EFFECT OF CURING AND MOLARITY ON GEOPOLYMER CONCRETE WITH FOUNDRY SAND

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ABSTRACT

Geopolymers, an alternate class of binders which is cement less one has emerged in the recent decades to replace cement. In view of the environmental humiliation caused by the cement industry and random sand mining, an attempt has been made in this research work to develop geopolymer concrete using Fly ash, GGBFS which are industrial by products as replacement for cement and Foundry sand, a byproduct from the foundries as replacement for natural sand and to assess their strength properties under ambient and oven curing conditions. The foundry sand is replaced at 10%, 20%, 30%, 40% and 50% in place of river sand. The molarities of the NaOH are also varied for 8M, 10M and 12M and the test results are discussed for Foundry Sand replaced Geopolymer Concrete. This paper discusses the test results of foundry sand replaced geopolymer concrete at varying molarities.

Keywords: Ambient curing, Foundry Sand, Geopolymer, Oven curing.

I. INTRODUCTION

Cement is an energy consuming and high green house gas emitting product. On the other hand, abundant availability of fly ash creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete. Geopolymer is an attractive material for building materials and hazardous waste encapsulation due to high strength, low shrinkage, low CO2 emission, sulphate and acid resisting properties. Most of the previous works on fly ash-based geopolymers concrete reveals that hardening is due to heat curing. Nowadays, precast concrete members are suitable with various heat curing condition of geopolymer concrete. Heat curing process requires unique arrangements which is energy consuming and may impossible to apply in cast-in-situ concreting. Therefore, development of geopolymer concrete suitable for ambient curing temperature will increase its application to concrete construction. Molding sand, also known as foundry sand, is sand that when moistened and compressed or oiled or heated tends to pack well and hold its shape. This study aimed to achieve fly ash-based geopolymer concretes replaced with foundry sand for fine aggregate suitable for both ambient and oven curing condition.

II. LITERATURE REVIEW

Karthik et al (2017) have investigated experimental results of foundry sand replaced geopolymer concrete. The suitability of replacement of cement with Fly ash and GGBS for making concrete, studied the possibilities of a partial replacement of sand with Foundry sand, compared the cost of modified mix with control mix and studied the engineering properties of geopolymer concrete with foundry sand replacement. The normal consistency obtained at 28 percentages. It has been proved that using Foundry sand doesn't affect the properties of geopolymer concrete majorly.

Lateef Assi et al (2016) have presented the Improvement of the early and final compressive strength of flyash-based geopolymer concrete at ambient conditions. Experimentation shows that application of external heat plays a major role in compressive strength. Sodium hydroxide concentration has a major effect on the compressive strength. In absence of heat, 10% Portland cement replacement is considered the optimum value because the compressive strength at 1 day is improved by 82% and the 28 days compressive strength is improved by 52% compared with free Portland cement geopolymer concrete, as well as good workability.

Pradip nath et al (2015) has discussed the early age properties of low-calcium fly ash geopolymer concrete suitable for ambient curing. The effects of the additives and total cementitious content were discussed on the initial properties such as setting time, workability and compressive strength. Compressive strength increased with the increase of the binder content for fly ash blended with 10% OPC. The 28-day strength increased from 26 MPa to 58 MPa by increasing the binder content from 450 kg/m^3 to 730 kg/m^3. The results show that fly ash geopolymers blended with small percentages of GGBFS, OPC or CH can be a appropriate binder for low to reasonable strength concrete production at ambient curing condition.

Prakash et al (2013) have presented Parametric Studies on Compressive Strength of Geopolymer Concrete. Various parameters i.e. ratio of alkaline liquid to fly ash, molarity of sodium hydroxide, ratio of sodium silicate to sodium hydroxide, strength attaining time, temperature required for curing, amount of superplasticiser, rest period and additional watercontent in the mix are discussed for different geopolymer mixes. The test results show that compressive strength increases with increase in the curing time, rest period, curing temperature, and concentration of sodium hydroxide solution and reduces with higher ratio of water to geopolymer solids by mass & admixture dosage, respectively.

Chindaprasirt et al (2011) have studied the synthesis of high-strength geopolymer using fine high-calcium fly ash. The heat-cured geopolymers were activated with sodium hydroxide (NaOH) and sodium silicate. A small amount of water was added for workable flow. The result shows that the setting time of mix decreases with an increase in fineness of the fly-ash. The workability, strength, and drying-shrinkage characteristics of mortars were increased using fine fly ash. Geopolymer mortars with high 28-day compressive strength of 86.0 MPa were obtained.

III. EXPERIMENTAL PROGRAM

3.1 Material used

Fly ash: Fly ash is a byproduct from burning pulverized coal in electric power generating plants. Class F Flyash obtained from Mettur Thermal power plant is used to make the Geopolymer Concrete.

