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Geopolymer concrete with replacement of silica fume and foundry sand

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ABSTRACT

A concrete use around the world is second only to water. The production of ordinary Portland cement contributes 5-7% of total greenhouse gas emission. It also consumes large amount energy. Hence it is essential to find an alternative to cement. Silica fume it is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production. It is also rich in silica and alumina. In this paper, silica fume is used to produce a geopolymer concrete. Geopolymer is a material resulting from the reaction of a source material that is rich in silica and alumina with an alkaline solution. Geopolymer concrete is totally cement-free concrete. In geopolymer, silica fume act as a binder and alkaline solution act as an activator. Silica fume and foundry sand are totally replaced and alkaline activator undergoes polymerization process to produce alumino silicate gel. Alkaline solution used for present study is a combination of sodium hydroxide (NaOH) and sodium silicate (Na2Sio3) with ratio 3. A grade chosen for the investigation were M25.The mix was designed for molarity of 8M. Hot air curing is done by placing the specimens on the electric oven at 60ºC for the 24hours duration and 7days 14 days and 28days test is carried after heating. The geopolymer concrete specimens were tested for their compressive strength, flexural strength and split tensile test. Experimental investigations have been carried out on workability, the various mechanical properties of GPCs.

Keywords: *Geopolymer concrete, Silica fume, Strength, Curing, Alkaline solution.*

1. INTRODUCTION

The cement industry is the second largest producer of the greenhouse gas. On an average, approximately 1 ton of cement is being produced each year for every human being in the world. Hence, in order to protect the environment, the main concern of minimizing CO2 emission can be realized by reducing the percentage of cement used in making concrete. Hence it is necessary either to search for another material or partly replace it with some other material. The alternative material will lead to the global sustainable development and lowest possible environmental impact. Due to substantial energy and cost savings industrial by-products are used as a partial replacement of cement. Silica fume is known by different names such as micro silica, silica dust, and condensed silica fume. When SF is used as an additive in cement concrete, a heat of hydration is observed resulting in the formation of pozzolanic material and calcium hydroxide. Due to large surface area, silica fume gets densely packed in the paste of cement and aggregate reducing the wall effect in the transition zone between the paste and aggregate. Silica fume shows improvement in both strength and durability properties of concrete. The main physical effect of silica fume in concrete is that it acts as a filler and because of its fineness, silica fume fit into the space between the cement grains just as sand fill the space between particles of coarse aggregate or cement grains fill the space between the sand grain. Realizing the pozzolanic nature of the materials, this has been used successfully as an admixture in producing concrete. For the improvement of strength and durability of the concrete, the use of silica fume as a replacement of cement has been tried with success in concrete. The use of silica fume in the concrete mix has engineering potential and economic advantage. The use of silica fume will not affect the weight of concrete. Silica fume will produce a much less permeable and high strength concrete.

2. MATERIAL USED

Silica Fume

Silica fume is a byproduct of producing silicon metal or ferrosilicon alloys. One of the most beneficial uses for silica fume is in concrete. Because of its chemical and physical properties, it is a very reactive pozzolan. Concrete containing silica fume can have the very high strength and can be very durable. Silica fume consists primarily of amorphous (non-crystalline) silicon dioxide (SiO_2). The individual particles are extremely small, approximately 1/100th the size of an average cement particle. Because of its fine particles, large surface area, and the high SiO_2 content, silica fume is a very reactive pozzolan when used in concrete. The quality of silica fume is specified by ASTM C 1240 and AASHTO M 307.

Sodium Hydroxide

Usually, NaOH is obtainable in pellets (or) flakes form with 90 % of purity where the economy of the product depends upon the purity level. The NaOH solution is formed by diluting it with distilled water based on the molarity concentration. It is urged to make the alkaline solution 45 mins before casting the specimens.

Sodium Silicate

Sodium silicate is the common name for compounds with the formula $(Na_2SiO_2)_nO$. A well-known member of this series is sodium metasilicate, Na_2SiO_3. Also known as water glass or liquid glass, these materials are available in aqueous solution and in solid form. The pure compositions are colorless or white, but commercial samples are often greenish or blue owing to the presence of iron-containing impurities

Fine Aggregate

Foundry sand is a substitute of river sand for concrete construction. Argillaceous materials have been used by mankind for construction from time immemorial. Every rising functional requirement of the structures and the capacity to resist aggressive elements has necessitated developing new materials and composites to meet the higher performance and durability criteria. The environmental factors and pressure of utilizing waste materials from industry have also been the major contributory factors in new developments in the field of concrete technology. Since concrete is the most important part of the structural construction, it should be in a form of good strength for structural purposes. Concrete is made up of aggregate, cement and water. Though this combination of three – a quarter of the mix is governed by aggregate. The aggregate itself is categorized as fine and coarse aggregate.

