Experimental Investigation on Geo-Polymer Concrete Under Acidic Conditions.

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Abstract : In general the Geo-polymer concrete results obtained from the reaction of a source material i.e. high in silica, alumina and with alkaline liquid. The word geo-polymer was coined by Davidovit's. Geo-polymer substances lately described as being acid resistant. This present paper studies the experimental investigation data on the Behavior of fly-ash based geo-polymer concretes replaced in chemical solutions for up to four weeks. The fly-ash deployed geo-polymer concrete was at first restored (cured) for 24 hours at 60°C. And also the attained results are comparison with the conventional concretes replaced to 5% acid solutions for up to four weeks. Of The attained compressive strength of geo-polymer concretes and conventional concretes cubes of 150-mm @ an age of 4 weeks are 31.9MPa and 48.4MPa. At first concrete cubes were restored for a period of 4 weeks and after cubes were submerged in chemical solutions, After immersion in chemical solutions, samples were tested at an age of 1week, 2 weeks and 4 weeks. In this work compressive strength and the weight loss reduction were determined. In this experimental investigation three types of chemical solutions are utilized that are HCl, H2SO4 and MgSO4.
The test results shows that the Geo-polymer concrete is more resistant to acid and having low loss of weight and compressive strength when compared to conventional concrete

Index Terms **- Geo-polymer Concrete, Fly Ash, Compressive Strength, Acid Attack.**

I. INTRODUCTION

The Concrete usage around the world is second only after water. Ordinary Portland cement (OPC) is conventionally used as the primary binder to generate concrete material. The environmental issues regarding with the production of OPC are well known to all. The amount of the CO_2 released during the manufacture of Ordinary Portland cement due to the calcination of limestone and combustion of fossil fuel is in the order of one ton for every ton of OPC produced. In addition, the extent of energy required to produce OPC is only next to steel and aluminum.

Geo-polymer Concrete

The emission of CO_2 coupled with non-absorption of the same on account of deforestation etc has caused tremendous environmental pollution leading to global warming and other bad effects. It is estimated that about 7% of greenhouse gas is being emitted into the atmosphere annually on account of production of OPC alone.

Therefore, it is necessary to reduce the emission of CO_2 into atmosphere by reducing the cement production and consumption.

It is suggested that consumption of cement could be reduced by three ways.

- Through economical mix design.
- By replacing cement with fly ash by adopting high volume fly ash concrete (HVFC) or by using other supplementary cementations materials.
- By using alternate binding materials for concrete such as Bacterial concrete or Geo-polymer concrete.(no cement in concrete)

Objective

As noted earlier, many of the research published papers on geo-polymers studied the behavior of various pastes using different types of source materials. In acidic environment concrete the geo-polymer binders is to be a good alternative material. The Geo polymer cement having eminent properties with in both salt and acidic environment atmosphere. This present paper studies the experimental investigation data on the Behavior of fly-ash based geo-polymer concretes replaced in chemical solution.

II. Review of Literature

CONCRETE AND ENVIRONMENT

In 2002 Mehta in order to manufacture ecofriendly concrete proposed suggested the importance of fewer natural resources, low energy, and minimize the release of carbon dioxide.

In 2002 McCaffrey explained that the bulk amount of release of carbon dioxide from the manufacturing cement industries can be minimized by decreasing the quantity of calcined material in cement.

FLY ASH

Fly ash is finely divided residue resulting from the combustion of powdered coal and transported by the flue gases and collected by electrostatic precipitator. In U.K. it is referred as pulverized fuel ash (PFA). Fly ash is the most widely used pozzolanic material all over the world. One of the well-known engineers, E.A Abdun-Nur has said the following in 1984.

In 1994 Malhotra and ramezanianpour, showed the chemical combination of different fly ashes shows a wider range, suggesting that there is a huge variations in the usage of coal in power plants.

Again in 1994 and 2003 Malhotra and ramezanianpour, indicated that the nature of fly ash can be dark gray colour, consist of an alumina silicate glass and it should be less than 10% of CaO.