GGBS: Ground-granulated blast-furnace slag (GGBS or GGBFS) is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam. The GGBS is obtained From JSW Steel Pvt ltd, Mecheri, Salem.

Foundry Sand: Waste Foundry Sand (WFS) is a byproduct from ferrous and non ferrous metal castings. The foundry sand is used as partial replacement for fine aggregate in making the geopolymer concrete. The foundry sand is obtained from Nandhini Castings, Coimbatore.

Alkali Activators: Sodium hydroxide flakes and sodium silicate solution is used as Alkali Activators in the geopolymer concrete. Sodium hydroxide is a co-product of chlorine production. Sodium silicate is also the scientific and universal name for a mixture of such compounds, mainly the metasilicate, also called water glass or liquid glass.

Fine aggregate: Locally available River sand conforming to the requirements of IS 383is used as the fine aggregate.

Coarse Aggregate: Locally available crushed granite stone which are retained on an IS 4.75 mm sieve is used as coarse Aggregate.

Super plasticizer: Ceraplast 300, a high performance modified naphthalene sulphonate based super plasticizer is used.

1.1. Mix Proportion

The mix design for the geopolymer concrete is mainly based on the density of the concrete. The total volume engaged by fine aggregate and coarse aggregate is adopted as 77%. The ratio of alkaline liquid to fly ash and GGBS ratio is maintained as 0.4. The ratio of sodium hydroxide to sodium silicate is fixed as 2.5. The mix ratio of the geopolymer concrete is shown in table 1. The extra water is added up to 10%. The super plasticizer is added with 2% weight of cement content.

Table 1 Mix Proportion of the Geopolymer Concrete.

Fly ash + GGBS	394 Kg/m^3
Fine Aggregate	554 Kg/m^3
Coarse Aggregate	1294 Kg/m^3
Sodium Hydroxide	45 Kg/m^3
Sodium silicate	113 Kg/m^3

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1.2. Mixing, Casting and Curing

Alkaline liquids are prepared by mixing NaOH of 12M and Sodium silicate solution just before mixing to prevent the heat produced during mixing for obtaining the optimum strength in ambient curing condition. Also the steam curing is done at a temperature of 50ºC. The dry materials are mixed firstly and then alkali activators are added and the mixing is continued. Then the extra water content mixed with Super plasticizer is added. Now the mix is ready for casting. The companion specimen i.e, cube, cylinder and prism are casted and covered with polythene sheet for 48 hours to prevent the heat under ambient curing condition. After the rest period, the specimens are demoulded and kept in laboratory condition for 28 days. For oven curing, the specimens are kept in oven at 50ºC for 28 days. The companion specimens are casted with 10%, 20%, 30%, 40% and 50% replacement of fine aggregate with waste Foundry Sand.

IV. TESTING OF CONCRETE SPECIMENS

4.1. Compressive Strength Test

The cube specimens of size 150mm X150mm X 150mm are casted and cured for 28 days to determine the compression strength of the geopolymer concrete. The compression test results are compared to get the optimization for foundry sand replaced geopolymer concrete. The test results are shown in fig.1.

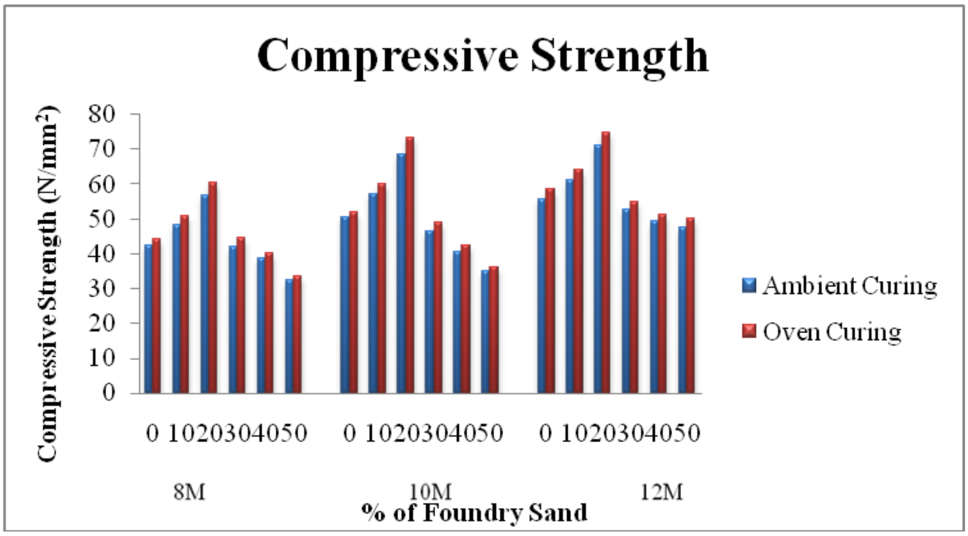

Fig.1 Compressive Strength Results

4.2. Split Tensile Strength Test

The cylinder of 300mm length and 150mm diameter are casted for determine the Split tensile strength. The split tensile strength is higher for 20% replacement of foundry sand for fine aggregate in the geopolymer concrete. The Split tensile test values are shown in fig.2.

