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Temperature Variation for Low Calcium Fly Ash Based Self Compacting Geopolymer Concrete

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ABSTRACT

Cement is commonly used as the main material to produce concrete; however, the process of production of cement is causing environmental problems. The amount of CO2 emission from cement industries due to the calcinations of limestone and combustion of fossil fuel is in the order of approximately one ton for every ton of cement produced. To produce environmentally friendly concrete called geopolymer, it was proposed that a new material could be produced by a polymerization reaction of alkali liquids with Si and Al as source materials of geological origin materials. Si and Al are derived from pozzolanic materials or aluminosilicate mineral powders, for example, powders of metakaolin or by-product of industrial and agricultural materials such as lignite ash and agricultural ashes. This research was conducted to study geopolymers made partly from < 45 μm powders of fly ash, bagasse ash. Sodium hydroxide concentration of 14 molar and sodium silicate (Na2SiO3) solutions were used as alkali activators by the mass ratio of Na_2SiO_3: NaOH at 2.5.

The present work deals with the results of the experimental investigation carried out on fly ash based geopolymer concrete. The study analyses of fly ash in geopolymer concrete on compressive strength, split tensile strength. All tests were conducted according to Indian standard code procedure. The effect of percentage of fly ash in geopolymer concrete is studied in detailed. Test results for each variation are tabulated and discussed in details and some important conclusions are made.

Keywords : Geopolymer, Ordinary Portland, OPC

I. INTRODUCTION

Concrete usage around the world is second only to water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The environmental issues associated with the production of OPC are well known. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminium.

On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilise this by-product of burning coal, as a substitute for OPC to manufacture concrete. When used as a partial replacement of OPC, in the presence of water and in ambient temperature, fly ash reacts with the calcium hydroxide during the hydration process of OPC to form the calcium silicate hydrate (C-S-H) gel. The development and application of high volume fly ash concrete, which enabled the replacement of OPC up to 60% by mass (Malhotra 2002; Malhotra and Mehta 2002), is a significant development.

In 1978, Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminium in source materials of geological origin or by-product materials such as fly ash and rice husk ash. He termed these binders as geopolymers. Palomo et al (1999) suggested that pozzolans such as blast furnace slag might be activated using alkaline liquids to form a binder and hence totally replace the use of OPC in concrete. In this scheme, the main contents to be activated are silicon and calcium in the blast furnace slag. The main binder produced is a C-S-H gel, as the result of the hydration process.

1.1 . Geopolymer.

Geopolymer concrete is a high strength and lightweight inorganic polymer that can be used in place of normal concrete. The main difference between normal concrete and geopolymer concrete is that normal concrete uses ordinary Portland cement (OPC) as a binder whereas geopolymer concrete uses a chemical and fly ash mixture as a binder.

Geopolymer is a class of alumina silicate binders synthesized by activation of solid alumina silicate source materials such as fly ash, granulated blast furnace slag, Bagasse ash obtained from industrial wastes or calcined clays like metakaolin, with an alkali metal hydroxide and silicate solution. These binders are currently attracting widespread attention due to their potential utilization as a high performance, environmental friendly and sustainable alternative to Portland cement.

The term geopolymer was coined by Davidovits in 1978 to represent a broad range of materials characterized by chains or networks of inorganic molecules (Geopolymer Institute 2010). There are nine different classes of geopolymers, but the classes of greatest potential application for transportation infrastructure are comprised of aluminosilicate materials that may be used to completely replace port land cement in concrete construction (Davidovits 2008).

1.2 Fly ash

Fly ash is the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses from the combustion zone to the particle removal system' (ACI Committee 232 2004). Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere.

In the present experimental work, low calcium, Class F (American Society for Testing and Materials 2001) dry fly ash obtained from the silos of Thermal Power Station, was used as the base material. Fly ash (Pozzocrete 63) is a high efficiency class F pozzolanic material confirming to BS 3892, obtained by selection and processing of power station fly ashes resulting from the combustion of pulverised coal. Pozzocrete 63 is subjected to strict quality control.

II. PROBLEM STATEMENT

Fly ash based geopolymer concrete is most widely used construction material which is environment friendly and cost effective material. Global cement industry contributes about 7% of greenhouse gas emission to the earth atmosphere. There are some effort have been taken In construction industry use of waste material as partial replacement of cement ,fine aggregate or coarse aggregate.

