Impact Factor: 5.731

IJETIR

ISSN (Online) 2583-0554

International Journal of Emerging Technologies and Innovative Research (IJETIR)

Volume 2, Issue 9, September 2020

Study on Evaluation of Strength Properties on Geopolymer Concrete with Different Combinations of Pozzolonic Materials

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Abstract: *Geo-polymer concrete is totally different in materials and chemistry which is synthesized from waste material like fly-ash (Class F or C), rice husk along with binding solution which is free of cement. This paper gives an overall view of the process and parameters which effect the geo-polymer concrete till date. It is an inorganic 3D polymer which is synthesized by activation of aluminosilicate source like fly ash or GGBS (waste materials). Due to its high mechanical properties combined with substantial chemical resistance (magnesium or sulphate attack), low shrinkage and creep and environment friendly nature (very less amount of CO2 production in comparison with OPC), it is a novel construction material for future. Till date it was seen that the strength of geo-polymer concrete mostly depends on the molarities of the alkaline liquid NaOH& Na2SiO3 (are used for binding of materials.). It was seen that geo-polymer concrete made of fully Fly-ash or partial replacement by GGBS results with 80% reduction in CO2 emission compared to OPC, although the alkaline solution to some extent pollutes the environment.*

Keywords: Geo-polymer concrete

I. LITERATURE REVIEW

1. Davidovits introduced the term 'Geopolymer' in 1978 to represent the mineral polymers resulting from geochemistry. Geopolymer, an inorganic alumina-silicate polymer, is synthesized from predominantly silicon (Si) and aluminum (Al) material of geological origin or by-product material. The chemical composition of Geopolymer materials is similar to zeolite, but they divulge an amorphous microstructure. During the synthesized process, silicon and Aluminum atoms are combined to form the building blocks that are chemically and structurally comparable to those binding the natural rocks. Most of the literature available on this material deals with Geopolymer pastes.

2. Bhosle (2012) carried out an experimental investigation on the processing of geopolymer using fly ash and alkaline activator. Sodium hydroxide and sodium silicate solution were used as an alkaline activator. The ratios of Na2SiO3 and NaOH were 0.39 and 2.51. Some geo polymer samples were cured at ambient temperature and some were cured at 600C. The compressive strength for 8M to 14M concentration of sodium hydroxide were observed and it was found that, the compressive strength in creases with the increase in the molarity and Na2SiO3 / NaOH ratio. Also, the compressive strength was more for oven drying as compared to specimen left in ambient temperature.

3. Pavia & Condren (2008) examined the durability properties of GGBS added concrete. Evidently, concrete incorporating GGBS proved more durable than that made with OPC alone in aggressive environments under the action of acids and salts such as those produced by silage. The durability increased with increasing amount of GGBS.

4. Brooke et al(2005) reported that the behavior of Geopolymer concrete beam column joints was similar to that of members made of Portland cement concrete. It was found that the application of Geopolymer concrete structural members was correlated well with the OPCconcrete.

5. Kumar Setal (2014) have conducted experimental study on the structural behavior of reinforced GPC beams of size 100 mm x 150 mm x 1200 mm undertwo-point loading. They have concluded that the flexural capacity of the beam increases with the increase in longitudinal tensile reinforcement ratio, and the tested ultimate moment capacity of beams

were found 1.35 times more than theoretical ultimate moment capacity. Stiffness of thin creases withincreaseinpercentageoftensilereinforcement,whichissimilartothe reinforced OPC concretebeams.

6. Vignesh and Vivek (2015) conducted experiments on the concrete specimens for FA based GPC with GGBS and observed that the water absorption for GPC is lesser than the nominal concrete. Hardjitoetal(2004)investigatedtheinfluenceofthealkaliactivatorsolution,curingtemperature,curing time, age of curing and water contentonthecompressivestrengthofgeopolymerconcrete.Shrinkage,creep and sulphate resistance in geopolymer concretewerealsoinvestigated.TheyusedclassFflyash,Na2SiO3 and NaOH solution for making geopolymer. They used 8 molar and 14 molar NaOH solutions and considered the ratio of Na2SiO3/NaOH as 0.4 and 2.5. Specimens were cured at 300C to 900C for 3hours to 100 hours. They observed that the molarity of NaOH, the ratio of Na2SiO3/NaOH, and curing temperature influences the compressive strength of GP concrete. Further, they observed a decrease in compressivestrengthwhenwatercontentdecreases.Theyalsoobservedalowdryingshrinkage,creepstrain and high sulphate resistance for GP concrete at water content corresponding to maximum compressive strength. Ismail et al (1996) said that even in case of higher burning temperature and having crystalline silica content, favorable results may be obtained by fine grinding RHA. The fine RHA can be used to make god quality concrete with reduced porosity and less Ca (OH)2 content (Zhang & Mohan 1996).

