Experimental Study of Geopolymer Concrete with Manufactured Sand

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***Abstract*- Geo-polymer concrete utilizes an alternate material called fly ash as binding material instead of cement. Fly ash reacts with alkaline solution (e.g NaOH) and Sodium silicate (Na_2SiO_3) to form a gel which binds the fine and coarse aggregates. Another Artificial material called as Manufactured sand (M-sand) is also used as the fine aggregate against the normal river sand in varying proportion. In this paper the strength parameters for Geo-polymer concrete with varying proportion of manufactured sand was tested and analyzed. The strength of ordinary Geo-polymer concrete is compared with Geo-polymer concrete with varying proportion of M-sand and found the strength of Geo-polymer concrete with M-sand is high. Hence, pollution free Geo-polymer concrete with M-sand can be an alternative to ordinary Portland cement concrete.**

***Index Terms*–fly ash, Geo-polymer concrete, manufactured sand**

I. INTRODUCTION

Concrete is one of the most widely used materials in the world. Ordinary Portland cement (OPC) is conventionally used as the primary binder to produce concrete. The amount of the carbon dioxide released during the manufacture of OPC due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete. Low calcium fly ash based Geo-polymer is used as the binder, instead of Portland or other hydraulic cement paste , to produce concrete .The fly ash based Geo-polymer paste binds the loose coarse aggregates, fine aggregates and other un-reacted materials together to form the Geo-polymer concrete, with or without the presence of admixtures. The silicon and the aluminum in the fly ash reacted with an alkaline liquid that is a combination of sodium silicate and sodium hydroxide solutions to form the Geo-polymer paste that binds the aggregates and other un-reacted materials.

With the world wide decline in the availability of construction sands along with the environmental pressures to reduce extraction of sand from rivers, the use of manufactured sand as a replacement is increasing. There is a need for 'clean sand' in the construction from the point of view of durability of structures. As the demand for natural river sand is exceeding the availability, it has resulted in fast diminution of natural sand sources. Hence, river sand is replaced by manufactured sand to overcome the demand.

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II. OBJECTIVE

- To determine the strength characteristics for geo-polymer concrete.
- To study the different properties of geo-polymer concrete with percentage replacement of manufactured sand.

III . SCOPE

- The incorporation of geo-polymer concrete in construction field has led to the total elimination of cement from concrete which ultimately becomes "GREEN CONCRETE"
- Increase the efficiency of the construction while at the same time maintaining the highest levels of product quality under the conduction of natural sand shortage.

IV. LITERATURE REVIEW

Geo-polymer has been a subject of research which helped me in understanding the enhanced properties of this concrete.

The compressive strength and the workability of geo-polymer concrete are influenced by the proportions and properties of the constituent materials that make geo-polymer concrete. Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of geo-polymer concrete and will make good bonding between aggregate and paste of the concrete. Higher the ratio of sodium silicate solution-to-sodium hydroxide solution ratio by mass, higher is the compressive strength of geo-polymer concrete. The slump value of the fresh geo-polymer concrete increases when the water of the mixture increases (Rangan, 2003).

The curing temperature in the range of 60°C TO 90°C increases, the compressive strength of fly-ash based

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geo-polymer concrete also increases. Longer curing time, in the rage of 24 to 72 hours, produces higher compressive strength of fly-ash based geo-polymer concrete .The fresh fly-ash-based geo-polymer concrete increases with increase of extra water added to the mixture. The compressive strength of heat- cured fly-ash-based geo-polymer concrete does not depend on age. Geo-polymer concrete has excellent properties within both acid and salt environment. (Nguyen Van chanh 2008).

V. METHODOLOGY

A. Collection of materials

The raw materials for casting are cement, coarse aggregate, fine aggregate, manufactured sand, sodium silicate, sodium hydroxide, water, fly ash has been collected and the aggregate are cleaned and preserved.

