

## **AN EXPERIMENTAL STUDY ON GEOPOLYMER CONCRETE BY REPLACEMENT OF NATURAL SAND WITH MANUFACTURED SAND**

Jangam John Sudeepth<sup>1</sup>, Maddi Anirudh<sup>2</sup>, Ganguluri Manideepthi<sup>3</sup>

<sup>1</sup>PG Student, Department of Structural engineering & Vignan Deemed to be University,  
sudeepthjangamjohn@gmail.com

<sup>2</sup>Profissor, Department of Structural engineering & Vignan Deemed to be University, maddi.anirudh@gmail.com

<sup>3</sup>PG Student, Department of Structural engineering & Vignan Deemed to be  
University,manideepthi.ganguluri@gmail.com

**Abstract** - Concrete is the most common material for construction all over the world. The demand for concrete as a construction material leads to the increase of demand for Portland cement. Geo-polymer is an eco-friendly binding material alternative to OPC. Geo-polymer concrete is obtained by mixing the ingredients such as sodium hydroxide, sodium silicate solution (NaOH and Na<sub>2</sub>SiO<sub>3</sub>), or potassium hydroxide, potassium silicate solutions (KOH and K<sub>2</sub>SiO<sub>3</sub>) fly ash, grounded granulated blast furnace slag (GGBS) and, fine aggregate and coarse aggregate and water are used. The blend of sodium hydroxide solution and sodium silicate solution is termed as alkaline liquid solution. This paper presents an investigation deals with Geo-polymer concrete by replacing of fine aggregate material with the Msand. Complete 100% replacement of natural sand with Msand and compare the results with GPC natural sand and GPCM

**Key Words:** GPC, GPCM, OPC, GGBS, MANUFACTURING SAND.

### **I. INTRODUCTION**

Concrete is the most versatile material of construction over the world. The usage of concrete were increasing day by day. The cement industry is the second largest producer of the greenhouse gas. Manufacturing process of cement involves in emission of large amount of greenhouse gases like Carbon dioxide into atmosphere. For the production of 1 TONE of cement produce approximately 1 TONE of carbon dioxide. Burning of lime stone, clay and other materials @1500°C produces of carbon dioxide. Concrete is the material of choice for a variety of applications such as housing, bridges, highway pavements, industrial structures, water-carrying and retaining structures, etc.

Davidovits (1978) is father of geo-polymer concrete. Geo-polymer is a new family of cementitious materials which is more Environmental friendly due to its less emission of CO<sub>2</sub> gas and energy consumption. geo-polymers can be used as cementitious material that utilize high siliceous materials like fly ash, Ground Granulated Blast furnace slag (GGBS), Silica Fume (SF), Rice Husk Ash (RHA), and Metakaolin (MK) for binding which can produce an eco-friendly material. These materials available with less cost and only for transportation it costs. By increasing the Molarities the strength of GPC were also increases. Geo-polymer is a combined product of aluminum and silicon. It is produced by geochemistry process. Alkaline solution is used as the binding material for geo-polymer concrete. Alkaline solution is made using sodium hydroxide (NaOH) and sodium silicate (Na<sub>2</sub>SiO<sub>3</sub>) solutions. Fly ash based geo-polymers use fly ash as the material which acts as source of silicon and aluminum for reaction by an alkali to make silicon and aluminum atoms to form geo-polymer paste. Geo-polymer materials are generally low density due to the existences of micro sized and nano sized pores within the final products.

### **II. MATERIALS USED FOR GPC**

**A. Fly ash (Class F):** The majority of fly ash used, in a by-product from the burning of pulverized coal to generate electricity at power stations. Fly-ash mainly contains silica, alumina and minor amounts of oxides such as iron (Fe), sodium (Na), calcium (Ca), magnesium (Mg) and potassium (K). But major chemical constituents in class-F fly ash are alumina and silica, both together occupies more than 90% of fly ash and low in calcium. Where as in class F fly ash low in calcium. The class-F fly ash used in our work is obtained from National Thermal Power Project (NTPC) Vijayawada, ANDHRAPADESH.

