

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 7, Issue 3, March 2018

Experimental Study on Mechanical Properties of Geo-polymer Concrete with Replacement of Coarse and Fine Aggregates by Using Steel Slag, Fly Ash and GGBS

R.Dhilipkumar¹, R.Balasubramanian², S.Muvendhar³, P.Pravinkumar⁴, S.Raghavendhar⁵

Assistant Professor, Department of Civil Engineering, Kavery Engineering College, Salem Tamilnadu, India¹

U.G. Student, Department of Civil Engineering, Kavery Engineering College, Salem Tamilnadu, India^{2,3,4,5}

ABSTRACT: Concrete has occupied an important place in construction industry in the past few decades and it is used widely in all types of constructions ranging from small buildings to large buildings infrastructural dams or reservoirs. Cement is major ingredients of cement. The cost of cement is increasing day by day due to its limited availability and large demand. At the same time the global warming is increasing day by day. Manufacturing of cement also releases CO₂. Experimental investigation on the concrete using by replacing cement with FLYASH and GGBS to decrease the usage of cement as well as emission of concrete. The concrete made with fly ash performed well in terms of compressive strength, split tensile strength, and water absorption showed higher performance at the age of 7,14,28 days than conventional concrete.

KEYWORDS: Compressive strength, Split tensile strength and Flexural test, Fly-ash, silicate, GGBS, Steel Slag

I. INTRODUCTION

The term geo-polymer was first introduced by Davidovits in 1978 to represent the mineral polymers resulting from geochemistry. Geo-polymers are manufactured from secondary raw materials such as fly-ash and slag. The use of fly-ash has potential ecological benefits and much lower cost than other source materials. Geo-polymer are alkali-activated alumina silicates, with a much lower carbon dioxide emission than ordinary Portland cements

Depending on the selected raw material and processing conditions, geo-polymer concrete exhibit a variety of diverse properties, including high compressive strength, low shrinkage, fast (or) slow setting, acid resistance, fire resistance and low thermal conductivity. The manufacture of geo-polymer concrete is carried out using the usual concrete technology methods.

The production of Portland cement, which is used for ordinary concrete, causes a serious green house gas pollution problem. Therefore new techniques to produce concrete with reduced green-house gas emission are needed. Unlike ordinary Portland cement (opc) concrete, geo-polymer concrete does not require Portland cement to bond aggregate it uses geo-polymer cement as the cementing material. Given the fact that fly-ash is considered as a waste material, the low-calcium fly-ash based geo-polymer concrete is, therefore, cheaper than the Portland cement concrete.

The special properties of geo-polymer concrete can further enhance the economic benefits. Geo-polymer materials represent an innovative technology that is generating huge amount of interest in the construction industry considering sustainable material. Although geo-polymer concrete is a new technology but the use of this technology has started from time of pyramids though that time it did not come in the front of the researchers like now to grasp their interest in it. Moreover, reduction of one ton of carbon-dioxide is possible by using geo-polymer the main objective of this paper is to examine the physical properties of coarse aggregate, fine aggregate and cement. The combination of potassium hydroxide and sodium silicate was used as alkaline liquids.

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II.LITREATURE REVIEW

Geo-polymer Concrete as a new type of sustainable construction Materials:

Alkali activated slag cements have been known for about four decades and usually for activation 2-7% Na₂O or 3-10% K₂O of the Slag content is necessary. This kind of concrete has shown progressive gain of strength from 21Mpa in 3 days to 36 days in 1 year and 40 Mpa in 6 years (w/c ratio is 0.46).An Experimental Study On Slag/Fly Ash-Based Geo-polymer Concrete:For the alkaline solution, a weight ratio sodium silicate solution 44.1% solution in water was used to react with the slag and fly ash develop polymerization.

III.MATERIALS STUDY

GGBS

- Ground granulated blast furnace slag is used as replacement for cement in geopolymer concrete.
- The specific gravity of GGBS is 2.54

Fly ash

- It is the waste product from thermal power plant
- The specific gravity of fly ash is 2.33

Fine aggregate

- This material which passes through BIS sieve number 4(4.75mm) is called as fine aggregate
- The specific gravity of Fine aggregate is 2.4.
- The sieve analysis conducted to the F.A shows the sand belongs to zone iii as per IS: 383-1917
- Water absorption for the F.A is 1%

Coarse aggregate

- The material which is retained on BIS test sieve number greater than 4.75mm size aggregate termed as C.A(aggregate size used is 20mm and 10mm its S.G is 2.64,2.57 respectively)

Alkaline liquid:

- The alkaline liquid used is the combination of sodium silicate , sodium hydroxide solution. The % used is (SiO₂=25%, NaOH= 15% and water =60%)

Super plasticizer:

- To increase the workability of fresh concrete, bonding agent the TEC MIX 550 is used.

Steel Slag:

- It is the waste produced from the steel plant
- Specific Gravity of steel slag is 2.56.

