Strength and Durability Characteristic of Geopolymer Concrete with Micro Silica Nano Silica and m-sand

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Abstract- The main aim of the project is utilization of waste material as well as produces an alternative material for cement concrete. In this study, the performance of Fly Ash-Based Geopolymer Concrete was investigated. The binding material of required quantity of fly ash collected from mettur Power station. River sand and silica fumes were collected as fine aggregate and 12mm size coarse aggregates were used. In order to study the performance of the geopolymer concrete the various mix ratio's were designed. And the binding material of fly ash was collected. Initial tests on fine aggregate and course aggregate such as specific gravity,. From that the optimum ratio of geopolymer concrete was found. It was 85 % of fly ash,14% of silica fume and 1% of nano silica (10MF85S14N1m100)..

Keywords – Geopolymer concrete,strength,durability

I. INTRODUCTION

Concrete is the most widely used construction material in the world. An important ingredient in the conventional concrete is the Portland cement. The production of one ton of cement emits approximately liberates one ton of carbon dioxide to the atmosphere. On the other hand, already huge volumes of fly ash are generated around the world; most of the fly ash is not effectively used, and a large part of it is disposed in landfills. As the need for power increases, the volume of fly ash would also increases.

The main aim of the project is utilization of waste material as well as produces an alternative material for cement concrete. In this study, the performance of Fly Ash-Based Geopolymer Concrete was investigated. The binding material of required quantity of fly ash collected from mettur Power station. River sand and silica fumes were collected as fine aggregate and 12mm size coarse aggregates were used. In order to study the performance of the geopolymer concrete the various mix ratio's were designed. And the binding material of fly ash was collected. Initial tests on fine aggregate and course aggregate such as specific gravity, water absorption, and finesse modulus has been carried. The different Proportion of fly ash (80%,82.5%,85%,87.5%),Msand(100%),coarseaggregate(100%)macrosilica(18%,16%,14%,12%), nanosilica(2%,1.5%,1%,0.5%) and molarity (8,10) were used. From that the optimum ratio of geopolymer concrete was found.

Fly Ash

It was 85 % of fly ash,14% of silica fume and 1% of nano silica (10MF85S14N1m100). The cube, cylinder and beam samples were casted with that optimum mix proportion. Then the required characteristics studies were carried out. From this, it is concluded that Geopolymer concrete has better strength compared to conventional concrete and also economical.

II. MATERIAL

A. Materials –

Fly ash is removed from the combustion gases by the dust collection system, either mechanically or by using electrostatic precipitators, before they are discharged to the atmosphere. Fly ash particles are typically spherical, finer than Portland cement and lime, ranging in diameter from less than 1 μm to no more than 150 μm. The binding material of required quantity of fly ash collected from mettur Power station.

Fine aggregate and coarse aggregate

The aggregates are the main components of the concrete which greatly varies the strength, density and other properties of the concrete. The fine aggregate used in this project was conformed to grading zone II as per IS: 383:1970. It was sieved through 4.75 mm sieve to remove any particles greater than 4.75 mm and the required quantity of coarse aggregate having the maximum size of (12mm) were collected from hilly valley construction, Coimbatore.

Admixtures

According to ACI 116 R, silica fume is a very fine amorphous (non crystalline) silica produced in electric arc furnaces as a byproduct of the production of elemental silicon or alloys containing silicon; also known as condensed silica fume or macrosilica To reduce the cement content in concrete mixes is the use of silica fines. One of the silica fines with high potential as cement replacement and as concrete additive is nano-silica (NS). NS addition increases density, reduces porosity, and improves the bond between cement matrix and aggregates. The effective admixture of silica fume was collected from civil doctor, Coimbatore and nano silica is ordered in AvantikaEnterprise, Chennai.

chemicals

In these project chemicals are the very important constituents. Sodium Silicate and Sodium Hydroxide liquid are obtained commercially from local suppliers in Singanallur.

Mix design

Following parameters of geopolymer concrete were fixed on the basis of various trial mix tests conducted.

Fixed Parameters

Percentage replacement of cement by fly ash: 100%

Sodium silicate-to-sodium hydroxide ratio: 2.0

Solution-to-fly ash ratio: 0.45

Concentration of Na_2SiO_3 in sodium silicate solution 124.68 liter

Concentration of sodium hydroxide solution: 8 M & 10 M.

Type of curing: Steam Curing

Fineness of fly ash: 500 m^2/kg

Water to Geopolymer binder ratio: 0.30

Variable Parameters

- Temperature: 120°C
- Duration of Curing: 24 hours.