GEOPOLYMERS

Compared with ordinary Portland cement, newly developed inorganic binder geo-polymers possess the following characteristics.
Abundant raw material resources: Any pozzolanic compound or source of silicates or aluminosilcates that is readily dissolved in alkaline solution will suffice as a source for the production of a geopolymer.
In 1999-2002, Davidovits, Barbosa, Teixeira-Pinto, proposed a silicon and alumina is a possible source material to the production of geopolymer in 1992 – 2003 palomo, strydom, Xu and van deventer, Chang And Chiu, suggested combination of non-calicined, calicined mineral materials, metakalion and fly ash, granulated blast furnace slag have in studied as source material .

In 2003 Gourley studied and gave the clarity about low calcium fly-ash is better as a source material when compared with high calcium fly-ash.

In the year of 1999 to 2002, Davidovits, Palomo et al, Barbosa et al. ; Xu and van Deventer, Swanepoel and Strydom; Xu and van Deventer, are gave the many common alkaline liquid worn in geo-polymerisation is a composit of potassium silicate potassium hydroxide (KOH) and sodium hydroxide (NaOH).

In 1999 Palomo et al was established that the alkaline liquid plays a vital role in the polymerisation operation.

ACID ATTACK

Concrete is not fully resistant to acids. Most acid solutions will slowly or rapidly disintegrate Portland cement concrete depending upon the type and concentration of acid. Certain acids, such as oxalic acid and phosphoric acids are harmless. The most vulnerable part of the cement hydrate is $Ca(OH)_2$, C-S-H gel can also be attacked. Siliceous are more resistant than calcareous aggregates.

Concrete can be attacked by liquids, with p^H value less than 6.5. But the attack is sever only at a p^H value below 5.5. At a p^H value below 4.5 the attack is very sever. As the attack proceeds, all the cement compounds are eventually broken down and leached away.

If acids or salt solutions are able to reach the reinforcing steel through cracks or porosity of concrete, corrosion can occur which will cause cracking.

III. EXPERIMENTAL INVESTIGATION

Fly Ash

"In the real world of modern concrete fly ash is as essential an ingredient of the mixture as are Portland cement, aggregate, water and chemical admixtures. In most concretes, I use it in larger amounts (by volume) than Portland cement, and therefore it is not an admixture i.e.., an addition to the mixture. Concrete without fly ash and chemical admixture should only be found in museum showcases.

In the current laboratory work, low calcium, dry fly ash collected from the Thermal Power Plant, IBRAHIMPATNAM VIJAYAWADA, A.P,INDIA, was used as the base material.

Alkaline Liquid

A composition of sodium hydroxide and sodium silicate solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions.

The chemical composition of the sodium silicate solution was varied as fallows

Na2O=14.7%,

SiO2=29.4%,

water 55.9% by weight.

Physical properties of Cement:

The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the cement. The obtained results are listed as fallows.

1. Fineness of cement = 6.50
2. Specific gravity = 3.10
3. Normal Consistency = 29%
4. Normal Consistency = 50min
5. Final Setting Time = 320min

FINE AGGREGATE

Fine aggregates can be natural or manufactured. The grading must be uniform throughout the work. The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the fine aggregate. The obtained results are listed as fallows.

1. Specific gravity =2.61
2. Fineness modulus=2.70
3. Bulk Density

   Loose =16.20kN/m^3

   Compacted =17.20kN/m^3

4. Grading = Zone II

COARSE AGGREGATE

The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the course aggregate. The obtained results are listed as fallows.

1. Specific gravity = 2.77
2. Bulk density Loose = 14.90kN/m^3
   Compacted = 16.7kN/m^3
3. Water absorption = 0.5%
4. Fineness modulus = 7

WATER

The following tests as per IS: 4031-1988 is done to ascertain the physical properties of the water. The obtained results are listed as fallows.