**B.GGBS (ground granulated blast-furnace slag)**

GGBS is a by-product from the manufacture of iron. Molten slag is tapped off from the blast furnace during the production of molten iron. The iron ore is reduced to iron and the remaining materials form a slag that floats on top of the iron. This is separated from separate hopper and collected in the cyclone filters. This slag is periodically tapped off as a molten liquid and if it is to be used for the manufacture of GGBS.

**C. Alkaline solution;**

A combination of the sodium hydroxide and sodium silicate solutions was used as the alkaline liquid to activate Fly ash and GGBS. Sodium based solutions were chosen because they were cheaper than Potassium based solutions. The sodium hydroxide solids were either a technical grade in flake or pellets. The sodium hydroxide flakes were obtained from SREE chemical agencies Gollapudi, Vijayawada and fusion chemicals & products pvt.Ltd.Telangana.

**D. Manufacture sand (Msand):**

Manufactured sand is used as secondary material of fine aggregate and which is collected from stone crusher. In this process stone is crushed in 5 different crusher's stages to get Msand. Dust is nuisance and technically undesirable in both coarse aggregate and more so in fine aggregate. The 75 $\mu$  is the maximum permissible particle of size that we get in Msand. Water sprinklers are used to prevent air pollution. In Each water is added to the stone and proper care is taken in the crusher mill to prevent accidents and hence they As per IS: 2386 (Part III)-1963 [8], the bulk specific gravity in oven dry condition and water absorption of the fine aggregate are 2.84 and 1.2% respectively.



**Fig.1 Manufactured sand**

**E. Coarse aggregate**

Locally available coarse aggregate were used.

Specific gravity = 2.85

**F. Water**

Water is available in laboratory. pH value is 7.

**G. Super Plasticizer**

ConplastSP430 Is used as super plasticizer

### **III. MIX DESIGN**

The process of mix design starts with the calculation of the quantity of the aggregates based on the percentage of total aggregates in the whole mix. The measure of sodium silicate and sodium hydroxide are calculated based on the ratio between the sodium silicate and sodium hydroxide. First the value of sodium silicate is found, the quantity of NaOH and water can be found based on constant percentage of n the molarities chosen. Usually 3% of super plasticizer with a constant percentage of water chosen based on the stiffness of the mix is used in the design. The correctness of the mix can be checked by finding the absolute weight of the materials, using their specific gravities, whose sum should be around 1000 kg. A sample mix design of 8M NaOH with 50% of FA and 50% of GGBS is shown below.

#### STANDARDS

|                                           |                                       |
|-------------------------------------------|---------------------------------------|
| Alkaline liquids/GGBS                     | 0.3 to 0.45                           |
| Sodium silicate/ sodium hydroxide         | 2 to 2.5                              |
| Water / GGBS                              | 0.16 to 0.24                          |
| Total aggregate in mass of concrete       | 65% to 85%                            |
| Fine aggregate content in total aggregate | 30%                                   |
| Extra water content                       | 20 % of mass of cementitious material |
| Super plasticizer                         | 3% of mass of cementitious material   |

#### FINAL MIX PROPORTION

|                                   |                         |
|-----------------------------------|-------------------------|
| Mass of coarse aggregate          | 1176 Kg/m <sup>3</sup>  |
| Mass of fine aggregate            | 504 Kg/m <sup>3</sup>   |
| Fly ash                           | 266.5 Kg/m <sup>3</sup> |
| GGBS                              | 266.5 Kg/m <sup>3</sup> |
| Mass of sodium silicate           | 134 Kg/m <sup>3</sup>   |
| Mass of sodium hydroxide          | 17 Kg/m <sup>3</sup>    |
| Mass of super plasticizer         | 18.3 Kg/m <sup>3</sup>  |
| Water content in sodium hydroxide | 36 Kg/m <sup>3</sup>    |