Coarse Aggregate

The locally available crushed aggregate was been used as coarse aggregate. The aggregate passing through 12.5 mm IS sieve and retained on 4.75 mm IS sieve was used in the preparation of geopolymer concrete

3. MIX PROPORTION AND EXPERIMENTAL INVESTIGATION

Geo-Polymer Mix Design

Unit weight of-of geopolymer concrete is 2400 kg/m³.The aggregates occupy about 77% of unit weight in Geopolymer concrete. The mix design process as there isn't a standard mix design procedure available as per IS codes.

Fig -1 Geopolymer concrete dry mix

Table -1: Mix Proportions ratio

Content	Mix proportions ratio
Alkaline solution	0.44
Silica Fume	1
Fine aggregate	1.69
Coarse aggregate	3.01

Preparation of Alkaline Activator Solution

The sodium hydroxide and sodium silicate chemicals are weighted as per mix design and diluted by water and it is used as an alkaline solution. The alkaline activators solution should be prepared 24hours before casting because it exits a large amount of heat (exothermic reaction).After the polymerization process, the alkaline solution is mixed with the dry mix of concrete. The alkaline solution is utilized within 24 hours of preparation.

Casting geopolymer concrete:

Steel moulds of cubes (0.15×0.15×0.15m), cylinder (diameter of 0.15m and height of 0.3m) and prism (length is 0.5 and depth is 0.1m) were coated initially with oil as to enable easy removal of the moulds. The surface was cleared off.The moulds were placed on an even surface. The moulds were tightened well on all the sides so as to prevent the bulking of the specimens once the concrete is poured inside.

Fig -3 geopolymer concrete casting

4. TEST SETUP

Compressive strength:

The concrete specimens of the cube are tested by compression test machine after the curing period of 24 hours. The load should be applied gradually at the rate of 140 kg/cm2 per minute, till the specimens fail. Load at the failure divided by area of specimen gives the compressive strength of concrete.

Fig -4 compressive strength

Split tensile strength:

Apply the load continuously without the shock at a rate of approximately 14 to 21 kg/cm2 per minute which corresponds to a total load of 9900 kg/min to 14850 kg/min note down the failure or breaking load.

Fig -5 split tensile test

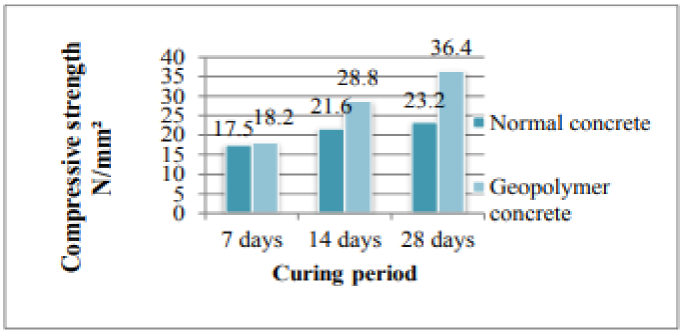
Flexural strength:

The flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand a failure in bending. The flexural test on concrete can be conducted using either three-point load test (ASTMC78) or center point load test (ASTM C293).

