TO STUDY THE PROPERTIES OF FLY ASH BASED GEOPOLYMER CONCRETE

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Abstract: Cement production is highly energy intensive and produces greenhouse gases in huge amounts. Concrete is being extensively used as construction material throughout the world and its demand is increasing day by day. In order to cater this demand, we have to adopt ecofriendly materials to produce concrete. We have to look for the alternatives that can be used instead of cement in concrete to cater the increasing demand of concrete efficiently.In 1978, Davidovits proposed that binders could be produced by polymeric reaction of alkaline liquids with the silicon and the aluminum in source materials of geological origin or by-product materials such as fly ash and rice husk ash. In this study fly ash has been used as source material. Fly ash available in plenty as waste product. In this study some durability properties are also studied like permeability and acid attack. From the test result it was cleared that geo-polymer concrete possesses good compressive strength and offers good durability characteristics. Geo-polymer concrete can be used efficiently in concrete industry especially in precast members.
Keyword: Cement Production, Geo-Polymer Concrete, Alkaline Liquids, Fly Ash.

I. INTRODUCTION

In the context of raising awareness of the adverse effects of overexploitation of natural resources, environmentally friendly technologies need to be developed to effectively manage these resources. Specific uses of concrete around the world are second only to water. Traditionally, cement has been used as the primary binder for concrete production. Environmental issues related to cement production are very dangerous. An important element in traditional concrete is Portland cement. The amount of carbon dioxide emitted during cement production is per ton of cement produced due to limestone degradation and fossil fuel combustion. In addition, the energy required for cement production is limited to steel and aluminum. The cost of concrete components is constantly increasing and must reflect the methods and means of reducing the cost per unit of production. At the same time, increased industrial activity in key sectors such as energy, steel and transportation has led to the production of large quantities of materials such as fly ash, blast furnace slag, tantalum powder and quarry powder, leading to disposal problems.

II. OBJECTIVES OF THE PROJECT

So far, there are no codal guidelines for the design of geo polymer concrete. Mixing geo polymer concrete mixtures is one of the challenges of the project. Mixtures of different ratios were prepared and tested for effectiveness.

The objectives of the project are:

1. Develop a mixed consistency process to produce fly ash based geo polymer concrete.
2. Identify and study the effects of significant parameters affecting the performance of fly ash based geo polymer concrete.
3. To Study some properties of durability, such as permeability and resistance to acids of geo polymer concrete.

III. BACKGROUND

Several factors have been identified as important parameters affecting the properties of geo polymers. It concludes that Palomo et al. (1999), the degree of heat treatment is accelerated based on the working geo polymer of fly ash and greatly affects the mechanical strength as well as the type of liquid alkali treatment time. Higher processing temperatures and longer processing times have been shown. In high voltage power supply, it has been shown to contain a liquid alkali metal silicate having a solubility increase compared to a solution containing only a hydroxide alkaline solution.

Van Jaarsveld et al. (2002), produced cracks at high temperatures and had a negative impact on the properties of the material. Finally, they proposed using light therapy to improve the physical properties of matter. In another study, Van Jaarsveld (2002), to determine the source material determine the geo-polymeric properties, particularly the CaO content, and the ratio of fly ash to water.

IV. FLEXURAL STRENGTH OF GEOPOLYMER CONCRETE

Flexural strength test of concrete is performed on beams. The loading applied on the beam is a two point loading in which loads are applied at (1/3) rd points of the beam. The beams shall be placed in the testing machine such that the distance between the load points and each support shall be 13.3 cm. The load increases until the sample fails and the load is observed as a failed load. Then calculate the weakness according to the following formula

Flexural strength =Pl/bd2

Where, P = Load at failure

l = Length of beam between supports

b = Breadth of beam (100mm)

d = Depth of beam (100mm)

V. TENSILE STRENGTH OF GEOPOPLYMER CONCRETE

In order to determine the tensile strength of the concrete cylinder split test, it is carried out on a geological concrete cylinder. This is an indirect test for measuring the tensile strength of concrete.

VI. COMPRESSIVE STRENGTH

After overcoming the problems encountered in the initial casting, the similar cubes are again squared and the compressive strength of the concrete is determined by testing the cube under UTM or pressure testing equipment. In order to determine the compressive strength of six concrete cubes, the dimensions were 150 mm x 150 mm x 150 mm. The hot box was processed in a 24-hour oven. The oven temperature was maintained at 50°C. After taking out the 24-hour cube, the cube was removed from the oven and kept in open air for 6 days. The cube was then tested to determine the compressive strength for 7 days

Use mixing parameters similar to those used in the initial tests listed below:

- The ratio of Alkaline liquid to fly ash is 0.35.
- The ratio of sodium Alkaline liquid to NaOH is 2.5.
- NaOH at a concentration of 12 meters.
- 10 M NaOH is prepared by mixing 400 g of NaOH pellets in 1 liter of water. After mixing NaOH in water, it must be left for 24 hours due to the release of a large amount of heat.
- Use commercial sodium silicate.
- Pre-cast for 24 hours to mix sodium silicate and NaOH solution

Fig 1 Compressive Strength Test Of Cube on UTM

Table 1Compressive Strength of Cubes

cube	Compressive strength in (MPa)
Cube 1	7.36
Cube 2	8.23
Cube 3	7.72
Cube 4	8.57
Cube 5	8.87
Cube 6	7.62
Average strength	**8.06**

VII. CYLINDER SPLITTING TENSION TEST

Testing was performed by placing a cylindrical sample horizontally between the loading surfaces of the pressure testing machine and applying a load along the vertical diameter until the cylinder failed.

