Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406
International Journal of Advance Engineering and Research Development
Volume 4, Issue 3, March -2017

GEO POLYMER CONCRETE WITH BASE MATERIAL AS A FLY ASH BASE MATERIAL

Milan manek[1], Kinjal Rank[2], jaydeep bhanderi[3]

[1]*Civil Engineering department, VVP Engg. College,*
[2]*Civil Engineering Department, VVP Engg. College,*
[3]*Civil Engineering Department, VVP Engg.Colleg.*

Abstract —*Concrete is one of the most widely used construction material. It is usually associated with Portland cement as the main component for making concrete. The demand for concrete as a construction material is on the increase. It is estimated that the production of cement will increase from 1.5 billion tons in 1985 to 2.2. Billion tons in 2010(Malhotra, 1999). On the other hand, the climate change due to global warming, one of the greatest environmental issues has become a major concern during the last decade. The global warming is caused by the emission of greenhouse gases such as CO2, to the atmosphere by human activities. Among the greenhouse gases CO2 contributes about 65% of global warming. The cement industries are responsible for above 6% of all CO2 emissions, because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere. To solve the problem of emission of co2 we can use geo polymer as a binding agent in concrete.in geo polymer we are using two chemicals sodium silicate and sodium hydroxide, and base material as a fly ash. In geo polymer concrete cement is not playing any role so geo polymer concrete dose not emits any kind of green gases. The strength and costing of geo polymer is same as the normal concrete.*
Keywords-About four key words or phrasesecofriendly concrete,geo-polymer concrete, fly ash,acid resistance.

I. INTRODUCTION

Concrete is one of the most widely used construction material'.It is usually associated with Portland cement as the main component for making concrete.The demand for concrete as a construction materal is on the increase.It is estimated that the production of cement will increase from 1.5 billion tons in 1985 to 2.2. billion tons in 2010(Malhotra,1999).On the other hand ,the climate change due to global waming,one of the greatest environmental issues has become a major concern during the last decade.The global warming is caused by the emission of greenhouse gases such as CO2,to the atmosphere by human activities.Among the greenhouse gases CO2 contributes about 65% of global warming (McCaffrey,2002).The cement industries is responsible for above 6% of all CO2 emmisions,because the production of one ton of Portland cement emits approximately one ton of CO2 into the atmosphere(Davidovits,1994'McCaffrey,2002).

Although, the use of Portland cement is still unavoidable until the foreseeable future,many efforts have been made in order to reduce the use of Portland cement in concrete.This efforts include the utilization of supplementary cementing material such as fly ash,silicafume,granulated blast furnace slag,rice husk ash,andmetakaoline,and finding alternative binders to Portland cement.In this respect the geopolymer technology proposed by Davidovits(1998a'1998b) shows considerable promise for application in concrete industries as an alternative binder to Portland cement.Inteerms of reducing the global warming,thegeopolymer technology can reduce the CO2 emmision to the atmosphere caused by cement and aggregates industries by about 80%(Davidovits,1994c).

II. FLY ASH BASED GEOPOLYMER CONCRETE

In Geopolymer concrete is manufactured using source materials that are rich in silica and alumina.While the cement based concrete utilizes the formation of calcium silica hydrates(CSHs) for the matrix formation and strength,geopolymers involve the chemical reaction of alumino silicates oxides with alkali sillicates yielding polymeric Si-O-Al bonds. In this experimental work fly ash is used as the source concrete.The manufacture of geopolymer concrete is carried out using the usual concrete technology methods.As in the Portland cement concrete,in fly ash based geopolymerconcrete,the aggregates occupy the largest volume i.e. about 75-80% by mass.

Sodium based activators were chosen because they were cheaper than potassium based activators. The Sodium Hydoxide was used in flake or palleteform.It is recommended that the alkaline liquid is prepared by mixing both solution together atleast t24 hours prior to use.The mass of NaOH s olids in the solution varied depending on the concerntrationoof the solution expressed in terms of molarity M.Theconcerntration of sodium hydroxide solution can vary in range between 12M to 16M.The mass of water is major component in both the alkaline solution.In order to improve the workability,a melamine based superplastticiser has been added to the mixture.

