EFFECT OF ACTIVATOR RATIO ON STRENGTH PROPERTIES OF GEOPOLYMER CONCRETE

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ABSTRACT

Objective: To examine the impact of activator ratio on strength properties of Geopolymer concrete, activator solution, ratio of NaOH to Na₂SiO₃, time of curing. Method: The mix is designed for 12 Molarity. The Activator solution used in the present study is a combination of Sodium Hydroxide (NaOH) solution and Sodium silicate solution (Na₂SiO₃) with the varying ratios 1:2, 1:2.5, 1:3. The total number of specimens 81 is being cast. The Geopolymer specimens are tested for the Compressive, Flexural and Tensile strength at the ages of 3, 7, 28 days. Finding: As there is an increment in the activator ratio the compression, tensile and flexural strengths of geopolymer concrete specimens have increased and with the increment in a time of ambient curing of GPC specimens, the strength parameters were increased. Applications/Improvements: Geopolymer concrete can be widely used in precast girders, beams, electricity poles, railway sleepers. Geo-polymer offers good resistance to fire and permeability.

Key words: Geopolymer concrete, Fly ash, Sodium Silicate, Sodium Hydroxide.


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1. INTRODUCTION

The most widely used material in the construction field is concrete, in which major proportion is cement. Portland cement production contributes major emission of carbon-di-oxide. Due to the emission of these gasses like CO₂ into the atmosphere, mother earth is facing many challenges like global warming¹. Apart from all greenhouse effects, CO₂ contributes 65% of global warming ². To reduce the usage of OPC in concrete many efforts have been made. The materials which alter cement are fly ash, rice husk, GGBS, metakaolin, etc. GPC helps in reducing about 80% of CO₂ emission to nature which results in a reduction of global warming³. In this project, a trail was made to observe the behavior of Geopolymer concrete and its strength parameters⁴. The essentials in are GPC are Fly ash, Activator solution, and system of aggregates⁵. The following are some of the basic properties of

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Fly ash based GPC. A compression value of GPC depends upon time and type of curing i.e., the age of curing and temperature to which moulds are subjected. There is an increment in compressive strength with increment in a time of curing and temperature. Geopolymer moulds have better greater durability and thermal strength characteristics.

2. OBJECTIVES
The main objectives of the study are to examine the behavior of fly ash based geopolymer concrete, to pinpoint and analyze the effect of parameters such as Activator ratio, types of curing that affect the properties of GPC.

3. METHODOLOGY

3.1. DESCRIPTION OF MATERIALS USED

3.1.1. Fly ash
Class F type of Fly ash, which was collected from Vijayawada Thermal Plant is used are an ingredient of the cast concrete.

3.1.2. Alkaline Activator solution
An amalgamation of alkalescent hydroxide solution and alkalescent salt was preferred. The Sodium-based solutions were preferred as they are economical than potassium-based.

3.1.3. Fine Aggregate
The locally available fine aggregate, confining to grading zone II as per IS: 383:1970. Initially, the aggregate chosen is sieved through 4.75mm and passing material is chosen for the test.

3.1.4. Coarse Aggregate
Locally accessible coarse mixture of about 10mm linear unit size was chosen. In determining structural properties of Geopolymer concrete, the conventional approach is adopted.

3.2. PREPARATION OF ALKALINE ACTIVATOR SOLUTION
An amalgamation of the alkaline salt solution, alkalescent hydroxide solution was selected which results in an alkaline liquid, 480g (12x40= 480) of caustic soda flakes dissolved in one liter of water to rearrange element hydroxide resolution of 12M. The alkaline activator resolution should be prepared twenty-four before its intended use. The sodium hydroxide solution is mixed with glass resolution to induce the required alkaline resolution twenty minutes before making the Geopolymer concrete, the varying ratios of NaOH to Na₂SiO₃ are 1:2, 1:2.5, 1:3 respectively as shown in Figure 1.