Fig -6 flexural strength

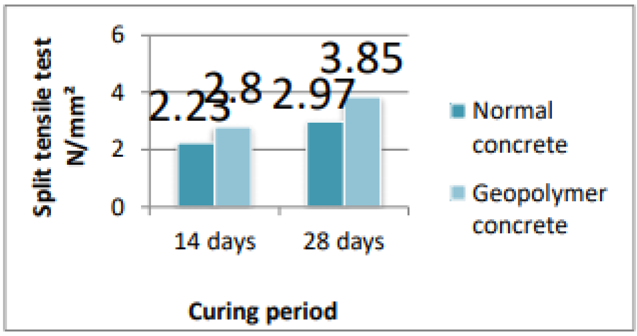
5. TEST RESULT

a) Compression strength test



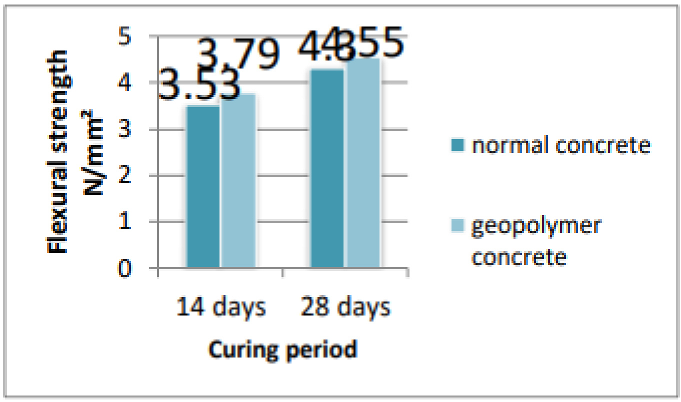
Graph -1 compressive strength result

b) Split tensile test:



Graph -2 split tensile test result

c) Flexural strength:



Graph -3 flexural strength result

6. FAILURE PATTERN

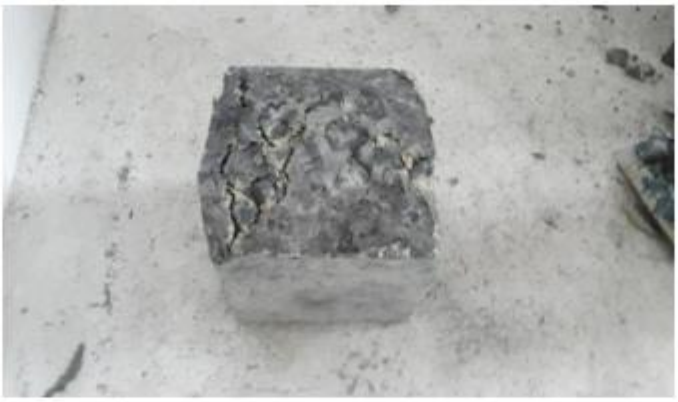


Fig -7 cube failure pattern

Fig -8 cylinder failure pattern

Fig -9 beam failure pattern

7. CONCLUSIONS

The possibility of using silica fume as an alternative for cement was discussed based on the investigation done by other researchers. Silica fume which is a by-product of silicon and ferrosilicon industry can be effectively used in construction industry along with other supplementary cementitious material. Replacement of 100% of cement with silica fume made possible in compressive strength. The development of compressive strength of silica fume based geopolymer concrete at pat with control concrete. Silica fume was effective in modifying the microstructure of geopolymer concrete and in the geopolymerisation process. It also developed very good bondage with alkaline liquids to yield a better strength and alkali activation process. Geopolymer concrete use as an alternative of Portland cement and it reduce the CO2 emission in the world so it can be said that it helps to the nature that's why Geopolymer concrete represents as a "Green concrete" and also as an "Eco-friendly concrete". Due to use of the industrial waste, Geopolymer concrete also play a role as an economical product and it also affects the cost of the geopolymer concrete

8. REFERENCES

[1] Abhilash A.Parmar. "Workability properties of geopolymer concrete using the accelerator and silica fume as an admixture" International Journal for Technological Research in Engineering Volume 1, Issue 8, April-2014.
[2] AmarendranathDeshini, Fineness of Densified Microsilica and Dispersion in Concrete Mixes‖ Concrete-General, ODOT Item 499.03(2006).
[3] C.D. Atis, F. O¨ zcan, A. Kilic , O. Karahan, C. Bilim, M.H. Severcan,‖ Influence of dry and wet curing conditions on compressive strength of silica fume concrete‖, Building and Environment, vol. 40,pp. 1678– 1683,(2005).
[4] Cisse, M. Laquerbe, ―Mechanical characterization of filler sandcretes with rice husk ash additions Study applied to Senegal‖ Cement and Concrete Research, vol. 30 ,pp. 13–18 (2000).
[5] Davidovits. J. (1999, 30 June -2 July). "Chemistry of Geopolymer systems, Terminology", Paper presented at the Geopolymer '99 International conference, (1999),saint-Quentin, France.
[6] Davidovits. J. "Global warming impact on cement and aggregates industries", world resource review, (1994). 6(2), 263-278.