Design stipulations

Assume density of aggregate as unit weight of concrete

$$= 2400 kg/m^3 .(M20 \text{ concrete})$$

Mass of Combined aggregate = 75-80 % (consider 0.75%)

$$= 2400 \times 0.75\% = 1800 \text{ kg/m}^3$$

Now, mass of combined aggregate = 1800 kg/m^3

Mass of Fly ash and alkaline Liquid = 2400-1800 = 600 kg/m^3

Let us take alkaline liquid to fly ash ratio as 0.45.

Now the mass of fly ash = (600) / (1+0.45) = 413 kg/m^3

Mass of alkaline liquid = 600-413 = 187 kg/m^3

Let us consider the ratio of NaOH to $Na2SiO_3$ as 2.

Now mass of NaoH solution = (187)/ (1+2) = 62.34 kg/m^3

Mass of Na_2sio_3 solution = 187- 62.34 = 124.66 kg/m^3

Sodium Hydroxide solution (NaOH):

The following calculations are carried out for calculating the total amount of mass of water and mass of solids in the sodium hydroxide and sodium silicate.

Considering 8M concentration, where in the solution

Mass of solids = (0.32/1) × (62.34) =19.94Kg

Mass of water = 62.34 – 19.94 =42.40 Kg

Sodium Silicate Solution (Na2SiO3)

The water content in the silicate solution in observed as 63.5%.

So, the Mass of solids = (63.5/100) × (124.68) =79.18 Kg

Mass of Water = 124.68 – 79.18 = 63.50 Kg

Total mass of solids:

Mass of solids in NaoH solution + mass of solids in Na_2SiO_3

Solution + mass of Fly ash = 19.94 + 79.18+ 413 =512.12Kg.

Ratio of water to Geopolymer Solids: Ratio = (105.90) / (512.12) = 0.20

Table No 1 Alkaline Value of 8 M And 10M

Parameters	**8M**	**10M**
NaOH	8*40=320 gm = 19.94	10*40=400 gm =24.936
Na_2SiO_3	124.68liter	124.68 liter

Table No.2 Quantity Of Material For 1m^3

S.No	Material	Quantity (Kg/1m^3)
1.	Fly ash	307
2.	Micro Silica	86
3.	Nano silica	23
4.	NaOH	62.34
5.	Na_2SiO_3	124.68
6.	M – Sand	720
7.	River Sand	720
8.	Coarse Aggregate	1080

III. TRIAL MIX

The different Proportion of fly ash (80%,82.5%,85%,87.5%),M-sand(100%), coarse aggregate(100%) macro silica (18%,16%,14%,12%), nano silica (2%,1.5%,1%,0.5%) and molarity (8,10) were used.

Table No.3 Trail mix value

Mix identification	Fly ash %	Micro silica %	Nano silica %	Compressive strength @28 days N/mm^2
8MF80S18N2m100	80	18	2.0	18.5
8MF82.5S16N1.5m100	82.5	16	1.5	18.5
8MF85S14N1m100	85	14	1.0	20
8MF87.5S12N0.5m100	87.5	12	0.5	20.5
10MF80S18N2m100	80	18	2.0	20.5
10MF82.5S16N1.5m100	82.5	16	1.5	22
10MF85S14N1m100	85	14	1.0	24.8
10MF87.5S12N0.5m100	87.5	12	0.5	24.5

IV. STRENGTH PROPERTY

Compressive strength

For test specimens cube size are 10cm X 10 cm x 10 cm depending upon the size of aggregate are used. Here 12mm size of aggregate is used.

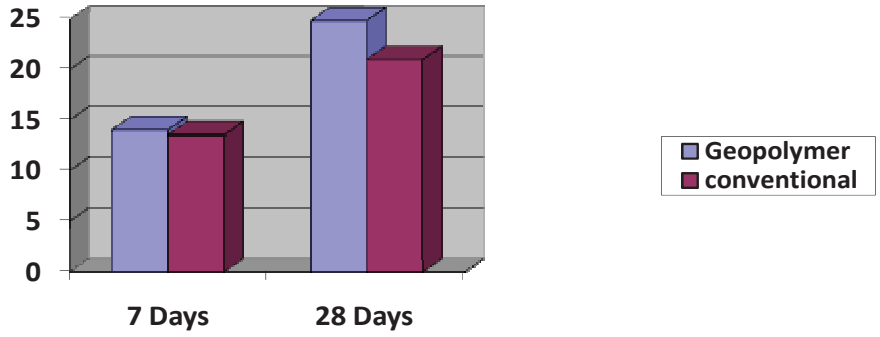


Table No.4 Compressive strength in Gpc Vs Opc

S.No	Type of concrete	Days	Compressive strength
1	Geopolymer concrete	7	14
2	Geopolymer concrete	28	24.8
3	Conventional concrete	7	13.5
4	Conventional concrete	28	21