II. INTRODUCTION

Concrete, the most widely used building material in the world, has gained popularity due to its many advantages: relatively low production costs, ease of handling, moldability to the desired shape, achieving the desired strength from low to very high, ease of maintenance and durability. The main component of concrete is cement, usually Portland cement (OPC), which acts as a binder and keeps the aggregates intact. Unfortunately, the OPC is associated with some adverse effects on the environment. OPC production uses a lot of energy and releases a significant amount of CO2 into the atmosphere, which contributes significantly to the greenhouse effect.

At the same time, however, numerous industrial and agricultural wastes with inherent cement properties accumulate in abundance. However, they are mainly disposed of in landfills. The use of by-products as a cement substitute has a number of benefits, including environmental preservation, resource sustainability, and the solution to the problem of byproduct disposal. Especially in India, the environmental impact of the OPC is significant due to the growing demand for cement for rapidly developing construction and infrastructure projects. It is therefore immediately necessary to monitor the use of UCIs by developing potential alternatives.

Concrete is the most essential aspect of any construction. and widely used material in the construction industry. Selection of concrete depends on various factors like environment, energy consumption, budget and technical aspects. Hence the concrete technology stepped towards the development of alternative building material which can fulfil these aspects and are locally available so as to reduce the cost of construction. Many materials are used for these purposes like ground granulated blast furnace (GGBS), Rice Husk Ash (RHA), silica fume, fly ash etc. All these materials are categorized as pozzolanic admixtures or mineral admixtures. They are also known as a supplementary cementations material.

To produce environmentally friendly concrete, we have to replace the cement with some other binders which should not create any bad effect on environment. The use of industrial by products as binders can reduce the problem. In this respect, the new technology geo-polymer concrete is a promising technique. In terms of reducing the global warming, the geo-polymer technology could reduce the CO2 emission to the atmosphere caused by cement and aggregates industries by about 80% (Davidov its, 1994c). And, the proper usage of industrial wastes can reduce the problem of disposing the waste products into the atmosphere

III. SUMMARY

In the present experimental work, the properties of concrete are thoroughly studied with addition of Rice Husk Ash as a replacement for cement, which are obtained in the form of agricultural wastes. The Rice Husk Ash is replaced with cement with following variations of 0%, 10%, 20%, 30%, and 40% by weight of cement. Following parameters such as strength aspects are studied in this work.

The materials like Cement, River Sand, Rice Husk Ash, Natural Coarse Aggregate, and grade of concrete are selected and their characteristics has been thoroughly analyzed. Using these materials, Design mix is done with required w/c ratio for M25 concrete grade. The different proportions of Rice Husk Ash is replaced with cement is done. The cubes, beams and cylinders are casted and tested for different mixproportions. Finally, with obtained results, comparison will be done and conclusions are drawn.

The following are the materials were utilized in this investigation is given below:

1. Fly ash
2. Ground granulated blast furnace slag
3. Rice Husk Ash
4. Coarse aggregate
5. Fine aggregate
6. Alkaline Solution
7. Water

Acombinationofsodiumhydroxide(NaOH)andsodiumsilicate(Na_2SiO_3)solutionswereusedforthe activation of fly ash. The laboratory grade sodium hydroxide in pallets form, with 98% purity and three differentconcentratedlaboratorygradesodiumhydroxideandsodiumsilicatewereused.Sodiumhydroxide solution was prepared by mixing the pellets with Water for the preparation of required molarities of alkaline solution. As there is no practicing code available for mix design of Geopolymer concrete, the mix design is done in trend similar way as Portland cement concrete. The coarse and fine aggregate occupy 75-80 % of total mass of the Geopolymer concrete like OPC concrete . Except for the aggregates, there are two major ingredients of Geopolymer concrete namely the source material and alkaline liquids.

The choice of source material depends upon the researcher and the purpose of the research. The RHA can be used alone for making Geopolymer concrete as well as it can be used in addition with other materials likefly ash, GGBS, calcine sludge etc. As a source material for GPCproduction.