1. pH = 7.10
2. Taste = Agreeable
3. Appearance= Clear
4. Turbidity = 1.75
5. Hardness = 250 mg/l

FLY ASH

Physical properties of Fly ash collected at Vijayawada Thermal Power Station are as fallows

1. Specific Gravity = 1.975
2. Fineness Modulus = 1.195

IV. RESULT AND DISCUSSIONS

RESULTS

In this Chapter, the laboratory results are executed and discussed. The details are as fallows in tables and figures.

Table: 1.1 Residual compressive strength on acid sunk.

S.NO	Concrete	Compressive strength 28days (Early acid immersion)	After 7 days Compressive strength (N/mm^2)			After14 days Compressive strength (N/mm^2)			After 28 days Compressive strength (N/mm^2)		
			Nature of curing: Acid immersion								
			Type of Acid			Type of Acid			Type of Acid		
			HCl	H2SO4	MgSO4	HCl	H2SO4	MgSO4	HCl	H2SO4	MgSO4
1	Conventional concrete (M35)	49.83	44.34	35	45	42.35	29	44	40.86	21	42

2	Geo-polymer concrete	32	29.44	27.36	28.8	28.8	25.69	27.52	27.5	23.2	26.4

Table: 1.2 The percentage of loss compressive strength on acid sunk.

S.No	Type of concrete	7 days % loss of Compressive strength (N/mm2)			14 days % loss of Compressive strength (N/mm2)			28 days % loss of Compressive strength (N/mm2)		
		Nature Of Curing – Acid immersion								
		Type of Acid			Type of Acid			Type of Acid		
		HCl	H_2SO_4	$MgSO_4$	HCl	H_2SO_4	$MgSO_4$	HCl	H_2SO_4	$MgSO_4$
1	Conventional concrete (M35)	11	29.76	9.61	15	41.8	11.69	18	57.85	15.65
2	Geo-polymer concrete	8	14.5	9	10	19.7	14	14.06	27.5	17.5

Table: 1.3 Conventional concrete

S.No	Acid Type	Weight (Kg) of concrete cubes before acid sunk			Weight (Kg) of concrete cubes after acid sunk		
		7 days	14 days	28 days	7 days	14 days	28 days
1	Hcl	8.781	8.802	8.762	8.581	8.532	8.431
2	H_2SO_4	8.79	8.78	8.7	8.30	8.20	8.0
3	$MgSO_4$	8.78	8.79	8.8	8.60	8.60	8.56

Table: 1.4 Geo-polymer concrete

S. No	Acid Type	Weight (Kg) of concrete cubes before acid sunk			Weight (Kg) of concrete cubes after acid sunk		
		7 days	14 days	28 days	7 days	14 days	28 days
1	Hcl	7.841	7.852	7.833	7.81	7.792	7.761

2	H_2SO_4	7.95	7.78	7.82	7.87	7.64	7.65
3	$MgSO_4$	7.88	7.9	7.8	7.85	7.86	7.74

Percentage weight loss on acid sunk.