B. Preliminary test

The preliminary test of materials are specific gravity of cement, fine aggregate, coarse aggregate, fly ash, and manufactured sand. Fineness of cement and sieve analysis for sand. All the preliminary tests have been conducted and results are tabulated in table 1

Table 1: Results of Preliminary test

S.No	Materials	Properties	Results
1	Cement	Specific gravity Fineness	3.15 98.03%
2	Fly ash	Specific gravity	2.45
3	Fine aggregate	Specific gravity Sieve analysis Fineness modulus	2.66 Zone II 2.708
4	Coarse aggregate	Specific gravity Fineness modulus	2.77 2.1
5	Manufactured sand	Specific gravity	2.07

C. Mix design

The mix design is in accordance with Indian mix design method. A sample of mix design was shown that the aggregates occupy the largest volume, (about 75-80% by mass) in GPCs. The silicon and the aluminum in the fly ash are activated by a combination of sodium hydroxide and sodium silicate

Unit weight of concrete = 2400kg/m^3

The total volume occupied by the aggregates is assumed to be 77%.

Mass of combined aggregate = 77%of total mass of concrete
= 1848 kg/m^3

The grading 70% (10mm) + 30% (fine) has been adopted in the mix design

Coarse aggregate = 70% of 1848 kg/m^3 = 1294kg/m3

Fine aggregate = 1848 – 1294 = 554 kg/m^3

The mass of low calcium fly-ash and alkaline liquid = 2400 - 1848 = 552 kg/m^3

Alkaline liquid / fly - ash ratio = 0.35 (assuming)

Mass of fly-ash = 552 / (1+0.35) = 408 kg/m^3

Mass of alkaline liquid = 552 – 408 = 144 kg/m^3

Let sodium silicate solution-to-sodium hydroxide solution to be 2.5 (assuming)

Sodium hydroxide solution = 144 / (1+2.5) = 41kg/m^3

Mass of sodium silicate solution = 144 – 41 = 103 kg/m^3

Super plasticizer 1.5 % of fly ash = 6.12 kg/m^3

Table 2: Mix Proportion Value

CONSTITUENTS	DENSITY (kg/mm^3)
Coarse aggregate	1294
Fine aggregate	554
Fly-ash	408
Sodium silicate	103
Sodium hydroxide	41
Super plasticizer	6.12

D. Casting of Geo-polymer concrete

The sodium hydroxide solution was prepared one day prior to allow the exothermically heated liquid to cool to room temperature. Dry mixing of aggregates and source materials by mixing all the materials manually in the laboratory at room temperature .The aggregates and source materials were first mixed homogeneously. Then NaOH solution and Na_2SiO_3 solutions were mixed with each other and stirred to obtain a homogeneous mixture of the solutions before adding them to the solids .The fresh concrete was used to caste cubes and cylinder to determine its compressive strength. Each specimen was casted in three layers by using table vibrator in the laboratory .The geo-polymer specimen were then placed in a steam curing at a temperature of 60° for 24hours .And then the specimens were taken out and cured under room temperature till the time of testing.

Table 3: Mix proportion of GPC with M-sand

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CONSTITUENTS	GPC1(kg/m^3)	GPC2(kg/m^3)	GPC3(kg/m^3)	GPC4(kg/m^3)	GPC4(kg/m^3)	GPC5(kg/m^3)
FLY ASH	408	408	408	408	408	408
COARSE AGGREGATE	1294	1294	1294	1294	1294	1294
FINE AGGREGATE	554	443.2	332.4	221.6	110.8	-
MANUFACTURED SAND	-	110.8	221.6	332.4	554	-
SODIUM SILICATE	103	103	103	103	103	103

GPC- Geo-polymer Concrete

E. Testing of specimen:

The specimens were tested in the laboratory using universal testing machine and strength was calculated for 7 and 28 days and results were tabulated.

VI. RESULTS AND DISCUSSIONS

In this paper, strength properties of geo-polymer concrete were studied, 6 different mixes were prepared by replacing river sand by manufactured sand in varying proportion as shown in table 4

A. Compressive strength

150mm X 150mm cubes were casted and oven dried for 24hours at 60°c and compressive strength for 7 and 28 days were tested. The manufactured sand is varied in20%, 40%, 60%, 80%, 100%.for river sand. Results are tabulated below in table 4

Table 4: Compressive strength of geo-polymer concrete with manufactured sand

MIX	CUBE STRENGTH (N/mm^2)	
	7days	28days
GPC1	24.44	34.22
GPC2	24.66	34.60
GPC3	25.11	35.11
GPC4	25.77	36
GPC5	26.44	36.66
GPC6	27	37.33

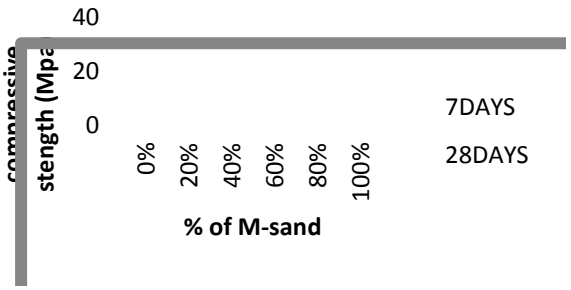

Figure 1: Compressive strength of geo-polymer concrete with manufactured sand

From the test results obtained from above for compressive strength, shows that there is 9% increase in strength when manufactured sand is fully replaced by river sand.