**Table1. Final mix proportion**

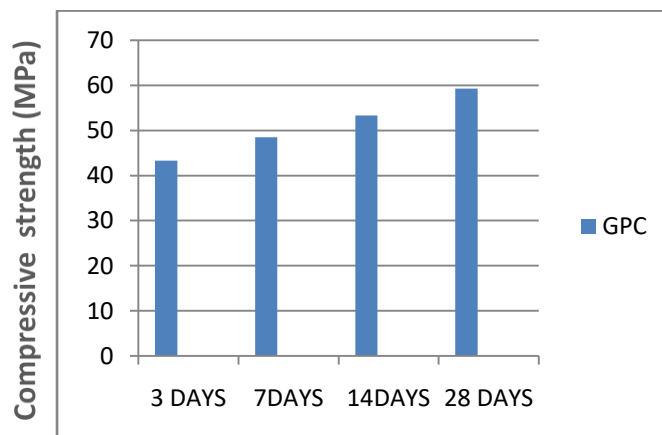
### IV. EXPERIMENTAL INVESTIGATION

#### A. Test Specimen

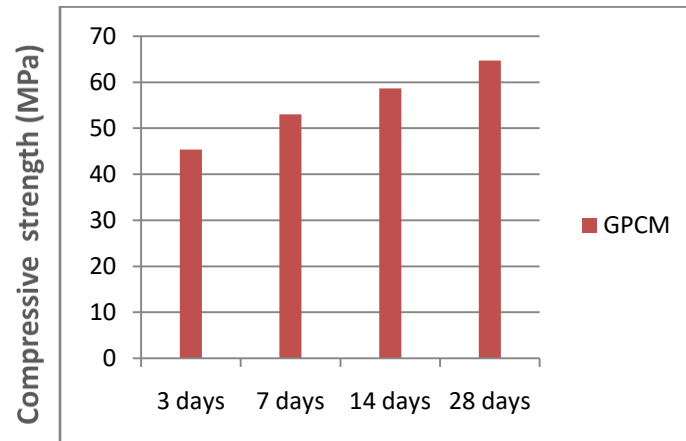
The test moulds for compressive strength were made on cubes cast in iron moulds having a size of 150 mm x 150 mm x 150 mm. For each mix proportion three numbers of cubes were cast and tested correspondingly at the age of 7 and 28 days. The test moulds for split tensile strength test were made of cast cylinders having a size of 150 mm diameter and 300 mm height. For each mix proportion three numbers of cylinders were cast and tested at the age of 7 days and 28 days. Following this the flexural strength test was carried out on prisms of size 500 mm X 100 mm X 100 mm. For each mix proportion three numbers of prisms were cast to be tested after 7, 28 days.

#### B. Compressive Strength results

The compressive strength results obtained by 50% of GGBS 50% of fly ash. Natural river sand is used as fine aggregate.

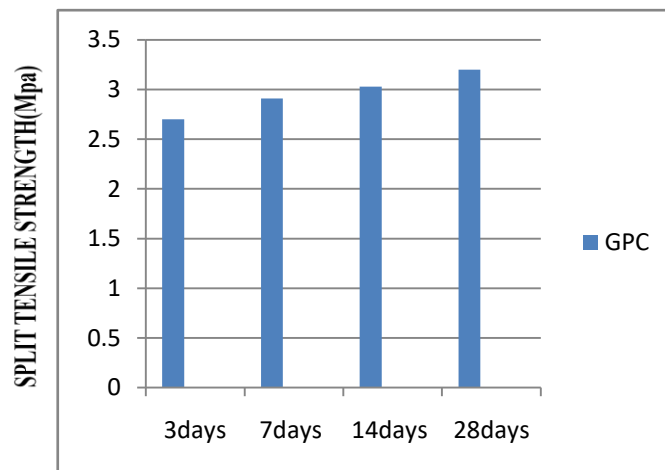


The results obtained from the test by replacement of natural sand with Msand are tabulated below for GPC 8M. In this complete 100% of replacement of natural sand with Msand were done.