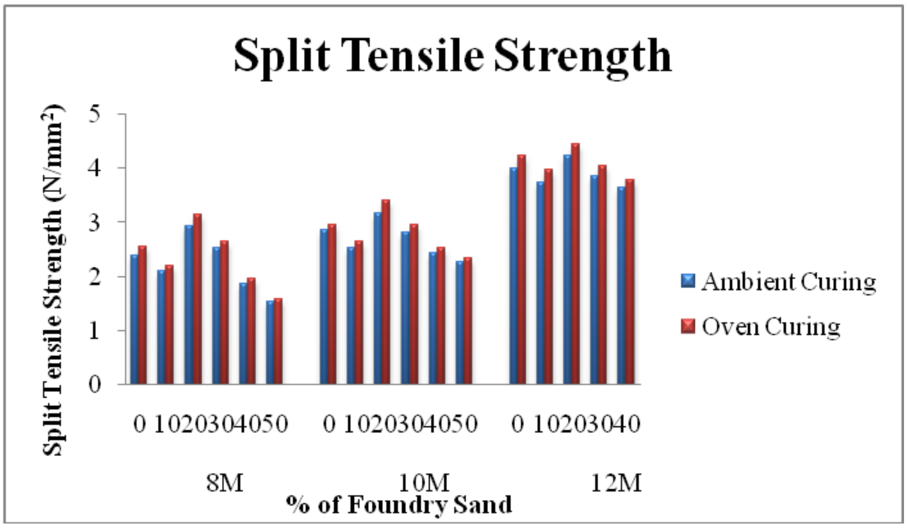

Fig.2 Split Tensile Test Results

4.3. Flexural Strength Test

The prism of length 500mm are used for testing the Flexural Strength of the concrete. The test values are shown in the fig.3.

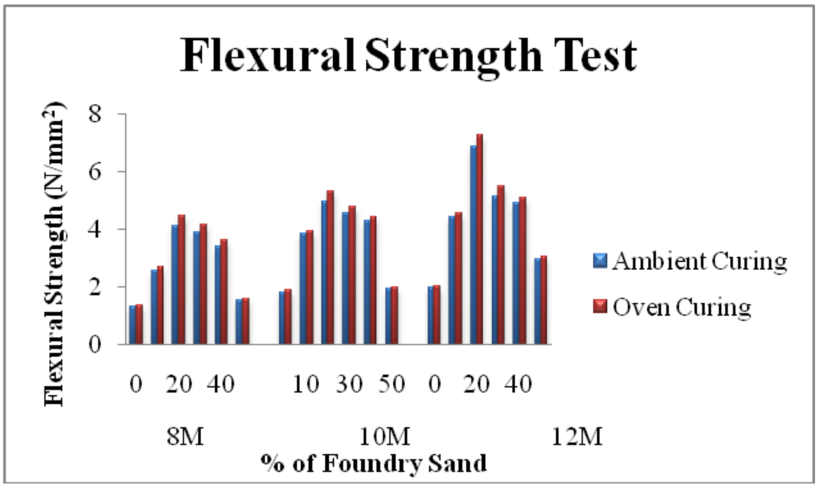

Fig.3 Flexural Strength Test Results

V. CONCLUSION

The aluminosilicate material such as Fly ash and GGBS provides an alternative binder to the concrete. The optimum mix of 60:40 mix proportions of Fly ash and GGBS are used for casting of specimens. Foundry sand is considered to be a more beneficial replacement of fine aggregate in geopolymer concrete. The geopolymer concrete is prepared under ambient curing temperature. From the work the following results are obtained,

- The compressive strength of the geopolymer concrete is higher for 20% replacement of foundry sand replaced geopolymer concrete when compared to conventional geopolymer concrete.
- The split tensile strength and the flexural strength are also increased at 20% replacement of fine aggregate with foundry sand in the geopolymer concrete.

- The molarity of the alkaline liquid is maintained as 12M which gives optimum strength for both steam curing and ambient cured geopolymer concrete.
- The oven cured geopolymer concrete gives higher strength when compared to ambient cured geopolymer concrete.

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