Figure 1 Preparation of Solution
3.3. TRAIL MIX PROPORTION
Table 1. represents the Quantities of materials for 1 cubic meter of Geo Polymer concrete.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Material</th>
<th>Quantity 1:2</th>
<th>Quantity 1:2.5</th>
<th>Quantity 1:3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Fly Ash</td>
<td>331.04 kg/m³</td>
<td>331.04 kg/m³</td>
<td>331.04 kg/m³</td>
</tr>
<tr>
<td>2</td>
<td>Metakaolin</td>
<td>82.76 kg/m³</td>
<td>82.76 kg/m³</td>
<td>82.76 kg/m³</td>
</tr>
<tr>
<td>3</td>
<td>Fine aggregate (Passing through 4.75 mm size sieve)</td>
<td>540 kg/m³</td>
<td>540 kg/m³</td>
<td>540 kg/m³</td>
</tr>
<tr>
<td>4</td>
<td>10mm size coarse aggregate</td>
<td>1260 kg/m³</td>
<td>1260 kg/m³</td>
<td>1260 kg/m³</td>
</tr>
<tr>
<td>5</td>
<td>Mass of NaOH Solution</td>
<td>62.1 kg/m³</td>
<td>53.2 kg/m³</td>
<td>46.6 kg/m³</td>
</tr>
<tr>
<td>6</td>
<td>Mass of Na₂SiO₃ Solution</td>
<td>124.1 kg/m³</td>
<td>133 kg/m³</td>
<td>139.6 kg/m³</td>
</tr>
<tr>
<td>7</td>
<td>Liquid to Fly ash Ratio</td>
<td>0.45</td>
<td>0.45</td>
<td>0.45</td>
</tr>
<tr>
<td>8</td>
<td>Extra water</td>
<td>45.5 kg/m³</td>
<td>45.5 kg/m³</td>
<td>kg/m³</td>
</tr>
</tbody>
</table>

3.4. MIXING AND CURING

3.4.1. Mixing and casting
The mixing procedure of GPC is as same as that of ordinary concrete mix only. All the ingredients were mixed for about 3 minutes. After casting specimens compaction was done. Specimens are compacted in vibrating machine for 10 seconds. Three different mixes were cast in this study, for which 27 cubes of 150mm, 27 cylinders of diameter 150mm and 27 beams of 500mmx100mmx100mm are done respectively, shown in Figure 2. After hardening the strength parameter test is to be carried out.

3.4.2. Curing
Curing temperature adopted is also an important factor. After demolding the specimens, they are subjected a room temperature of 27°C. The normal temperature to be maintained during test action of the samples was 23°C. As curing time increases it reflects in the polymerization of GPC and results in increase in compressive strength, shown in Figure 3.

Figure 2 Casted Specimens
3.4.3. Testing

The cube specimens which subjected to ambient curing are brought to test in Compression testing machine, shown in Figure 4. The GPC specimens were tested and strengths were calculated for 3, 7 and 28 days, in the same manner, cylinder and beam specimens were tested for their tensile and flexural strengths respectively at the ages of 3, 7 and 28 days respectively shown in Figure 5-6.

Fig 4 Testing of Specimen

Fig 5 Testing of beams Specimens

Fig 6 Testing of cube Specimens
4. RESULTS AND DISCUSSION

Various strength parameters those to be tested on specimens were listed respectively.

4.1. Compressive strength

The Compression strength on cubes has been conducted according to IS Specifications (IS: 516–1959). Figure 7. Represents the compression test results.

![Figure 7](image)

**Figure 7** Compressive strength of GPC at the age of 3,7,28 days for different Activator ratios

4.2. Split tensile strength

The cylinders samplings are tested in CTM for obtaining split tensile test of concrete. Represents the tensile value of GPC. Split tensile strength of GPC at the age of 3,7,28 days for different Activator ratios are shown in Figure 8.

![Figure 8](image)

**Figure 8** Split tensile strength of GPC at the age of 3,7,28 days for different Activator ratios

4.3. Flexural strength

The following are results of two-point loading method as per IS 516-1959, the flexural strength of concrete. Flexural strength of GPC for different Activator ratios are shown in Figure 9.
5. CONCLUSIONS

- The strength parameters of GPC (Compressive, Split tensile and Flexural strengths) of fly ash based GPC specimen’s shown increment with increment in Activator ratio i.e., 1:2, 1:2.5 and 1:3 and with Ambient Curing period.
- The percentage rise in compressive strength with the control specimens for ratios 1:2, 1:2.5, 1:3 were 3.68% for 3 days, 11.24%, for 7 days 17.3%, 12.48% and 18.85%, 15.37% for 28 days.
- The percentage increment in split-tensile strength with the control specimens for ratios 1:2, 1:2.5, 1:3 were 16.5% for 3 days, 15.15%, for 7 days 40.42%, 57.57% and 52.9%, 38.6% for 28 days.
- The percentage growth in flexural strength with the control specimens for ratios 1:2, 1:2.5, 1:3 were 25% for 3 days, 40% for 7 days 45%, 59 % and 36.86%, 7.5% for 28 days.

REFERENCES