The load condition creates a high voltage under the two lines where the load is applied. However, the depth of the larger portion is subjected to equal tensile stress. It is estimated that the compression pressure is applied to each depth (1/6) and the remaining 5/6 depth is subjected to tension. The horizontal tensile pressure is given by the following formula [6]

Horizontal tensile stress=2p/π DL

Where, P= Load at failure

L= Length or height of cylinder (300mm)

D = Diameter of cylinder (150mm)

7.1 Proportioning of mix for casting of cylinders

In order to determine the tensile strength, three cylinders were cast from a height of 150 mm and 300 mm. The size of a disc is 5.29 * 10-3m3. The volume of about 3 cylinders is 16.5 * 10-3m3. The total casting size is 16.5 * 10-3 m 3.

The different parameters used in the mix are as follows:

- The ratio of alkaline liquid to fly ash is 0.35.
- The ratio of sodium silicate to NaOH is 2.5.
- NaOH at a concentration of 12M.
- 12 M NaOH was prepared by mixing 480 g of NaOH pellets in 1 liter of water. After mixing NaOH in water, it must be left for 24 hours due to the release of a large amount of heat.
- Commercial sodium silicate is used in current castings.

A solution of sodium silicate and NaOH was mixed together 24 hours prior to casting.

Table 2, proportioning of mix for casting of cylinders.

Materials		Mass kg/m3	Amount required for 3 cylinders. (kg)
Coarse aggregate	2o mm	445.73	7.35
	16mm	297.15	4.5
	10mm	495.264	8.17
Fine sand		609.84	10.06
Fly ash		408	6.73
Sodium silicate solution		103	1.69
Sodium hydroxide solution		41	0.67

VIII. TEST RESULTS AND DISCUSSIONS

Gravity is defined as the mass imparted to the solid at 4°C equal to the mass of the water volume. Therefore gravity is qualitative,

G = total solid density / water quality

The density of the laboratory can be used to determine the specific gravity of the laboratory. Clean the bottle and density in this way. Block the bottle, including the stopper. Approximately 5-10 grams of dried kiln samples were taken from the fly ash in the bottle and its weight. The sample was then covered with distilled water. The sample was then allowed to absorb water for about 2 hours. Add more water until the bottle is full. The air inside the building is removed by good heating. Add more water to fill the bottle. Insert the stopper into the bottle and remove the mass.

The bottle was emptied, washed, and then filled with

distilled water. The quality of the bottle is full of water. Gravity can be calculated using the following equation:
G = (M2 – M1) / [(M2 –M1) - (M3- M4)]
Where,
M1 = mass of empty bottle
M2= mass of the bottle and dry fly ash
M3= mass of bottle soil and water
M4= mass of bottle filled with water only
Readings are tabulated as under:

Table 3, Determination of specific gravity of fly ash

S No.	Empty mass of bottle (M1)	Mass of bottle + soil (M2)	Mass of bottle + soil + water (M3)	Mass of bottle + water (M4)	Specific gravity G
1.	30.45	38	85.21	80.96	2.28
2.	31.00	38.7	85.39	81	2.32
3.	30.28	38.20	86.15	81.55	2.35

Average of the three values is taken as the specific gravity of fly ash. So specific gravity of fly ash is 2.31.

8.1 Grading of aggregates

A convenient system of expressing the gradation of aggregate is one in which the consecutive sieve openings are constantly doubled, such as 10 mm, 20 mm, 40 mm, and the like. Under such a system using a logarithmic scale the lines can be spaced apart by equal distances. The aggregates used in the concrete industry are typically 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, 2.36 mm, 600 microns, 300 microns and 150 microns. The total fraction from 80 mm to 4.75 mm is called coarse aggregate. These parts are collectively referred to as 4.75mm to 150 microns. The size of 4.75 mm is a common part of the total roughness and fine aggregate (C.A. and F.A.). The classification mode of the C.A sample was evaluated by having a larger sieve at the top of the F.A. by screening the samples separately through a sieve with each sieve mounted above the other sieve. The screen can be carried out manually or mechanically.
Apparatus used for sieving:
The set of sieves of size: 80mm, 63mm, 50mm, 40mm, 31.5mm, 25mm, 20mm, 16mm, 12.5mm, 10mm, 6.3mm,4.75mm, 3.35mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm and 75µm.
Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample.