III. RESEARCH IMPORTANCE

The linear technique upgrading of new technology has been goes on in Portland cement concrete industries.The ordinary cement production is more energy intensive and consume significant amount of non renewable natural

@IJAERD-2017, All rights Reserved

resources such as calcium stone deposits,stoneetc.Therefore,the ordinary Portland cement industries does not quite fit the contemporary desirable image of a sustainable ecofriendly industries.

This are a need to find out an alternative binder material which could be similar or superior to that of Portland cement for use in concrete in respect of parameters such as processing condition for production of concrete mixes,mechanical and durability properties,long term chemical stable for the binding system with common filler aggregates system such as sand,crushed natural stone etc. because low internal energy and low CO2 contents of ingredients of geopolymer based composites compare to those conventional ordinary Portland cement concretes,the new composites can be considered to be more ecofriendly environmental and their utility in practical application need to be developed.

IV OBJECTIVES & SCOPE OF WORK

4.1Objectives

To study various parameters,following objectives are decided for the major project.

- To study salient parameters that affect the properties into fly ash based geopolymer concrete.
- To devlop the mix design process for fly ash based geopolymer concrete.
- To study the change in compressive strength of geopolymer concrete with change in Fly ash and chemical contents.
- To compare a results on oven and sunlight cure specimen.
- To study the change in mechanical properties i.e. split tensile strength and flexural strength,compressive split tensile strength and flexural strength of computed mix at different ages.
- To study the durability properties i.e. acid resistance of mixes after various days of exposure.

4.2 Scope of work

- The normal information about constituents required to produce geopolymer concrete such as fly ash coarse aggregate,alkalineliquid,fine aggregates and superplasticizer are to be studied.
- For the primary studies,the effect of eleven parameters i.e composition of alkaline liquid ,ratio of alkaline liquid to fly ash replacements,concerntration of NaOHsolution,ratio of Na2SiO3 solutionto NaOHsolution,addition of superplasticizer,curedtime,curedtemperature,restingperiod,water content of mix are investigated.
- Nine mix concrete mixes are produced for studying the salient parameters of geopolymer concrete as a part of prelim investigation.It is planned to cast 9 cubes of size 150mmx150mmx150mm for the study.
- Planning to cast toal of 9 cubes for geopolymer concrete for calculated mechanical properties at 3,7,and 28 days respectively.
- Cubes of 150mmx150mmx150mm for the compressive strength test is to be used as per IS provision

V.METHODOLOGY

5.1 Experimental Program

This chapter provide for the experimentalwork.This includes material,mix proportions,method of mixing ,compaction,curing specimen are used.Various parameters and test procedure would be described as under

5.2 Material

Materials use for this study are fly ash as the source material,aggregate,water alkaline liquids which consist of sodium hydroxide and sodium silicate and super plasticizer**.**

5.2.1 Fly Ash

Fly ash obtaining from ultratechcements(alccofine-1206) are presented in table 1

Table:1Properties of fly ash

Oxides	**Percentage**
SiO_2	**60.54**
Al_2O_3	**26.20**
Fe_2O_3	**5.87**
CaO	**1.91**
MgO	**0.38**
K_2O+Na_2O	**1.02**
SO_3	**0.23**
Loss on ignition	**2**

@IJAERD-2017, All rights Reserved

5.2.2 Aggregates

Locally available 10mm and 20mm crushed aggregates had been used as coarse aggregates.Locally river sand is used as fine aggregates in the mixes.Testing for fine and coarse aggregates were conducting as per IS:2386-1963[20] and IS:383-1970[21].The sieve analysis of the fine aggregates are shown in Table 3.2.The sieve analysis of the coarse aggregate are shown in Table 2 and Table 3.