B. Tensile strength

150mm X 300mm cylinders were casted and oven dried for 24hours at 60°c and compressive strength for 7 and 28 days were tested. Manufactured sand is varied in 20%, 40%,60%,80%,100% for river sand.

Table 5: tensile strength of geo-polymer concrete with manufactured sand

MIX	TENSILE STRENGTH (N/mm^2)	
	7days	28days
GPC1	1.43	2.47
GPC2	1.46	2.53
GPC3	1.5	2.59
GPC4	1.53	2.65
GPC5	1.56	2.7
GPC6	1.59	2.75

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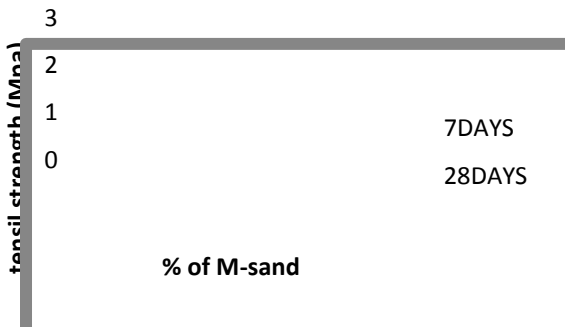

Figure 2: tensile strength of geo-polymer concrete with manufactured sand

C. Flexural strength

Concrete specimen for flexural strength has cross sectional area of 100mm width with 100mm depth and length of 500mm concrete beam was casted and oven dried for 24hours at 60°c and compressive strength for 7 and 28 days were tested. The manufactured sand is varied in20%,40%, 60%, 80%, 100%.for river sand. Results are tabulated below in table 6

Table 6: flexural strength of geo-polymer concrete with manufactured sand

MIX	FLEXTURAL STRENGTH (N/mm^2)	
	7days	28days
GPC1	2.06	5.9
GPC2	2.1	6
GPC3	2.16	6.18
GPC4	2.2	6.3
GPC5	2.24	6.36
GPC6	2.28	6.48

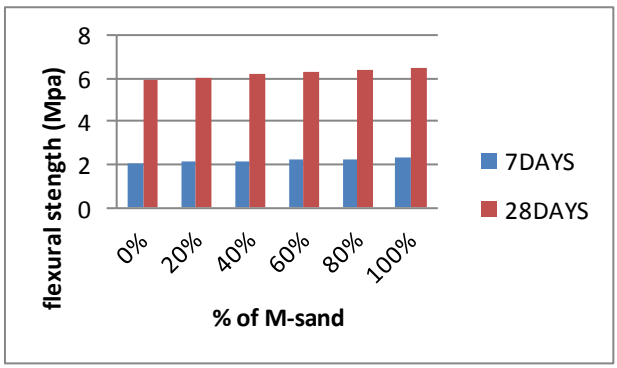

Figure 3: flexural strength of geo-polymer concrete with manufactured sand

From the test results obtained from above for flexural strength, shows that there is 10% increase in strength when manufactured sand is fully replaced by river sand.

VII. CONCLUSION

Based on the experimental investigation the following conclusions are listed below:

- The test results of compressive strength shows that there is 9% increase in strength when manufactured sand is fully replaced by river sand.
- The test results of tensile strength shows that there is 12% increase in strength when manufactured sand is fully replaced by river sand.
- The test results of flexural strength shows that there is 10% increase in strength when manufactured sand is fully replaced by river sand.

From the results obtained it proves that Geo-polymer concrete using manufactured sand can be an alternative to ordinary Portland cement concrete. Since no cement is used in Geo-polymer concrete; lot of energy can be saved which intern reduces the production of ordinary Portland cement. The use of waste material like fly ash helps in reducing the pollution of atmosphere which adds to pollution free environment.

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