Waste GGBS and baggage ash are the material when ground to a fine powder shows pozzolanic properties which can be used as partial replacement for cement in concrete.

III. OBJECTIVE

1. To investigate temperature variation of fly ash based self-compacting geopolymer concrete at elevated temperature.

2. To study microscopic investigation on alkaline binder ratio and Na2sio3/ NaoH ratio for self-compacting geopolymer concrete.
3. To investigate drying shrinkage for self-compacting geopolymer concrete at temperature variation.
4. To check workability of the concrete using waste GGBS and Baggage ash.
5. To provide economical construction material.
6. To Provide safeguard to the environment by utilizing waste properly.

IV. SCOPE OF PROJECT

The experimental work involved conduct of long-term tests on low-calcium fly ashbasedgeopolymer concrete. The tests currently available for Portland cement concrete were used. In the experimental work, only one source of dry low-calcium fly ash (ASTM Class F) from a local power station was used. Analytical methods available for Portland cement concrete were used to predict the test results.

In this research we prepared specimen of cubes for compressive strength test, cylinder for split tensile strength test. Three samples for each set of percentage have been taken for conducting test and average of results are taken.

The samples were tested at the age of 7 days,14 days and 28 days. The test on hardened concrete are destructive test while the destructive test includes compressive strength test as per IS: 516-1959, split tensile strength test as per IS: 5816-1999.

- Effective use of industrial waste
- Sufficient strength for local use
- Disposal system of waste
- Save conventional construction materials

V. RESULT & DISCUSSION

5.1 Compressive Strength Results

Following are the result of compressive test carried on % of varying of GGBS and Baggage Ash.

A) Normal concrete (N/mm²) – 100 % Cement

Table –A. 5.1

Table 5.1 Sr.No.	Days	C/S Area (Mm^2)	Load (KN^2)	Comp Strength (N/Mm^2)	Avg. Comp Strength (N/Mm^2)
1			497.3	22.5	
2	7	22500	475	21.11	21.40
3			465	20.66	

Table-A. 5.2

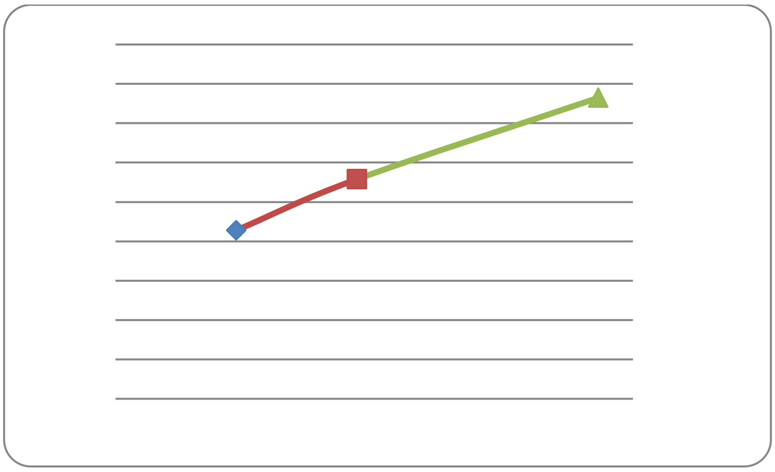
Table 5.1 Sr.No.	Days	C/S Area (Mm^2)	Load (KN^2)	Comp Strength (N/Mm^2)	Avg. Comp Strength (N/Mm^2)
1			633.8	28.16	
2	14	22500	602.3	26.76	27.89
3			647.4	28.77	

Table-A. 5.3

Table 5.1 Sr.No.	Days	C/S Area (Mm^2)	Load (KN^2)	Comp Strength (N/Mm^2)	Avg. Comp Strength (N/Mm^2)
1			893.7	39.72	
2	28	22500	820.8	36.48	38.23
3			866.1	38.49	

COMPRESSIVE STRENGTH OF 0% REPLACEMENT

CHART-A. 5.1



Y axis – comp strength in mpa

X axis – days

B) 30% replacement to Cement (N/mm²)