Table:2 .Sieve analysis of fine aggregates

Sieve Size	**Retained on each sieve**		**Cumulative Retained%**	**Passing through**		**Remarks**
	Wt	%		wt	%	
40mm	0	0	0	1000	100	
20mm	0	0	0	1000	100	
16mm	0	0	0	1000	100	
12.5mm	0	0	0	1000	100	
10mm	0	0	0	1000	100	
6.3mm	0	0	0	1000	100	
4.75mm	136g	13.6	13.6	864	86.4	13.6 oversized
2.36mm	263g	26.3	39.9	601	60	
1.18mm	201g	20.1	60	400	40	
600 micron	273g	27.3	87.3	127	12.7	14.7(Zone-I)
300 micron	103g	10.3	97.6	24	2.4	
150 micron	20g	2	99.6	4	0.4	
Passing 150 mic	4g	0.4	100	0	0	
Total			398			

Fineness modulus = 398/100=3.98 and zone-I

Table:3Sieve analysis of 10mm aggregates

Sieve Size	**Retained on each sieve**		**Cumulative Retained%**	**Passing through**		**Remarks**
	Wt	%		wt	%	
40mm	0	0	0	0	0	
20mm	0	0	0	0	0	
16mm	0	0	0	0	0	
12.5mm	0	0	0	0	0	
10mm	151g	15.1	15.1	849	84.9	
6.3mm	769g	76.9	92	80	8	
4.75mm	80g	8	100	0	0	

Table:4Sieve analysis of coarse aggregate(20mm)

Sieve Size	**Retained on each sieve**		**Cumulative Retained**	**Passing through**		**Remarks**
	Wt	%		wt	%	
40mm	0	0	0	1000	100	
20mm	640g	64	64	360	36	
16mm	180g	18	82	180	18	
12.5mm	103g	10.3	92.3	77	7.7	
10mm	68g	6.8	99.1	9	0,9	
6.3mm	9g	0.9	100	0	0	

5.2.3 Alkaline liquid

The alkaline liquid were a combination of sodium hydroxide and sodium silicate solution.12M,14M,16M solution are used.Where M=Molarity.Sodium hydroxide is commonly available in Flakes form is shown in as shown in Fig.3.1.2.1. Sodium Hydroxide(NaOH) in flakes of 98% purity is purchased from local suppliers had been used.The sodium hydroxide(NaOH) solution is prepared by dissolving the flakes in water.The mass of NaOH solids in a

@IJAERD-2017, All rights Reserved

solution varies dependoing in the concerntration of the solution expressed in terms of molarity(M),Mass of NaOH solids are only a fraction of the mass of NaOH solution and water will be major component.Normal tap water is used to dissolve the NaOH pallets.

FIG:1NaOH pallets

Sodium silicate solution (Na_2SiO_3) are available in liquid form are used.FirstNaOH flakes were mixed with water than sodium silicate solution is added.The alkaline solution was prepare one day before the casting of the specimen or concrete cubes.

5.3 Geopolymer Concrete Mix Design

In a geopolymer concrete, the silicon and aluminium oxides in fly ash with alkaline liquid to form the geopolymer bond between the coarse aggregate and fine aggregate to together to form the geopolymerconcrete.The average density of fly ash based geopolymer concrete had been considered similar to that of OPC concrete of 2440 kg/m^3 based on literature.The ratio of alkaline liquid to fly ash takes as 0.4,mass of Fly ash and mass of alkaline liquid were found out.By taking the ratio of sodium silicate solution to sodium hydroxide solution were 2.5,We have find out the mass of sodium sillicte solution and sodium hydroxide solution.

Using the above procedure,the mix has been designed

Casting for M25 Mpa

Density: It has been observed that the density for the Fly ash based geopolymer concrete varies between 2370 to 2480 kg/m^3.

