EXPERIMENTAL INVESTIGATIONS ON FLYASH BASED GEOPOLYMER CONCRETE

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Abstract

Environmentally responsible building materials are now being researched and produced all over the world in an effort to reduce the generation of greenhouse gases and the worrisome rate at which natural resources are diminishing. Geopolymer serves a crucial role in this regard, and various researchers have looked into the many aspects of its suitability as a binding substance. Fly ash-based geopolymer concrete (abbreviated as GPC) has been made using ground granulated blast furnace slag (abbreviated as GGBS) to modify the geopolymerization reaction of fly ash. In order to ascertain how the amount of Alkaline Activated Solution (AAS) in the mixture of GPC affects the compressive strength of the GPC under ambient temperature, this paper examines the influence of various proportions of GGBS (0100%) on Fly Ash based GPC. From the results of the experiments, it was determined that the sodium silicate solution, in which the concentration of sodium hydroxide in the aqueous solution is fixed at a constant value of 10M, increases the compressive strength of the GPC both with an increase in the percentage of GGBS and also with an increase in the amount. Despite the fact that there was a little quantity of sodium hydroxide in the solution remained the same.

Keywords: Alkaline Solution; GGBS; Geopolymer; Flyash

1. Introduction

Most people concur that one of the biggest environmental issues now facing humanity is climate change. Due to the decarbonization of limestone during the cement-making process, carbon dioxide (CO2) is released (Aleem, M.I.A., and Arumairaj, 2012; Aleem, 2016). One of the building materials that is utilised the most extensively across the world is cement. Significant volumes of carbon emissions are produced during the manufacture of cement and concrete. Emissions and should be taken into account when evaluating initiatives to minimise carbon emissions. Approximately 6% of all CO2 emissions are attributable to it (Bharti et al., 2020; Amran et al., 2021).

One of the biggest environmental risks to society today, according to many, is climate change. Carbon dioxide is released into the environment during the calcination of limestone, a process used to make cement. One of the building materials that is most frequently used in construction across the world is cement. When analysing alternative strategies for reducing carbon emissions, it is necessary to take into account the fact that cement manufacturing and concrete manufacture are both substantial sources of carbon emissions. It is in charge of around 6% of all CO2 emissions worldwide. For every tonne of Portland cement produced, about one tonne of carbon dioxide is discharged into the environment. such as silicate salts or non-silicate salts of weak acids. This was discovered over the course of the investigation. such are weak acid non-silicate salts or silicate salts. During the course of the inquiry, this was found.

Both silica and alumina may be found naturally existing within the source when geopolymer concrete is created utilising fly ash. According to Vijai et al. (2010) and Vora and Dave (2013), an inorganic aluminosilicate polymer is referred to by its more official name, geopolymer. A polymeric interaction between alkaline liquids, silicon, and aluminium in geological source materials or byproduct materials like fly ash may result in the production of binders, claims one study. In geological source materials, this reaction would occur. The scientific community named these binders geopolymers to describe them. The source materials and the alkaline liquids are the two essential components that make up geopolymers (Wasim et al., 2021). You should employ alumino-silicate source materials with a high proportion of silicon (Si) and calcium (Ca).

A thorough investigation of fly ash-based geopolymer concrete blocks has been done as part of this research effort. The main goal of the study is to discover a method for completely substituting cement with fly ash as a binding substance. The production method of low calcium fly ash-based geopolymer concrete and its attributes, such as compressive strength, split tensile strength, and flexural strength, among others, were examined in the first portion of the inquiry. Additionally, samples of geopolymer concrete were tested for chemical resistance. Studies on the characteristics of geopolymer concrete blocks and hollow blocks made of the substance have been conducted.

2. Material and methods

2.1. Materials used

2.1.1. Mineral Admixture

Class F low calcium fly ash is one of the deposits produced as a result of burning coal. In this work, the Class F fly is employed. For the experiment, ash that was collected from the Jamshedpur-based Tata Power Plant was used. Fly ash that is categorised as Class F typically includes less than 10% lime content (CaO) and a high level of pozzolanic activity. Ground Blast with Granules (GGB). Furnace Slag (GGBS) is a by-product of iron that was purchased from

JSW Steel Limited in Salem. In Table 1, the characteristics of Flyash and GGBS are contrasted and compared.

Table 1 Properties of Mineral Admixtures

Properties	**Flyash**	**GGBS**
Specific Gravity	2.200	2.900
Fineness Modulus	2.730	3.750

2.1.2. Alkaline Solution

Table 2 Properties of Alkaline Solution

<table>
<tr><th colspan="2">NaOH</th><th colspan="2">Na_2SiO_3</th></tr>
<tr><th>Properties</th><th>Values</th><th>Properties</th><th>Values</th></tr>
<tr><td>Appearance</td><td>Flaky</td><td>Appearance</td><td>Colorless viscous</td></tr>
<tr><td rowspan="5">Chemical Composition</td><td>NaOH (99.51 % by mass)</td><td>Specific Gravity</td><td>1.35</td></tr>
<tr><td>Na_2CO_3 (0.35% by mass)</td><td>Mg_2O</td><td>9%</td></tr>
<tr><td>Cl^- (0.05% by mass)</td><td>SiO_2</td><td>28%</td></tr>
<tr><td>SO_4^{2-} (0.005 % by mass)</td><td rowspan="2">Solids</td><td rowspan="2">35-40%</td></tr>
<tr><td>Iron (8 ppm)</td></tr>
</table>

The properties of the sodium silicate (Na2SiO3) and sodium hydroxide (NaOH)-based Alkaline Activated Solution (AAS) employed in this situation are listed in Table II below. The molecular weight of the solution might be controlled by dissolving sodium hydroxide flakes in distilled water. A larger amount of heat was produced when NaOH flakes and water were combined. As a result, the NaOH solution was prepared the day before Geopolymer Concrete was cast. During the casting process, the material goes through an exothermic process that eventually results in a drop in heat. The sodium hydroxide solution and sodium silicate solution are then mixed prior to batching. The features of alkaline solutions are mentioned in Table 2.