Table-B.5.1

Table 5.1 Sr. No	Temp variation	Days	C/S Area (mm²)	Load (KN)	Comp. Strength (N/mm²)	Avg. Comp. strength (N/mm²)
1	60			186	8.2	
2	70	7	22500	201	8.9	8.56
3	80			193.9	8.6	

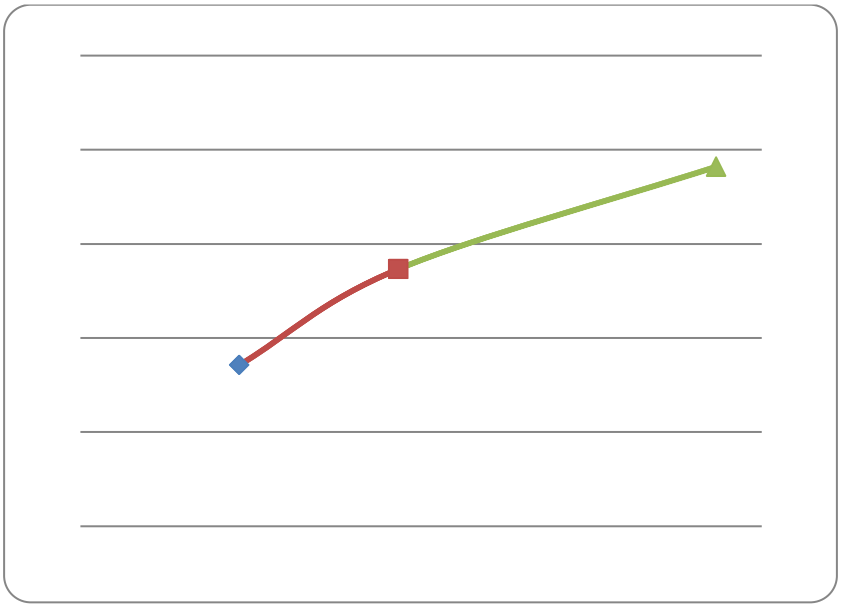
Table-B.5.2

Table 5.2 Sr. No	Temp variation	Days	C/S Area (mm²)	Load (KN)	Comp. Strength (N/mm²)	Avg. Comp. strength (N/mm²)
1	60			266.2	11.8	
2	70	14	22500	341.5	15.1	13.66
3	80			318.7	14.1	

Table-B.5.3

Table 5.3 Sr. No	Temp variation	Days	C/S Area (mm²)	Load (KN)	Comp. Strength (N/mm²)	Avg. Comp. strength (N/mm²)
1	60			414.4	18.4	
2	70	28	22500	448.5	19.9	19.1
3	80			395.2	17.5	

COMPRESSIVE STRENGTH OF 30% REPLACEMENT



5.2 Flexural Strength:

A) Normal concrete (N/mm²) – 100 % Cement

Table 5.2.1- 28 Days flexural strength

Sr. No	Temp variation	Days	Load (KN)	Comp. Strength (N/mm²)	Avg. Comp. strength (N/mm²)
1			280.3	3.96	
2	27	28	284.8	4.021	3.9
3			270.4	3.82	

B) 30% replacement to cement (N/mm²)

Table 5.2.2-28 Days flexural strength

Sr. No	Temp variation	Days	Load (KN)	Comp. Strength (N/mm²)	Avg. Comp. strength (N/mm²)
1	60		147.8	2.09	
2	70	28	140.6	1.98	2.01
3	80		136.5	1.93	

Flexural Strength

VI. CONCLUSION

1) It has been concluded that upto 20% replacement concrete is effective used for the development of paver block.
2) The workability of concrete had been found to be decrease with increase of Baggage ash but the GGBS increases the workability of concrete.
3) It has been seen that upto 20% replacement is effective for conventional concrete.
4) The cost of cement concrete is reduced.
5) The waste material is effectively utilized by using above method.
6) It is effective method for disposal of baggage ash and disposal cost is avoided.
7) This is an effective method of increasing strength by reducing cost.
8) The strength are reduced for 30% replacement of materials.
9) The partial replacement of OPC in concrete by GGBS, is not only economical but also facilitates environmental friendly disposal of the waste.
10) The usage of GGBS in concrete as cement replacement materials will lessen the CO2 is being emitted during its manufacture and acts as an eco-friendly material reducing the Greenhouse effect.

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