RESULT

Geopolymer concrete

i) Compressive strength of the concrete cube = 14 N/ mm^2 (at 7 days)

ii) Compressive strength of the concrete cube =24.8 N/mm^2 (at 28 days)

Conventional concrete

i) Compressive strength of the concrete cube = 13.5 N/ mm^2 (at 7 days)

ii) Compressive strength of the concrete cube =21 N/mm^2 (at 28 days)

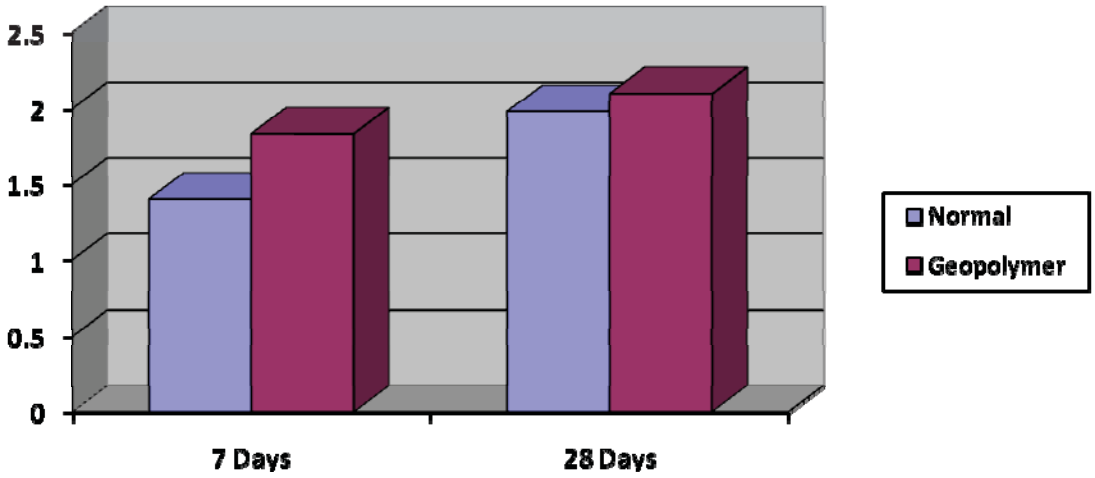
SPLIT TENSILE STRENGTH

Split tensile strength is used in the design of structural lightweight concrete members to evaluate the shear resistance provided by concrete and to determine the development length of reinforcement. The cylinder size is 150 mm ×300 mm are used.

Table No.5 Split tensile value

S.No	Type of concrete	Days	Split tensile strength
1	Geopolymer concrete	7	1.83
2	Geopolymer concrete	28	2.1

