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An Experimental Study on Strength and Durability Properties of GGBS based Geopolymer Concrete

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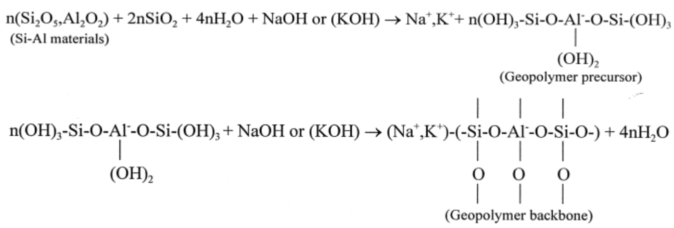
ABSTRACT

Huge amount of energy is consumed during for the manufacture of OPC , also emits CO_2 and other greenhouse gases leads to global warming. Nowadays the production of Portland cement and consumption of concrete is increasing enormously. Geopolymer concrete is considered as a new approach towards sustainability in which different industrial by products are used to replace OPC as a binder completely which minimizes the CO_2 emission. In this study, attempt is made to develop GGBS based geopolymer and the characteristic strength is studied. The concentration of sodium hydroxide solution was kept up as 10M. The compressive, split tensile and flexural strength of the GGBS based geopolymer concrete was studied at different ages like 3, 7, 28 days. Microstructural study has been conducted with SEM analysis to study the effect of temperature in curing of geopolymer.Also conducted the durability studies on geopolymer concrete exposed to severe exposure such as acidic and basic environments.

Keywords : Geopolymer, GGBS, SEM Analysis, Alkali Activators, Durability

I. INTRODUCTION

Geopolymers are inorganic alumino-silicate binders that have polymeric, silicon-oxygen-aluminum framework structures. Geopolymers binders result from reaction of solid alumino-silicate from source material (natural pozzolans , industrial and agricultural waste products) with highly concentrated aqueous alkali hydroxide or alkali silicate solution. The alkaline source supplies alkali metal cations thus raising the pH of solution it accelerates the dissolution of solid precursors[6] The geopolymerization involves a chemical reaction between various alumino-silicate oxides with silicates under highly alkaline condition, yielding polymeric Si-O-Al-O bonds. The two reactions are as follows [7]:



II. Materials & Methodology

3.1 GGBS Based Geo Polymer Concrete

GGBFS is obtained by finely grinding the granulated blast furnace slag (BFS), which in turn is obtained by sudden quenching of molten slag removed from the blast furnaces of the iron and steel industry. GGBS is a non-metallic, glassy, granular substance made primarily of calcium silicates and aluminates.[8] It possess both cementitious and pozzolanic properties. In this study, GGBS based geopolymer from JSW power plant has been utilized for the production of geopolymer concrete

Fig 1. Geopolymer cementing materials

Preparation of alkali activator solution

For NaOH solution with 10M concentration is prepared by contains 10x40 = 400 gm of NaOH pellets dissolved in 1 litre of distilled water. Commercially available sodium silicate solution is mixed with Sodium Hydroxide solution to produce the alkali activator solution. Water-to-geopolymer binder ratio is kept as 0.3, and sodium silicate-to-sodium hydroxide ratio of 1.0 by mass were fixed on the basis of workability and cube compressive strength. The aluminosilicate source material used in the present study for making geopolymer binder was GGBS and activated by alkaline solutions to act as a binder in the concrete mix ,given in fig:1[9,10]

Casting of fresh concrete

Geopolymer concrete can be manufactured by adopting the conventional techniques used in the manufacture of Portland cement concrete. In the laboratory, the GGBS and the aggregates were first mixed together in the steel tray for about 3 minutes. The aggregates were prepared in saturated surface dry condition. The alkaline solution was then added to the dry materials and the mixing continued for further about 5 minutes to manufacture the fresh concrete. The fresh concrete was cast into the moulds immediately after mixing, in three layers for mould specimens. For compaction of the specimens, each layer was given 25 manual strokes using a tamping rod.The geopolymer cubes were cured in two different curing temperatures at 100^0C and 200^0C for 3 days and tested to study the effect of geopolymerization in with increase in curing temperature.

3.2 Durability test on Acidic and Base medium

Durability test on geopolymer concrete cubes exposed to acidic and basic environments was studied. After the standard curing, cubes were placed in dilute $H_2S\ 0_4$ solution with a concentration of 6% in water and cured for the 90 days. Exposure to alkaline environment was studied by placing the cubes in alkaline solution containing 5% Sodium Hydroxide in water and cured for the 90 days .The cubes were tested for compressive strength after curing to study the durability in severe environment.