Aggregates:Mass of combined aggregates is selected as 75% of mass of concrete

Total aggregate=0.75X2400=1800 kg/m^3

Assume 35% of fine aggregate to the total mass of aggregate,

Fine aggregate=0.35X1800= 630 kg/m^3

Coarse aggregate=1800-630=1170 kg/m^3

Assume 60% of 20mm aggregate and 40% of 10mm aggregate to the total mass of coarse aggregate,

10mm aggregate=1170X0.4=468 kg/m^3

20mm aggregate=1170-468= 702 kg/m^3

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

Ratio of (Na_2SiO_3+NaOH)solution:fly ash is 0.4

Mass of Fly ash replacement =600/(1+0.4)=428.57 kg/m^3

Alkaline liquid:Mass of alkaline liquid=600-428.57=171.43 kg/m^3

Ratio of Na_2SiO_3solution to NaOH solution =2.5

Mass of sodium hydroxide solution = 171.43/(2.5+1)= 48.98 kg/m^3

Mass of sodium silicate solution = 171.43-48.98=122.45 kg/m^3

Extra water: It has been observed that 10% of extra water required for the workalbility of the geopolymer concrete

Extra water = 428.57X0.1= 42.86 kg/m^3

@IJAERD-2017, All rights Reserved

Table:5Geopolymer Concrete Mix design

Density of geopolymer Concrete	2400 kg/m^3
Coarse aggregate	1670 kg/m^3
Fine aggregate	630 kg/m^3
Total Aggregate	1800 kg/m^3
10 mm aggregate	600 kg/m^3
20 mm aggregate	702 kg/m^3
Mass of fly ash:alkaline liquid	0.4
Mass of fly ash	428.57 kg/m^3
Mass of (Na_2SiO_3+NaOH)solution	171.43 kg/m^3
Ratio of (Na_2SiO_3+NaOH)solution:fly ash is 0.4	2.5
Mass of sodium hydroxide solution	48.98 kg/m^3
Mass of sodium silicate solution	122.45 kg/m^3
Extra water	42.86 kg/m^3

Based on above mix design and proportion, we have decided the total masses of all the constituents of geopolymer concrete and prepare a table 3.2.2 for various concerntration of sodium hydroxide solution i.e. 12M,14M,16M. Following calculation are the total mass of sodium hydroxide solution and sodium silicate solution for 3 cubes each consisting of 12,14 and 16M concerntration of sodium hydroxide solution

Table:6Masses of solids of NaOH and Proportions for alkaline liquid

Molarity(NaOH) solution	Mass of Na_2SiO_3solution	Mass of NaOH solution	Mass of solids in NaOH solution	Mass of water in NaOH solution
12M	1.25 kg	495.92g	238.2g	257.5g
14M	1,25kg	495.92g	277.9g	218.3g
16M	1.25kg	495.92g	318g	179g

5.4 Conventional Concrete Mix Design

Conventional concrete mix design for M25 grade is done as per IS:10262-2009[23].Test data for materials
Specific gravity of cement= 2.5
Specific Gravity for coarse aggregate =2.78
Specific Gravity of fine aggregate =2.55
Fine aggregate Zone = I
Maxiumum water cement ratio =0.45
Water Content for 75 mm slump=191.58 litre
Cement=375 kg/m^3
Cement =OPC 53 Grade

Table:7Mix design for M25 grade of conventional concrete

Constituent	Quantity(kg/m^3)
Water	192.45
Cement	358
Fine aggregate	711.44
Coarse aggregate	1111.54

5.5 Casting method for geopolymer.

The mixing procedure was very important for getting consistency in production of geopolymerconcrete.If mixing procedures was not followed in the proper order,it is possible that the concrete may set in the mixer machine or inappropriate result from that fix is obtained .Specimen moulds are made ready for pouring of concrete by coating with the appropriate lubricant.Cubes of size 150mmX150mmX150mm were used.The procedure for mixes are as follows. The sodium hydroxide flakes were dissolved in distilledwater to make a solution with a desired concentration at least one day prior to use.