2.1.3. Aggregates

We used local aggregates, which comprised fine aggregates (fine sand) in a saturated surface dry condition and coarse aggregates of crushed granite-type materials with sizes of 20 millimetres, 14 millimetres, and 10 millimetres. You can see a list of all of their properties in Table 3.

Table 3 Physical Properties of Aggregates

Properties	**Coarse Aggregates (C.A)**	**Fine Aggregates (F.A)**
Specific Gravity	2.620	2.750
Fineness Modulus	2.720	2.970

Table 4 Properties of the Superplasticizers

Appearance	**Light Brown Liquid**
Relative Density	1.080 ± 0.010 at 25 °C
pH	≥ 6.0
Cl- content	< 0.20 %

2.1.4. Superplasticizers

In order to address difficulties with the material's poor workability and short curing time, chemical admixture was added to geopolymer concrete. In this study, concrete was treated with Gelenium B233 in an effort to make it more workable. It was then added after completely blending the basic components and aggregates. Their features, as disclosed by the makers, are listed in Table 4.

2.2. Methodology

2.2.1. Proportioning

GPCs are a brand-new type of construction material, hence there isn't currently a set method for creating their mixtures. OPC, or Ordinary Portland Cement, is in contrast to this. In order to attain a characteristic compressive strength of 40 MPa after 28 days, the mixes were created using the mix design approach used for OPC in line with IS 10262 (2009). To achieve a suitable workability range (Slump of 100mm to 160mm), the ratio of AAS to binder was altered using different proportions. After doing so, it was discovered that the ideal ratio was 0.55, and all of the mixtures were made with this quantity. The amounts and compositions of GPC and AAS, which are given in Table V, varied somewhat. The mixes were made with the ratio of AAS to binder fixed at 1.00 and 1.50, respectively, for varying amounts of flyash replacement with GGBS. Throughout all of the various mixes, the superplasticizer rate and the NaOH content were both held constant at 2%. The level of NaOH was kept constant at 10M throughout. No portion of the mixture has received any additional water. It has been shown that when mixing duration increases, the workability of the concrete reduces as a result of the mixing.

2.2.2. Test Specimens

To examine the material's compressive strength, cube specimens measuring 150 millimetres on a side were cast after the mixture was compacted using table vibration. After being within the mould for twenty-four hours, the specimens were taken out and left to continue curing at ambient temperature. The tests were conducted using a mix ratio of 1:1.08:3.44, and the results are displayed in Table 5.

Table 5 Proportions of Design Mix

Mix.	NaOH Concentration	AAS Ratio	Replacement of Flyash with GGBS (%)
GC-01	10.0 M	1.0	0.00
GC-02			20.00
GC-03			40.00
GC-04			60.00
GC-05			80.00
GC-06			100.00
GC-07		1.5	0.00
GC-08			20.00
GC-09			40.00
GC-10			60.00
GC-11			80.00
GC-12			100.00

3. Results and discussion

The slump cone test was used to assess the mixes' workability, and a compression testing equipment with a 3000 kN capacity was used to assess each mixture's compressive strengths. Table 6 displays the findings of these analyses.

Table 6 Test Results of Concrete

Mix	Slump Value (mm)	Compressive Strength (N/mm^2)	
		7 Days	28 Days
GC-01	100.00	11.220	17.570
GC-02	115.00	14.920	22.230
GC-03	120.00	30.170	37.610
GC-04	140.00	36.120	40.560
GC-05	150.00	37.100	41.230
GC-06	150.00	41.630	48.310
GC-07	110.00	12.640	21.350
GC-08	120.00	17.791	28.690
GC-09	140.00	30.700	39.460
GC-10	160.00	39.130	43.480
GC-11	160.00	40.920	46.44
GC-12	160.00	42.490	53.870

Based on the results of the experiments, it has been found that the value of the slump increases as the amount of GGBS in the mixture decreases. The compressive strength of the samples was assessed after 7 and 28 days of curing in order to determine the early age of the specimens and their usual strength at that time. It has been shown that the strength increases with an increase in GGBS concentration and is around 70% after 7 days. However, it has also been shown that when the slag component makes up all of the combination, the strength diminishes. Although the addition of superplasticizer in the amount of 2.0% of the binder did not affect the strength of the concrete, it did significantly increase its workability.

4. Conclusion

The following inferences may be made based on the results of the experimental investigations:

- The elimination of portland cement from usage has directly resulted in a significant drop in carbon dioxide (CO_2) emissions, which has lessened the quantity of environmental pollution.
- Geopolymer concrete's workability depends on how long it takes to mix the concrete, and as the time required to mix the concrete grows, the workability of the concrete decreases. Along with that, it develops when the mixture's slag content changes.
- The introduction of the chemical additive known as Glenium B233 has lessened the effects of Geopolymer Concrete's restricted workability and quick setting time.
- To determine whether Geopolymer concrete is suitable for use in cast-in-situ environments, the specimens were allowed to cure at room temperature rather than undergoing an accelerated curing process. This addition does not appear to have any effect on the compressive strength of the concrete, but it does appear to significantly improve the concrete's workability.
- It was found that the strength after 7 days is 70% of the strength after 28 days; this percentage rises with the volume of slag in the combination, but falls when the volume of slag in the mixture reaches 100%. The 28-day strength shows considerably higher strength as compared to OPC. This proves that geopolymer concrete is a competitive substitute for cement concrete and should be taken into account as such.

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