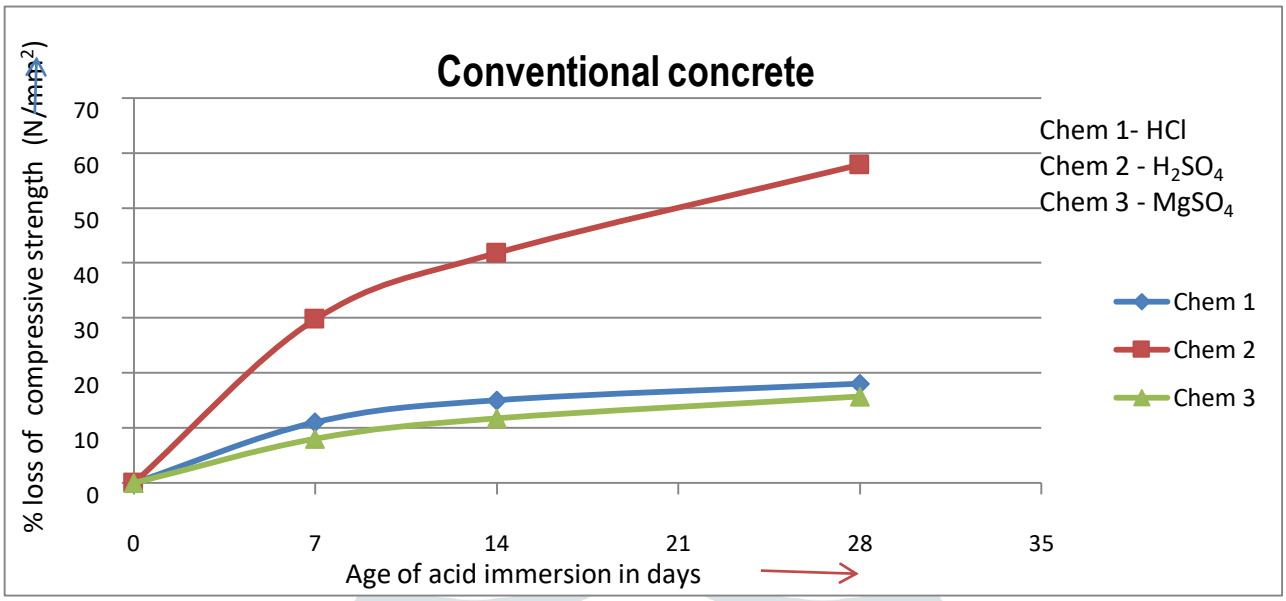
Table: 1.5 Conventional concrete

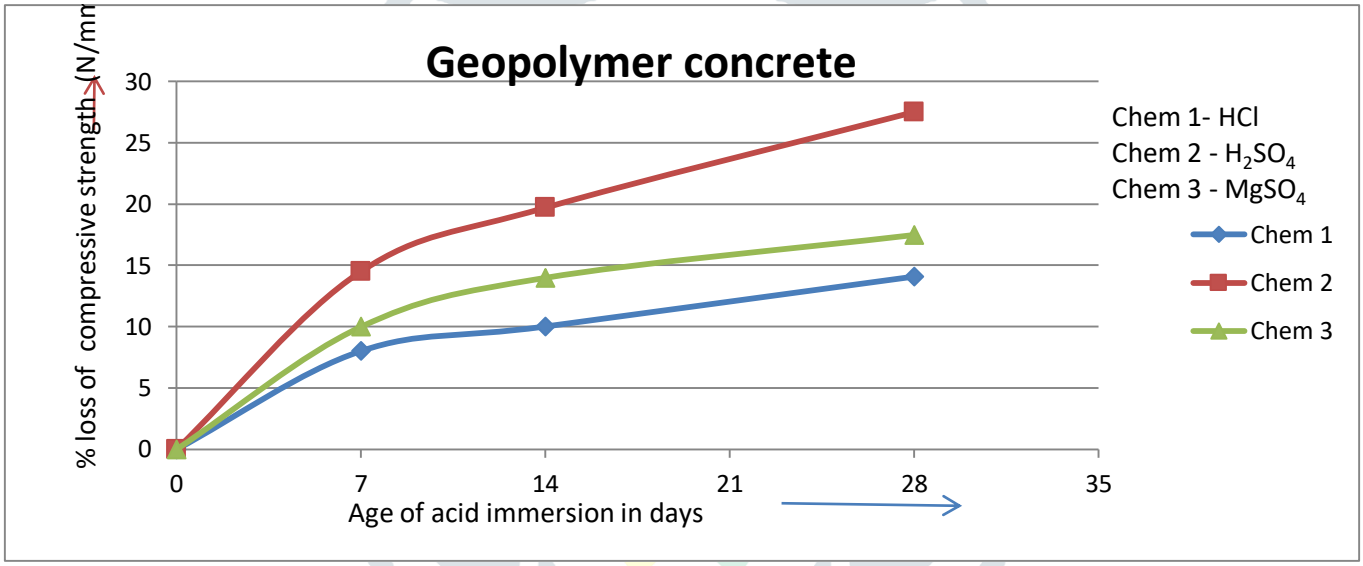
S.No	Acid type	% Weight loss of concrete cubes after acid sunk		
		7 days	14 days	28 days
1	Hcl	2.21	3.062	3.76
2	H_2SO_4	5.5	6.6	8
3	$MgSO_4$	2.0	2.16	2.72