The fly ash and the aggregates were first mixed together in a pan mixer for about three minutes.
The sodium hydroxide and the sodium silicate solutions were mixed together with superplasticizer then added to the dry materials and mixed for about four minutes.

The fresh concrete was cast into the molds immediately after mixing, in three layers and compacted with manual strokes and vibrating table.

@IJAERD-2017, All rights Reserved

After casting, the specimens were cured at 60°C for 24 hours. Two types of curing were applied, Heat curing and Ambient curing. For heat curing, the specimens were cured in an oven as shown in Fig and for Ambient curing the specimens were left to air for desires period.
The heat cured specimens were left to air-dry in the laboratory for the next six days until testing on the 7th day and 28th day.

For the designated grade of Geopolymer concrete mix about 7 mixture proportions were tested and optimized by taking the mix which is giving maximum compressive strength at 28 days under Heat curing (Oven curing) and Ambient cured conditions.

Based on earlier research conducted in Materials testing lab by the author, the following parameters were maintained constant throughout the Experimental work.

The parameters for curing are as follows

The ratio of sodium silicate to sodium hydroxide =2.5
The curing Temperature = 600C
The curing duration = 24Hrs
Ratio of Fine aggregate to total Aggregate = 0.35
The other parameters vary between different grades of concrete.

Figure:2Mixture used for casting of concrete

Figure:3Geopolymer Cubes after casting

Figure:3 Geopolymer Cubes after casting

Figure:5 Fresh geopolymer Concrete

@IJAERD-2017, All rights Reserved

5.6 Compressive strength

The compressive strength of concrete has been evaluated using 2000kN capacity hydraulic testing machine.There are two types of cube sizes are 150mmX150mmX150mm size of cubes used.For compressive strength test cube of size 150mmX150mmX150mm are tested in compression in accordance with test procedure given in IS:516-1959.Fig. shows the cube specimen which is being tested in compression testing machine.Finding out the compressive strength of cube specimen following equation is used

Compressive strength of concrete(N/mm^2) = P/A

Where,

P=failure of load of cube (KN)

A= area of concrete cube specimen in mm^2(150mmX150mm)

Figure 6.**Compression Testing Machine**

5.7 Results

In this chapter,results of preliminary analysis are presented in detail.Todevlop Fly ash based geopolymerconcrete,various mix proportion to compare with M25,the change in compressive strength of concrete with change in concerntration of sodium hydroxide solution i.e Molarity(M) was observed by keeping all other parameters like curing temperature,sodium silicate to sodium hydroxide solution ratioconstant,restingtime.There are two different curing are carried out i.e. oven curing and sunlight curing for all trial mixes.

Table:8Comparison of Compressive strength of different geopolymer mixes with conventional mix

Strength @ following days	**Conventional Concrete**	**Geopolymer Concrete(12M)**		**Geopolymer Concrete(14M)**		**Geopolymer Concrete(16M)**	
		O.C	S.C	O.C	S.C	O.C	S.C
3	16.05	19.85	14.81	22.37	19.85	29.6	5.45
7	21.77	23.11	19.7	34.07	22.96	30.93	14.74
28	33.62	26.67	21.63	36.3	27.7	34.25	32.25