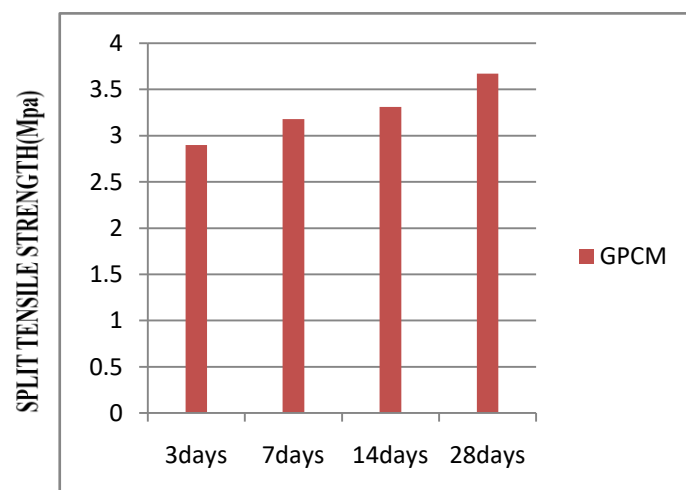
#### C. Split tensile strength of GPC

The split tensile strength results obtained by 50% of GGBS 50% of fly ash. Natural river sand is used as fine aggregate



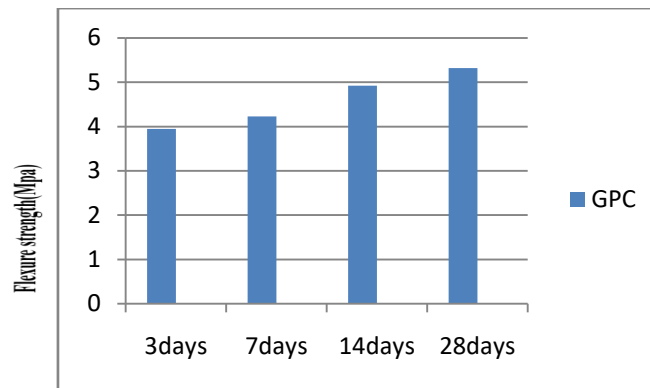
#### D. Split tensile strength of GPC for 8M for M sand

The results obtained from the test by replacement of natural sand with Msand are tabulated below for GPC 8M. In this complete 100% of replacement of natural sand with Msand were done



#### E. Flexural strength of GPC

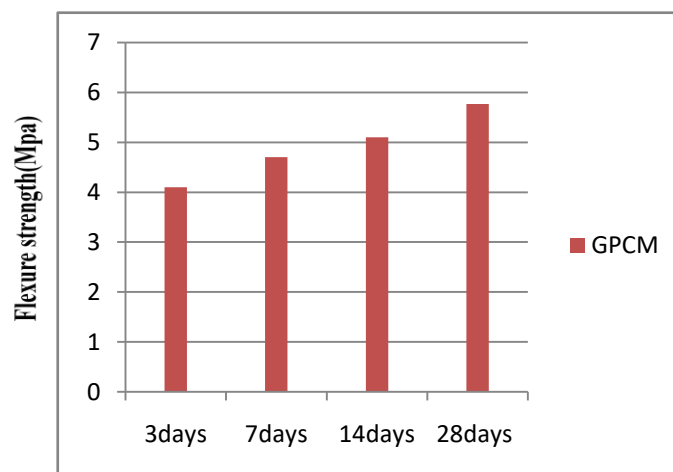
The split tensile strength results obtained by 50% of GGBS 50% of fly ash. Natural river sand is used as fine aggregate



