete mixtures was proportioned xiv. Fly ash was replaced in the range of 10% to 50% by GGBS of total binder content material. The ratio of sodium silicate to sodium hydroxide was 2.5 and also kept steady. The ratio of alkaline activator to the absolute binder was designed to maintain constant at 0.4. The above ratio was used in every replacement combination. Water was added if workability was needed. Table 2 explains the number of blends used for casting the specimen.

### Table 1 QUANTITIES OF INGREDIENTS

<table>
<thead>
<tr>
<th>Mix</th>
<th>Fly ash Kg/m³</th>
<th>GGB S Kg/m³</th>
<th>NaO H Soln Kg/m³</th>
<th>Na₂ SiO₃ in Kg/m³</th>
<th>FA Kg/m³</th>
<th>CA Kg/m³</th>
<th>Alk liquid to Binder Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>350</td>
<td>--</td>
<td>47.5</td>
<td>110</td>
<td>460</td>
<td>1100</td>
<td>0.45</td>
</tr>
<tr>
<td>M2</td>
<td>315</td>
<td>35</td>
<td>47.5</td>
<td>110</td>
<td>460</td>
<td>1100</td>
<td>0.45</td>
</tr>
<tr>
<td>M3</td>
<td>280</td>
<td>70</td>
<td>47.5</td>
<td>110</td>
<td>460</td>
<td>1100</td>
<td>0.45</td>
</tr>
<tr>
<td>M4</td>
<td>245</td>
<td>105</td>
<td>47.5</td>
<td>110</td>
<td>460</td>
<td>1100</td>
<td>0.45</td>
</tr>
<tr>
<td>M5</td>
<td>210</td>
<td>140</td>
<td>47.5</td>
<td>110</td>
<td>460</td>
<td>1100</td>
<td>0.45</td>
</tr>
<tr>
<td>M6</td>
<td>175</td>
<td>175</td>
<td>47.5</td>
<td>110</td>
<td>460</td>
<td>1100</td>
<td>0.45</td>
</tr>
</tbody>
</table>

### D. Mixing and Casting

The alkaline activator was made one day before mixing of the blend. Foremost fly ash, slag and aggregates were dry blended for 2-3 minutes. The made alkaline activator was then mixed with dry blend and wet blending was accomplished for 5 minutes. Extra Plasticizer was included when workability was required. At that point the geo-polymer cement was filled the molds and was compacted in a vibrating table. The top surface is finished. The size of the moulds utilized were cubes (150mm x 150mm x 150mm)

The molds were then demoulded following 24 hours and were left in room temperature until testing. The normal temperature recorded amid the curing time of the example was 23°C

### III. RESULT AND DISCUSSIONS

**A. Compressive Strength**

The compression test on cubes and cylinders were conducted according to Indian Standard specifications (IS: 516 – 1959). Figure 1 shows the compressive strength of various mixes.

**Table 2 Compressive strength of Mixes**

<table>
<thead>
<tr>
<th>Mix</th>
<th>7 days</th>
<th>28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>4.76</td>
<td>24.4</td>
</tr>
<tr>
<td>M2</td>
<td>7.41</td>
<td>30.52</td>
</tr>
<tr>
<td>M3</td>
<td>10.4</td>
<td>33.86</td>
</tr>
</tbody>
</table>

**Figure 1 Increase in Compressive Strength**

**Figure 2 % Increase in Compressive strength @ 7 Days**

**Figure 3 Figure 2 % Increase in Compressive strength @ 28 Days**

### IV. CONCLUSIONS
1. Compressive Strength increased with increase in GGBS content
2. There was a 350% increase in Compressive strength for 50% GGBS replacement as compared to Control mix at 7 days
3. There was a 60% increase in Compressive strength for 50% GGBS replacement as compared to Control mix at 28 days
4. Compressive strength of Geo-Polymer concrete increases with age

REFERENCES

ii. Wallah, S. E. and Rangan, B. V., “Low Calcium Fly Ash Based Geopolymer Concrete: Long Term Properties.” Research Report GC2, Faculty of Engineering, Curtin University of Technology, 2006