3	Conventional concrete	7	1.4
4	Conventional concrete	28	1.98

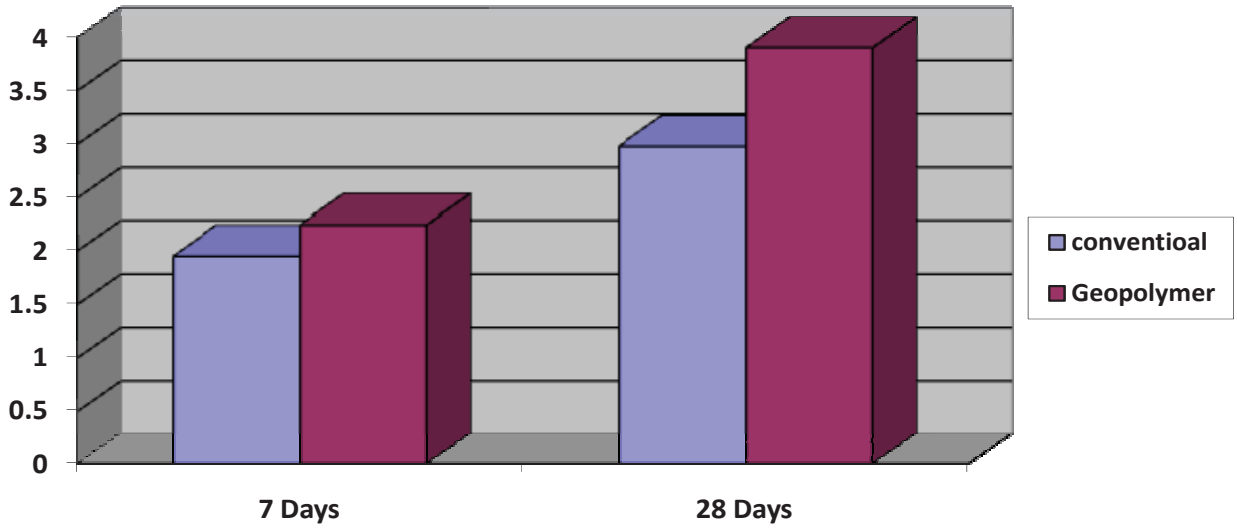


FLEXURAL STRENGTH

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. It is measured by loading 6 x 6 inch (150 x 150-mm) concrete beams with a span length at least three times the depth.

Table No.6 Flexural strength value

S.No	**Type of concrete**	**Days**	**Flexural strength N/mm^2**
1	Geopolymer concrete	7	2.25
2	Geopolymer concrete	28	3.9
3	Normal concrete	7	1.95
4	Normal concrete	28	2.98



V. DURABILITY

Durability of concrete may be defined as the ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties.

Resistance against Acid Attack

Table No 7 Sulphuric acid test value

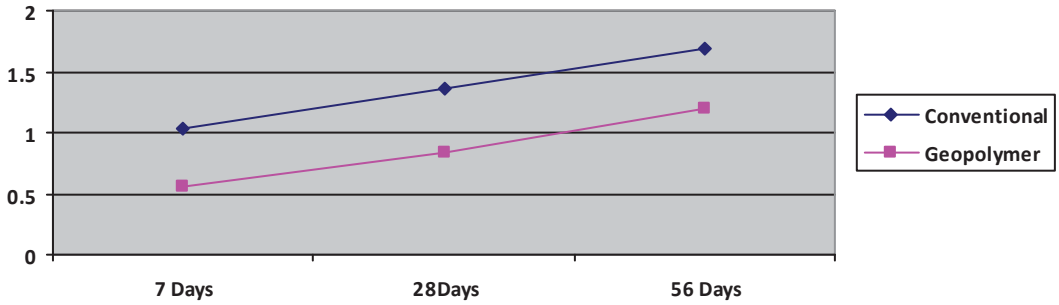
S.No	No. of days	Gpc		conventional		Reduction in weight (grams)		% Reduction in weight	
		Initial	Final	Initial	Final	Gpc	Opc	Gpc	Opc
1	7	2496	2482	2485	2459	14	26	0.56	1.04
2	28	2496	2475	2485	2451	21	34	0.84	1.36
3	56	2496	2466	2485	2443	30	42	1.20	1.69

Geopolymer concrete and conventional concrete cube are casted. The cubes are weighted and immersed in 5 % of sulphuric acid (H2SO4) solution for 56 days. During that 7, 28, 56 days cubes taken out and weighted. The result on sulphuric acid test corrosion resistance has 1.40 % geopolymer concrete less than conventional concrete.

Table No 8 Hydrochloric acid test value

S.No	No. of days	Gpc		conventional		Reduction in weight (grams)		% Reduction in weight	
		Initial	Final	Initial	Final	Gpc	Opc	Gpc	Opc
1	7	2450	2439	2496	2464	11	21	0.44	0.84

2	28	2450	2430	2496	2459	20	26	0.81	1.04
3	56	2450	2418	2496	2443	32	42	1.30	1.69

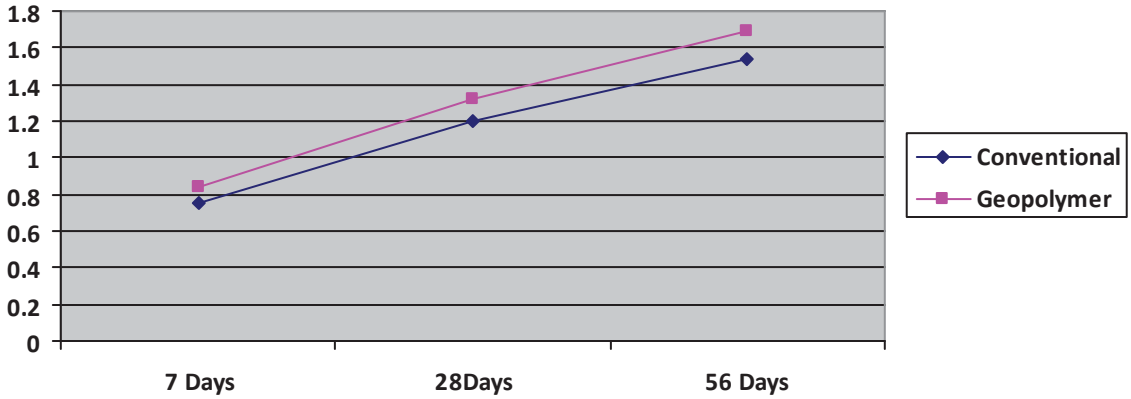


Geopolymer concrete and conventional concrete cube are casted. The cubes are weighted and immersed in 5 % of Hydrochloric acid (HCL) solution for 56 days. During that 7, 28, 56 days cubes taken out and weighted. The result on hydrochloric acid test corrosion resistance has 1.3 % geopolymer concrete less than conventional concrete.