@IJAERD-2017, All rights Reserved

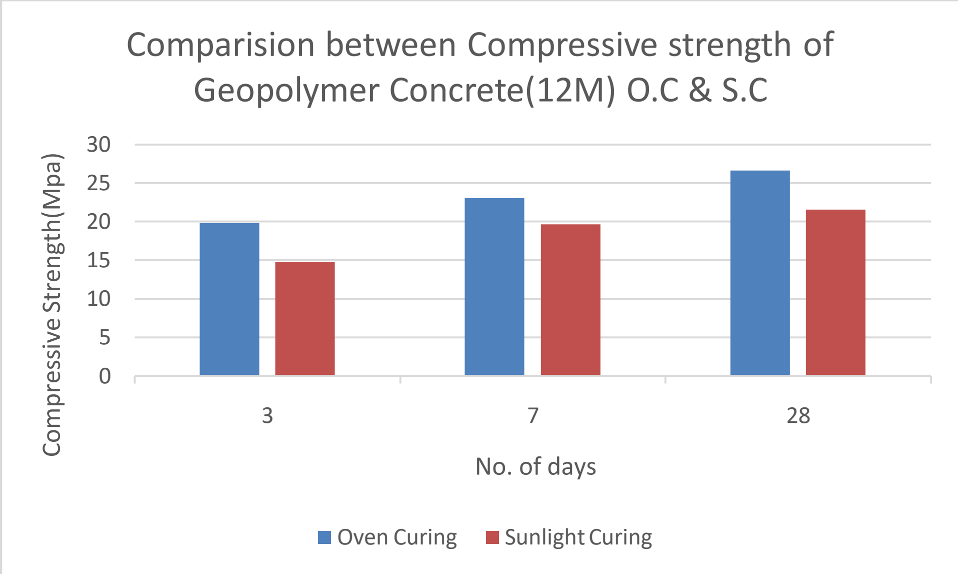

***Figure*7. Compressive strength of Geopolymer Concrete(12M)**

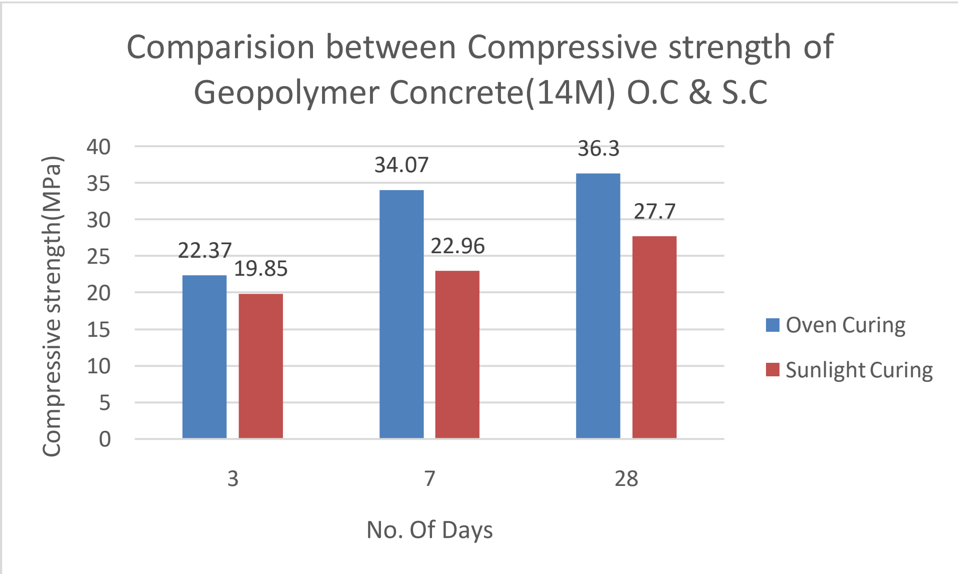

***Figure* 8. Compressive strength of Geopolymer Concrete(14M)**

@IJAERD-2017, All rights Reserved

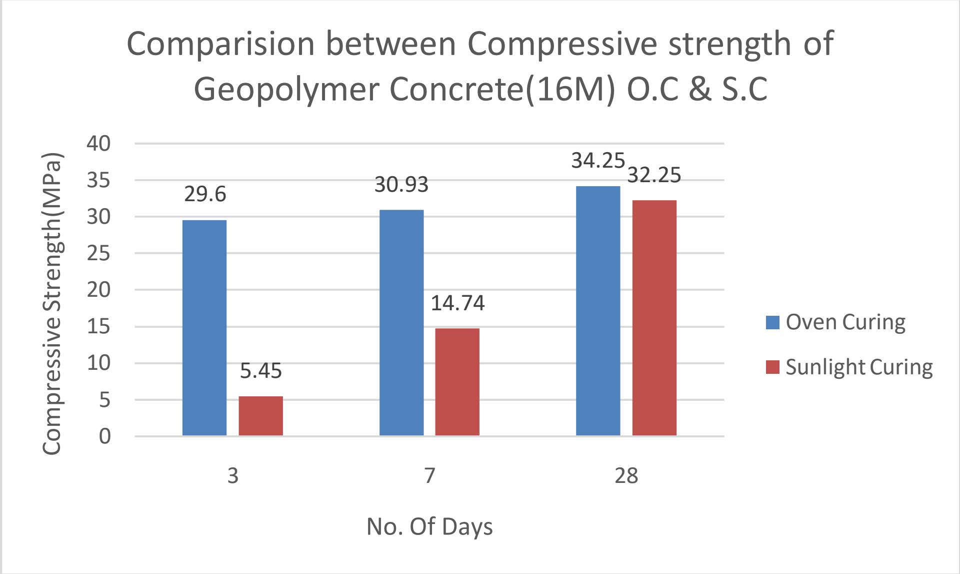

***Figure* 9. Compressive strength of Geopolymer Concrete(16M)**

From above result, it is found that geopolymer concrete gain more strength in oven curing than sunlight curing.So,the strength of oven curing is compared to the conventional concrete's compressive strength for 3,7,28 days respectively.