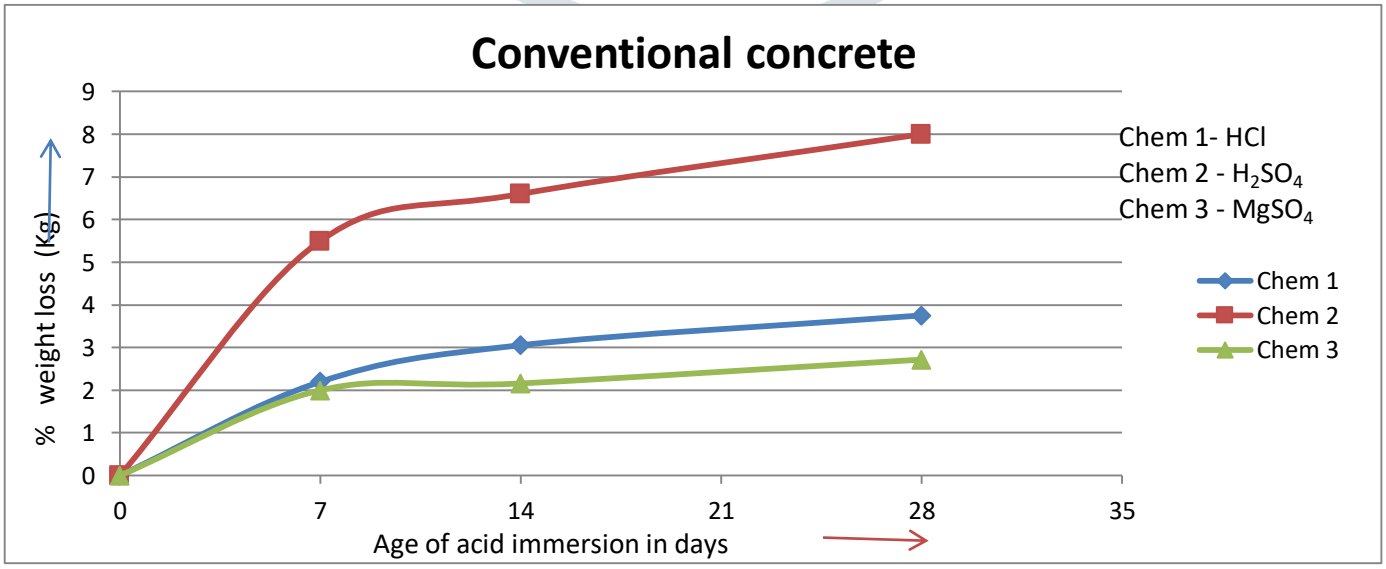
Table: 5.6 Geopolymer concrete

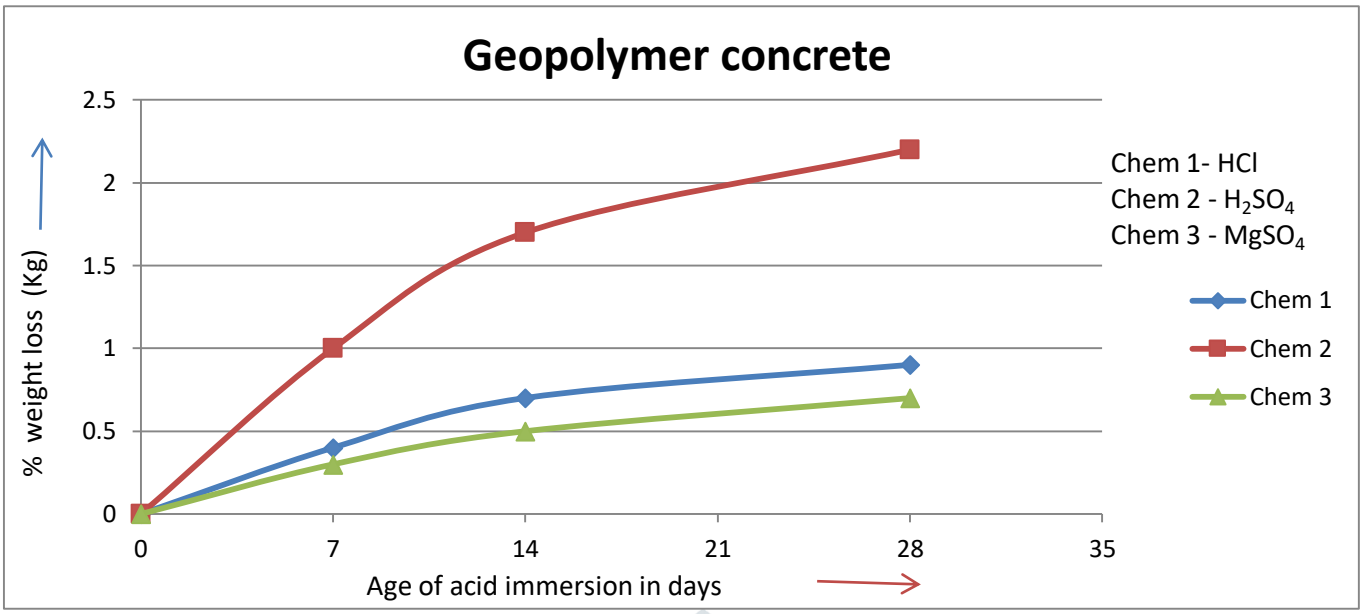
S.No	Acid type	% Weight loss of concrete cubes after acid immersion		
		7 days	14 days	28 days
1	Hcl	0.43	0.72	0.91
2	H_2SO_4	1.0	1.7	2.2
3	$MgSO_4$	0.3	0.5	0.7

GRAPHS


Conventional concrete
% loss of compressive strength (N/mm2)
70
60
50
40
30
20
10
0
0
7
14
21
28
35
Age of acid immersion in days
Chem 1- HCl
Chem 2 - H2SO4
Chem 3 - MgSO4
Chem 1
Chem 2
Chem 3


Geopolymer concrete
% loss of compressive strength (N/mm
30
25
20
15
10
5
0
0
7
14
21
28
35
Age of acid immersion in days
Chem 1- HCl
Chem 2 - H2SO4
Chem 3 - MgSO4
Chem 1
Chem 2
Chem 3


Conventional concrete
% weight loss (Kg)
9
8
7
6
5
4
3
2
1
0
0
7
14
21
28
35
Age of acid immersion in days
Chem 1- HCl
Chem 2 - H2SO4
Chem 3 - MgSO4
Chem 1
Chem 2
Chem 3



V. CONCLUSIONS

Based on information available about geo-polymers, the trial-and-error method has to be implemented to develop the making of fly ash-based geo-polymer concrete. In order to avoid the number of variables in this trial-and-error method, the thesis was limited to low-calcium fly ash.

1. Geo-polymer concrete mixes oppose acid attack in a good manner as compared to conventional concrete at 7, 14, 28days of exposure to HCl, H_2SO_4 and $MgSO_4$.

2. It is noticed that the % loss of Compressive strength of all Geo-polymer Concrete mixes are significantly lesser than that of Conventional concrete mixes.

3. It is also observed that the great loss of compressive strength and weight found in case of H_2SO_4 acid sunk as compared to HCl and $MgSO_4$ acids .

4. The loss of compressive strength of conventional concrete is nearly twice the loss of compressive strength of geo-polymer concrete in H_2SO_4 acid sunk.

5. The % weight loss of Conventional concrete is high when compared to Geo-polymer concrete.

6. It is noticed that the loss of compressive strength of Geo-polymer concrete is high when compared to conventional concrete in $MgSO_4$ acid sunk

7. The weight loss of Geo-polymer concrete is very less when compared to conventional concrete mixes are exposed to 5% acid attack.

VI. REFERENCES

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