The alkaline liquid which is used for polymerization is a mixture of sodium silicate & sodium hydroxide or potassium silicate & potassium hydroxide. The sodium based alkaline solution is widely used for its better performance and availability. The alkaline solution is prepared before few hours of use to reduce the heating effect of sodium hydroxide dissolution in the mixture. The sodium silicate is commercially available in the market with a wide verity of grades. The A53 is generally used for Geopolymer concrete which has an approximate ratio of 2 between sio_2 & Na_2O (i.e-sio_2= 29.4%, Na_2O=14.7% and water=55.9%) . Sodium hydroxide is available commercially in the form of pellet or flake with purity 97-98% . The sodium hydroxide solids are dissolved in the pure water in a range of 8-14 molarity. Yunyongkim et al. Prepared the Geopolymer concrete specimens with RHA & sand of ratio 1:2. They used sodium hydroxide of concertation 7, 8, 9 and 10 molar and the sodium silicate to sodium hydroxide ratio was 2.5% by mass.

Following steps are followed to make a 16 M NaOH solution in a 1 liter solution. To prepare a 1 M solution, 40 g of NaOH pellets in solid form are required. Although we mix 40 g granules in a 1 liter solution, we can get a 1 M sodium hydroxide solution. The evaluation of the heat takes place quickly when mixing the pellets in the water. NaOH solution was prepared one day prior to pouring the concrete cubes to avoid contamination when mixing the GPC components. Similarly, we prepare a 16 M solution for GPC by adding 16 x 40 = 640 g sodium beads. Then we get a solution of 16 M per liter of sodium hydroxide.

The solutions of Sodium hydroxide and Sodium Silicate are used as alkaline solutions in the present study.Sodium hydroxide is available in market in various forms as flakes, pellets and in powder forms. In the study, Commercial grade Sodium Hydroxide in flakes form (97%-100% purity) is used.

Sodium silicate is available in powder form. By using sodium silicate we may prepare solutionof required molarity. In this study, sodium silicate used in solution form having the followingchemical proportion is used.

Na_2O	-	7.5%-8.5%
Sio_2	-	25% -28%
Water	-	67.5%-63.5%.

Cubical moulds of size 150mm x 150mm x 150mm were used to prepare the concrete specimens for the determination of compressive strength of concrete. Care was taken during casting. The moulds were placed upon the compaction table for proper compaction. All the s the moulds were cleaned and oiled properly. These were securely tightened to correct dimensions before casting. Care was taken that there are no gaps left from where there is any possibility of leakageofslurry.Acarefulprocedurewasadoptedinthebatching,mixingandcastingoperations. The coarse aggregates and fine aggregates were weighed first with an accuracy of 0.5 grams. The concrete mixture was prepared by the concrete mixer. It was cleaned first by water and dried then, to ensure any impurities were not adhering to its surface form prior use. Dry fine aggregates are introduced first in the mixer & are thoroughly mixed. After those coarse aggregates are added to it. CementisreplacedbyRiceHuskAshindifferentproportions.Thenwaterwasaddedcarefullyso that no water was lost during mixing. A total of 24 cubes were prepared which consists of cubes incorporated with Rice Husk Ash. Proposed checks were made at 7, 14 and 28 days. The compaction machine was stopped as soon as the cement slurry appeared on the top surface of the mould. All the specimens were left in the steel mould for the first 24 hours at ambient condition. Afterthattheywerede-moldedwithcareuponrequirementofagingsothatnoedgeswerebroken and were placed in the curing tank at the room temperature for curing. The room temperature for curing was 27 ± 20(IS:10262-1982)
In this study, compressive strength, split tensile strength and flexural strength of the geopolymer concrete which were curedinovendryingfor600Cat3days,14days,28daysand 56 days. The ratio between sodium hydroxide and sodium silicate was kept as 2.5. The tests were carried out accordance with the specifications present in IS 516-1959 and IS 5816-1999. Prasanna Venkatesan Ramani et al. (2015) stated the RHA can be used as a source material in Geopolymer concrete in addition to ground granulated blast furnace slag (GGBS). They also reported the addition of RHA beyond 10% had a retarding effect on the compressive strength. At up to 20% replacement, the target strength was surpassed and compressive strength as high as51MPawasreachedat28days.Thesplittensileandflexuralstrengthsshowedatrendsimilar to that of compressive strength with respect to the RHA proportion.

IV. CONCLUSION

From the experimental investigations the following conclusions are drawn

- Geopolymer concrete made with FA and GGBFS can be efficiently used instead of conventional concrete to minimize the cement consumption without compromising the strength parameters which will reduce numerous environmental pollution issues like CO2 emission, global warming, landfill issues,etc.
- Addition of RHA beyond 20% has a retarding effect on the mechanical strength properties and target mean strength was achieved at the end of 28 dayscuring
- The strength gain was substantial till 7 days and became moderate till 28th day. As evident from the 56th day compressive strength results, the strength gain beyond28 days was only marginal forGPC.
- GPC mixes made with GGBFS shows better results than the GPC mixes based withFA.

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