3.3 Scanning electron microscopy (SEM)

A compound magnifying lens' conventional cluster of amplifying focus points allows for test amplification of up to 1000x using visible light frequencies in the 400–700 nanometre (nm) range. As the demand for nanoscale material representation and critical geography estimations became increasingly prevalent over the world, the frequency range of conventional microscopy became a limiting factor. SEM (scanning electron microscopy) was developed as a result, providing new approaches for test imaging using electron examining.

III. Results & Discussions

SEM analysis is conducted on the geopolymer concrete (GPC) cured at different curing temperatures. SEM images of GPC after 7 days curing at 100⁰C and 200⁰C are given in fig 2 & Fig 3. The extend of geopolymerization is observed to similar at both curing conditions.

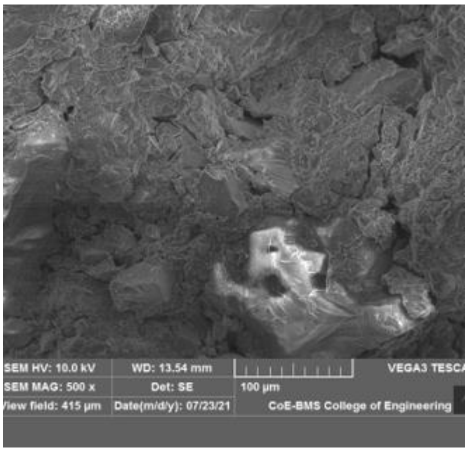


Fig:2 SEM analysis on 100ºC curing

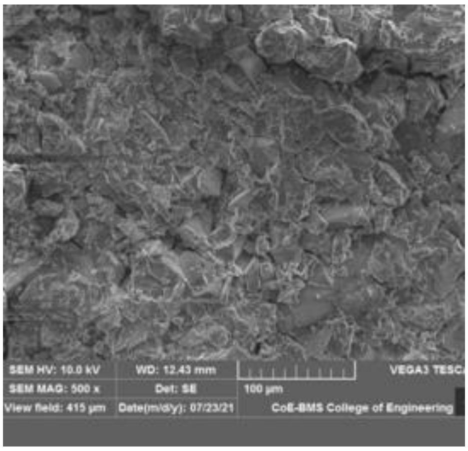


Fig: 3 SEM analysis of GPC at 200ºC curing

SEM images of geopolymer concrete exposed to acidic and alkaline environment for 90 days is given in fig 4 and fig 5 .Deterioration of the geopolymer compound is observed in both the cases

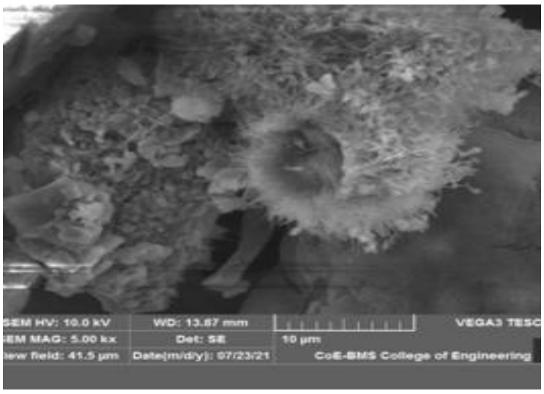


Fig: 4 SEM analysis of GPC on acidic environment

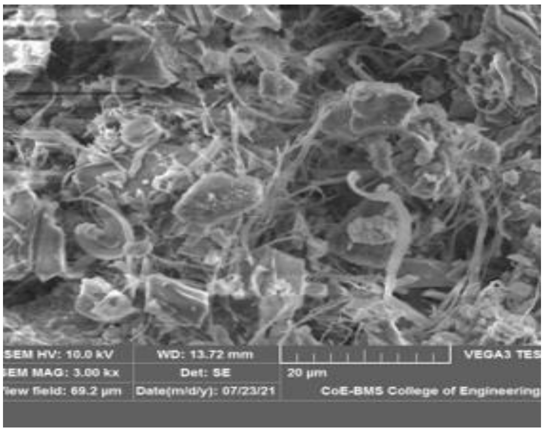


Fig 5.SEM analysis of GPC on basic environment

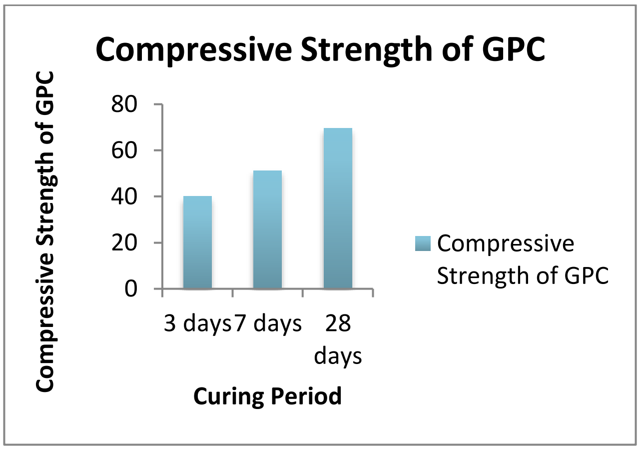


Fig:6 Compressive Strength of GPC

From above results it is observed that compressive of geopolymer concrete for 3, 7 and 28 days of curing is 40.02, 51.27 and 69.66 N/mm² respectively is given in fig 6.