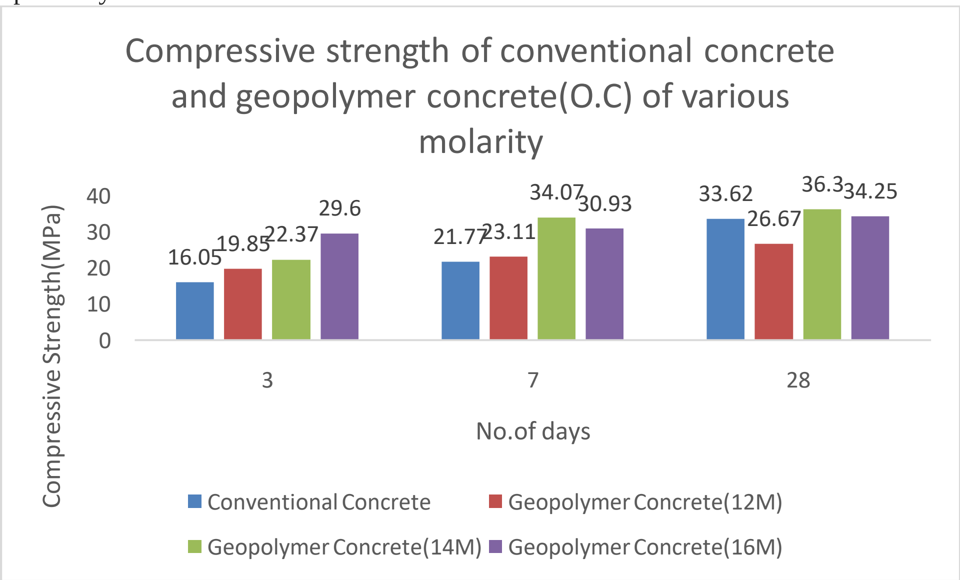

***Figure* 10. Comparisoncompressive strength of Geopolymer (12M),(14M),(16M)**

Comparision between Compressive Strength of conventional and Geopolymer Concrete of Various Mixes
From above data,it is found that keeping other parameters constant the strength of geopolymer concrete consisting of concerntration of 14M of sodium hydroxide solution which is cheaper as well as gave same properties like conventional concrete in terms of compressive strength.