Mix Design:

Procedure for concrete mix design calculation as per IS 10262-2009 based on strength and durability, workability, economy is discussed in this article.

To produce concrete of required strength and properties, selection of ingredients and their quantity is to be found which is called concrete mix design. Proper mix design will solve every problem arises in concrete while placing or curing etc.. The mix design also helps to produce economical concrete.

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Generally, cement is more costly than other ingredients of concrete. So, quantity and quality of cement is designed by proper mix design concept. In this article we are going to discuss about the concrete mix design concept as per IS 10262-2009.

MATERIAL	WEIGHT Kg/m ³
Coarse aggregate(20mm)	1087
Fine aggregate	786
Fly ash	362
GGBS	725
Steel Slag	239
Sodium Hydroxide	41
Sodium Silicate	102
Super plasticizer	20
Extra water	60

IV.EXPERIMENTAL RESULTS

Compressive strength

The compressive strength of concrete is one of the most important properties of concrete. Comparative strength of M35 grade of concrete for the replacement of cement by Steel slag, fly ash and GGBS. Then the cubes were tested their crushing strength at 3, 7 and 28 days. As per IS: 4031:1968, load was applied at the rate of 140kN/min.

$$F_c = \text{Failure load} / \text{Cross sectional area}$$



Fig No: 1 Compressive strength test

Split Tensile Strength

The test is carried out in a cylindrical specimen of 150mm diameter and 300mm length. The cylindrical specimen is placed horizontally between the loading surfaces of a compression testing machine and the load is applied until failure of cylinder, along the vertical diameter. The split tensile strength is given by the formula $2P/(\pi dl)$ and the stress value is in N/mm^2 . Where,
P – The ultimate load at which the cylinder fails. The diameter and length of the cylinder.

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Split Tensile Strength = $2p / \Pi dl$



Fig No:2 Split Tensile strength test

Flexural Strength

The systems of loading used in finding out flexural strength are central point loading and third point loading. The testing machine may be of any reliable type of sufficient capacity for the tests and capable of applying the load at the rate specified. Flexural strength is expressed as modulus of rupture which is given by M/Z .
Flexural Strength $f_b = pl/bd^2$