Resistance against Alkaline Attack

Table No 9 Alkaline test value

S.No	No. of days	Gpc		conventional		Reduction in weight (grams)		% Reduction in weight	
		Initial	Final	Initial	Final	Gpc	Opc	Gpc	Opc
1	7	2398	2380	2485	2464	18	21	0.75	0.84
2	28	2398	2369	2485	2459	29	33	1.20	1.32
3	56	2398	2361	2485	2443	37	42	1.54	1.69

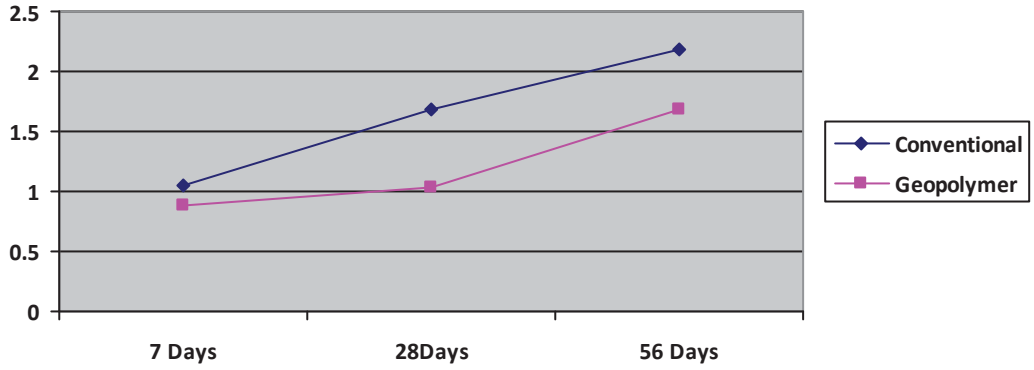


Geopolymer concrete and conventional concrete cube are casted. The cubes are weighted and immersed in 5 % of sodium sulphate (Na2SO4) solution for 56 days. During that 7, 28, 56 days cubes taken out and weighted. The result on alkaline test corrosion resistance has 1.10 % geopolymer concrete less than conventional concrete.

Resistance Against Sulphate Attack

Table No 10 Sulphate test value

S.No No. of days		Gpc		conventional		Reduction in weight (grams)		% Reduction in weight	
		Initial	Final	Initial	Final	Gpc	Opc	Gpc	Opc
1	7	2472	2446	2435	2408	26	32	1.31	1.05
2	28	2472	2430	2435	2386	42	49	1.04	1.69
3	56	2472	2418	2435	2374	54	61	1.69	2.18



Geopolymer concrete and conventional concrete cube are casted. The cubes are weighted and immersed in 5% sodium sulphate (Na2SO4) and 15% magnesium sulphate solution for 56 days. During that 7, 28, 56 days cubes taken out and weighted. The result on sulphate test corrosion resistance has 1.30 % geopolymer concrete less than conventional concrete.

VI. CONCLUSION

Initially casting of trail mix that mix duration strength test from 7 & 28 days. Here after finally finding optimum ratio samples. In the ratio of geopolymer concrete cube, cylinder, beam are casted. They test results of samples in 7 & 28 days are compared with normal concrete.

In geopolymer concrete M-sand is used as fine aggregate. In that conventional concrete, river sand is used for the same. And also from that characteristics studies, it is concluded that 1.18 % more compressive strength on geopolymer concrete, 1.3 % more tensile strength on geopolymer concrete and 1.15 % more flexural strength compare with conventional concrete .Durability test result conclude that corrosion resistance has geopolymer concrete less than conventional concrete

The following conclusions were drawn based on the above studies

- River sand can be replaced with M-Sand as geopolymer concrete

- Using geopolymer concrete can reduce the demand of river sand
- Waste utilisation was achieved by geopolymer concrete

So if demanding of river sand in now a day so i recommend to use in M-sand in geopolymer concrete. thats time some pollution are controlled.

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