Flexural strength of GPC

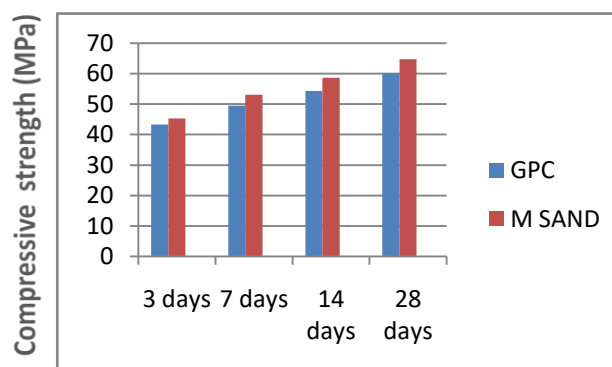
#### F. Flexural strength of GPC for M sand

The results obtained from the test by replacement of natural sand with Msand are tabulated below for GPC 8M. In this complete 100% of replacement of natural sand with Msand were done



### V.COMPARISON OF TEST RESULTS

Graphs showing the results of GPC with natural sand GPC with Msand. This represents Comparison OF compressive strength, split tensile strength and flexural strength.



Comparison of compressive strength (N/mm<sup>2</sup>)

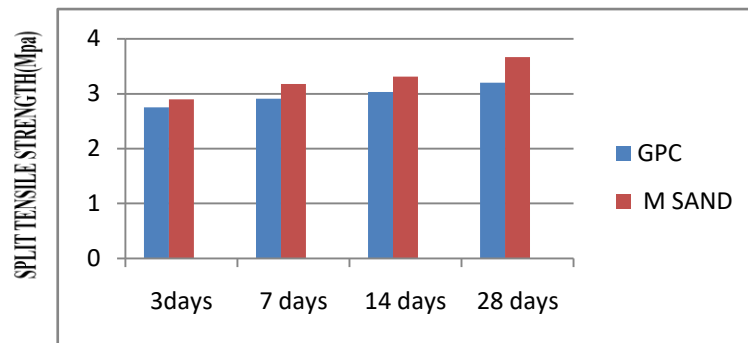


Fig 4.2 Comparison of split tensile strength (N/mm<sup>2</sup>)

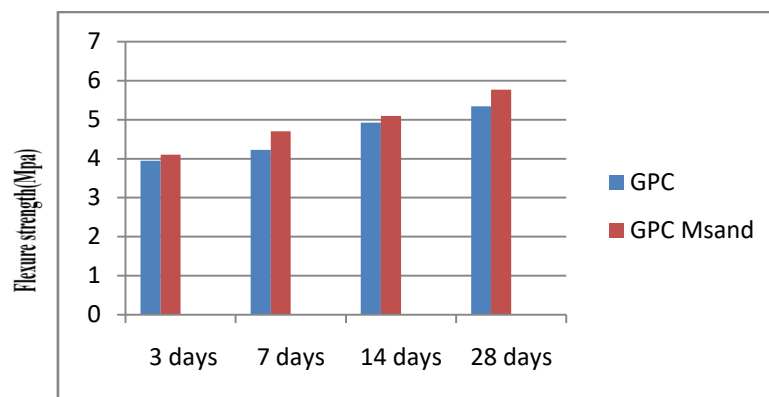


Fig 4.3 Comparison of Flexural strength (N/mm<sup>2</sup>)

## VI Conclusions

- Geopolymer concrete in structural applications has led to the total elimination of cement from concrete, which ultimately becomes “Green Concrete”
- The fly ash, once considered as waste material, has found usefulness through Geopolymer concrete in construction industries and become a valuable material
- The increase in the NaOH molarity increased the compressive strength of GPC
- By replacement of natural sand with Msand reduces the cost of concrete and no side effects
- Geopolymer concrete can be prepared at comparable cost with OPC based concrete provided transportation system for raw materials is well established.
- While the addition of Msand improved the loading capacity significantly, the improvement was marginal for ultimate load. The voids were reduced to 20% because Msand contains of dust particles.
- Energy absorption capacity increases in the cylinders and beams with Msand compared to natural sand.
- Its resistance against sulphate and acid attack makes it suitable to be used for construction in abrasive soils where ground water contains considerable amount of sulphate salts
- The compressive strength increased up to 35% for the durability

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