VI. Conclusion

- ✓ From the investigation it is clear that for Water/binder ratio & alkaline liquid/Flyash ratio are the governing factors in designing the Geopolymer mix design for various grades.The Water/binder ratio 0.21 and Alkaline liquid to flyash ratio of 0.40 are suggested for G40 which indicates improvement in compressive strength of geopolymer concrete can be achieved by decreasing water binder ratio.
- ✓ The compressive strength attained at 28 days for Geopolymer concrete under ambient curing is almost equal to compressive strength achieved by Geopolymer concrete at 7
- ✓ days. Because of the slow reactivity of flyash at ambient temperature, considerable heat must be applied to increase the geopolymerization process.

@IJAERD-2017, All rights Reserved

- ✓ The decrease in water content favors the formation of geopolymerization process ,which demands for increase of concentration of Sodium hydroxide and sodium silicate silicates.Hence increase in concentration of NaOH results in increase of compressive strength .Hence it is recommended 14M concentrations for medium grade.
- ✓ It is recommended to add Superplasticizers for high strength Geopolymer concretes, which is analogous to Conventional concrete of higher grades to secure required workability.
- ✓ It also reported that unlike in the past literature, inclusion of high alkaline solution content to the mix need not increases the strength which can be seen from reported Geopolymer mixes in the present work.

VII. Future Work

In future work,after finding the suitable concerntration of sodium hydroxide solution we are looking ahead of other properties that is acid resistance tests and all other properties and we are finding the work wheathergeopolymer concrete supports reinforcement or not.So in future we are designing prestressedgeopolymer concrete which has ultimate strength after prestressing or post tensioning so we are looking ahead for designing the prestressedgeopolymer concrete beams and small structural members in future

REFERENCES

[1] Al-mhaidib, Abdullah I. "Swelling Behaviour of Expansive Shales from the Middle Region of Saudi Arabia", Geotechnical and Geological Engineering Vol.16, pp. 291-307, 1999.
[2] Basma, Adnan A."Prediction of Expansion Degree for Natural Compacted Clays", Geotechnical Testing Journal, Vol.16, No.4, pp. 542-549, December 1993.
[3] Bishop, A.W. and Wesley, L.D. "A Hydraulic Triaxial Apparatus for Controlled Stress Path Testing" Geotechnique Vol.25,No.4, pp. 657-670,1975.
[4] Brackley, I.J.A., "A Model of Unsaturated Clay Structure andits Application to Swell Behaviour", Proc. of 6th Regional Conf. ForAfrica on Soil Mech. And Found. Engrg. Durban, South Africa, pp.71-79.1975
[5] Brackley, I.J.A., "Swell Under Load",Proc. of 6th Regional Conf. For Africa on Soil Mech. And Found. Engrg. Durban, SouthAfrica, pp. 65-70,1975.
[6] Katti, R.K. "Search for Solutions to Problems in Black Cotton Soils". Indian Geotechnical Journal, LG.S. Vol. 9, No.1,1979
[7] Skempton, A.W., "The colloidal activityof clays", Proc. 3rd Int. Conf. on S.M. & F.E.,Zurich, Vol.1, pp 57-61, 1953.
[8] Rees, S.W. And Thomas, H.R.,"Simulating seasonal ground movement in unsaturated clay", Jrl. of Geotech. Engg., ASCE ,Vol.119, pp 1127-1143,1993.
[9] Jennings, Snethen, D.R., "Characterization of expansive soil using soil suction data", Proc. 4th Int. Conf. on Expansive Soils, Vol.1, pp 54-75,1980
[10] Mohan, D. And Goel , "Swelling pressures and volume expansions on Indian black cotton soils", Jrl. of the Inst. Of Engineers (India), Vol.XL, No.2, pt.1, pp 58-62,1959.
[11] Almeida N., Branco, F., Santos, J.R., "Recycling of Stone Slurry in Industrial Activitie" Application to Concrete Mixtures, Building and Environment, Vol. 42, pp. 810–819, 2007.