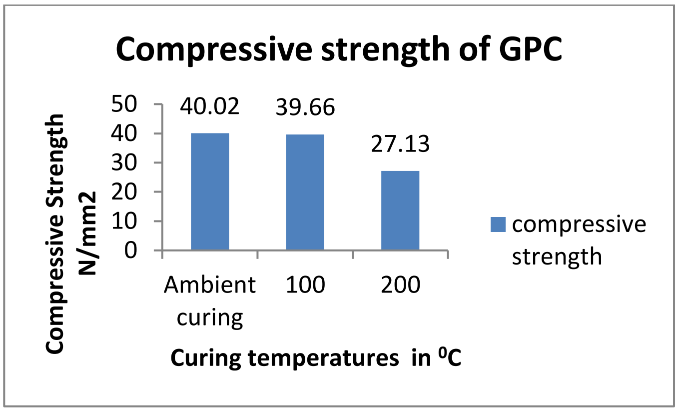


Fig 7 Compressive Strength of GPC at different curing temperatures

Test is conducted on different curing temperature at 100⁰C and 200⁰C. From test results it was observed that the compressive strength at 100⁰C was 39.66 N/mm² and at 200⁰ C was 27.13 N/mm².There is a decrease in the strength of GPC is observed with increase in curing temperatures is given in fig:7

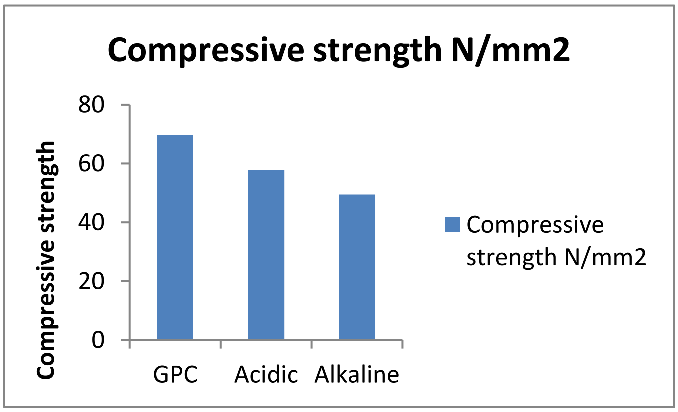


Fig 8 Compressive Strength of GPC exposed to acidic and alkaline environment

Test is conducted at GPC exposed to acidic and alkaline environment for a period of 90 days. The compressive strength of GPC cubes were tested after observation period and the compressive strength was obtained as 57.75 N/mm² and 39.30 N/mm² respectively when the GPC cubes were kept under acidic and alkaline conditions is given in fig 8.

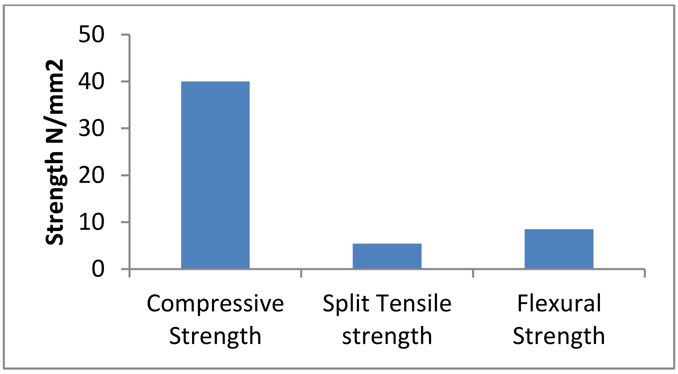


Fig 9. Strength comparison of GPC for 3 days of curing

The Compressive, Spit tensile and Flexural test was conducted for 3 day of curing and obtained average value is 40.02 N/mm², 5.41 N/mm² and 8.53 N/mm² is plotted in fig 9.

IV. Conclusion

- From the experimentation tested on the GGBS based Geopolymer concrete the compressive strength increases with the age of curing up to a certain age of the time.
- From the results it is seen that the maximum compressive strength is attained at the 28 days of the curing that is 69.66 N/mm².
- It has been noticed thermal curing test results of compressive strength,that as the temperature increases the compressive strength decreases.
- When exposed to on acidic and alkaline environment the compressive strength of Geopolymer concrete has showed better durability .
- The flexural strength and split tensile strengthof GGBS based geo-polymer concrete at ambient curing for 3 days is 8.53 N/mm² and 5.41 N/mm² respectively

V. ACKNOWLEDGMENT

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