Fig No:3 Flexural strength test

Compressive Strength of GPC in Cube Specimen N/mm^2

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

X axis- Trails of replacement Materials C.A & F.A for Steel slag, GGBS

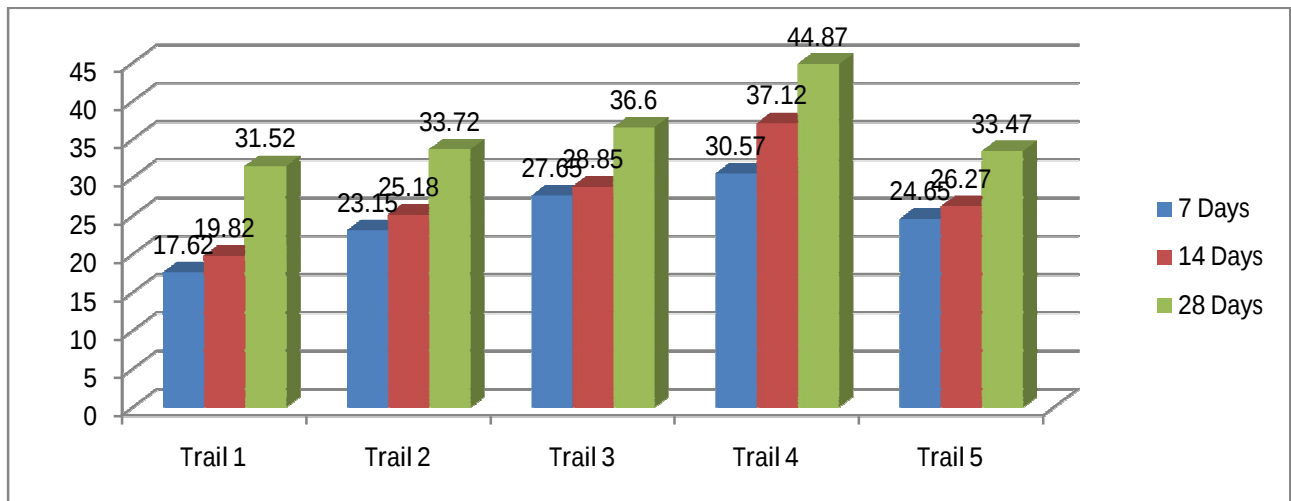
Y axis -Compressive Strength N/mm^2

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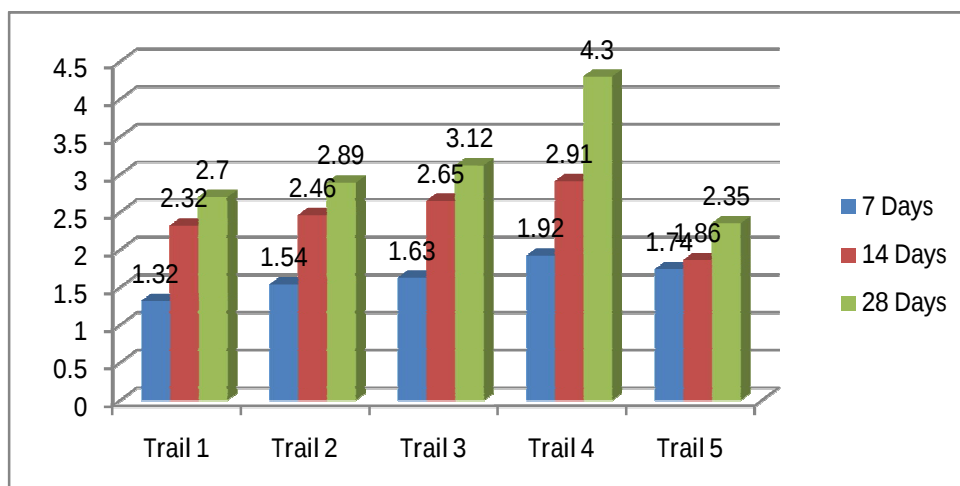
- The graph shown that trail 4 mix increases the compressive strength up to 25% compared with conventional mix.
- The graph exhibits compressive strength will be reduced after the trail 4
- Let we conclude that optimum percentage of replacement would be 40%

Split Tensile Strength of GPC :

X axis -Trails of replacement Materials C.A & F.A for Steel slag, GGBS

Y axis -Split Tensile Strength N/mm²

- The graph shown that trail 4 mix increase the Split Tensile strength up to 25% compared with conventional mix.
- The graph exhibits Split Tensile strength will be reduced after the trail 4
- Let we conclude that optimum percentage of replacement would be 40%.
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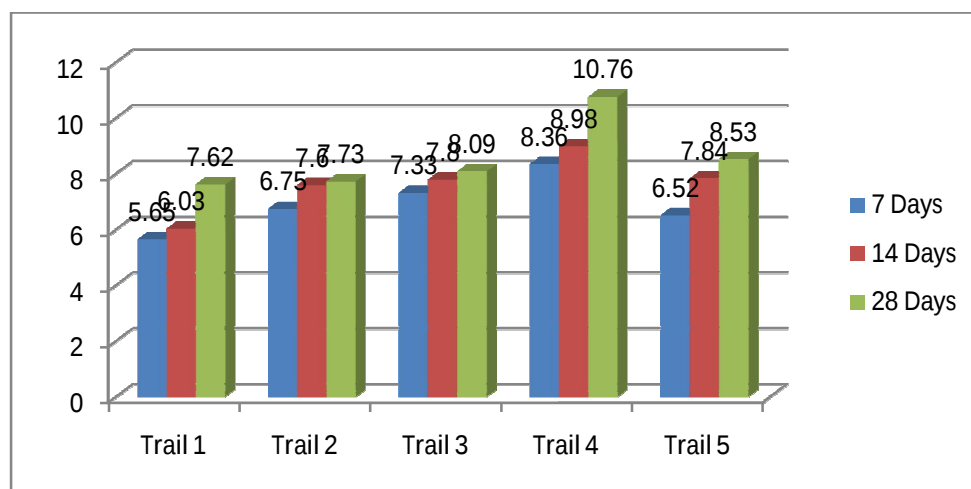
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Flexural Strength of GPC:

X axis -Trails of replacement Materials C.A & F.A for Steel slag, GGBS

Y axis -Split Flexural Strength N/mm²



- The graph shown that trail 4 mix increase the Flexural strength up to 25% compared with conventional mix.
- The graph exhibits Flexural strength will be reduced after the trail 4
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V.CONCLUSION

- Mix M35 can be effectively used in reinforced concrete structure for increased durability and economy.
- Workability of concrete decreased as percentage of fly ash increase in cement.
- The specimen F.A10%, F.A20%, F.A30%, F.A40% & 50% are subjected to compressive strength, split tensile strength and Flexural strength results are tabulated.
 - From test results it is observed that F.A30% and NaOH & NaSiO₂ 15% (30% cement replacement by fly ash and 15% NaOH & NaSiO₂) hold good strength.
 - Further in this experimental study, this F.A 30%, NaOH & NaSiO₂, GGBS area so added in the cement concrete is modified by partially replacing the Cement, percentages such as 10%, 20%, 30%, 40% & 50%. From the test results, it is observed that 45% replacement of Cement concrete gives strength in all the aspects.
 - Thus, when compared to conventional concrete 45% replacement of cement with fly ash, NaOH & NaSiO₂, GGBS and replacement of Cement has increase in compressive strength, split tensile strength and Flexural Strength.
 - Then the strength of compressive strength will be increased gradually with 1.6 to 1.7 times of 20%, 30%, and 40% of replacement properties of waste materials.

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