Procedure to determine particle size distribution of Aggregates

The test sample was dried to constant weight at 110 ± 5 °C and its weight.
Use a set of sieves to screen samples.
After the sieve is finished, weigh the material on each sieve.
Calculate the cumulative weight of each sieve as a percentage of the total weight of the sample.
Obtain a softness factor by adding the cumulative percentage of aggregates held in each sieve and dividing the total by 100.
There are several reasons for determining the estimate and the maximum size limit. Any combination of defects or excesses that comprise a smooth curved curve rather than any single particle size will generally result in a mixture having less space between the particles.

Due to the need for more space to paste, it is recommended to reduce the vacuum content as much as possible. If there is not enough sand to fill the gap between the coarse particles, the vacuum should be filled with a volatile alkaline liquid. This mixed mixture tends to be rough and difficult to accomplish. On the other hand, due to the large surface area of the fine particles, a large combination of excess sand or sand can produce excessively economical concrete.

8.2 Effect of sodium silicate to sodium hydroxide ratio:

After the correct mix slump is determined by the recession test. For the mixing 1 with a mixing value of 74 mm, the inclination value 2 was 80 mm, for the mixing, the inclination 3 was 85 mm, and for the mixture 4, the value was 85 mm. All slump values in the medium applicable concrete range specified in IS 456 2000. The prepared cubes were heat treated in an oven for 24 hours. After 24 hours, the mold was taken out, the cube was taken out of the oven and kept outdoors for 6 days at room temperature. After 7 days, test the cube on the CTM. The test results are arranged as follows:

Table 4: compressive strength of various mixes with different sodium silicate to sodium hydroxide ratio.

150*150*150 mm^3 cubes.	Compressive strength (N/mm^2)			
	Mix 1 (0.4)		Mix 2 (1)	
	Load (KN)	Strength (N/mm^2)	Load (KN)	Strength (N/mm^2)
	440	19.55	475	21.11
	430	19.11	460	20.44
	415	18.44	440	19.55
Average strength		19.03		20.36

For mix 3 and mix 4 results are as under:

150*150*150 mm^3cubes.	Compressive strength (N/mm^2)			
	Mix 3 (2.5)		Mix 4 (3.5)	
	Load (KN)	Strength (N/mm^2)	Load (KN)	Strength (N/mm^2)
	525	23.33	460	20.44
	520	23.11	430	19.11
	540	24.00	470	20.88
Average strength		23.48		20.14

Graphical representation of results:
The variation of strength with sodium silicate to sodium hydroxide ratio can be represented graphically sodium silicate to sodium hydroxide ratio along x axis and strength in N/mm^2 along y axis.

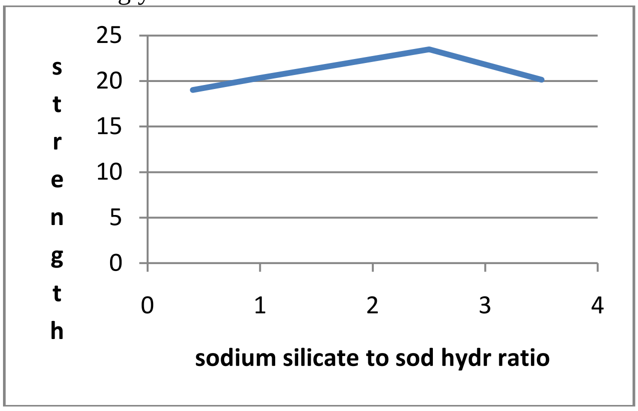

Fig 2 variation of strength with varying sodium silicate to sodium hydroxide ratio.

It is apparent from the above results that as the ratio of sodium silicate to sodium hydroxide increases, the strength increases. This increase until the ratio reaches 2.5, after which the strength decreases to the proportion of NaOH as the sodium silicate increases. Therefore, the optimum ratio of maximum strength is 2.5, which means that there is a desired concentration of sodium hydroxide and sodium silicate solution for efficient polymerization.

8.3 Flexural strength:

After determining the appropriate mixing potential of the mixture through a decay test, Slump value comes out to 86 mm, which is the average working range. The cast beams were heated in the oven for 24 hours. After 24 hours, the package was removed from the oven and the mold removed. Then save the in open air bar for 5 days. After 7 days, the bending strength of the beam was determined by the third point loading method as described above. The test sequence is shown in Figure 2;

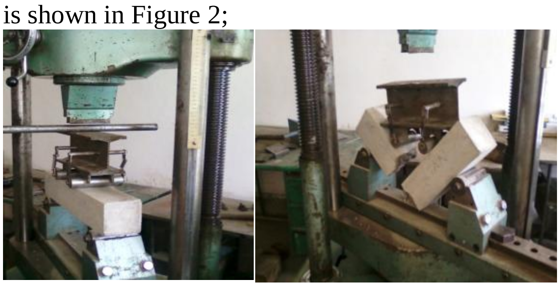

Fig 3: Flexure testing of beam.

Beam before loading Beam at failure

Table 5:Flexural strength of geopolymer concrete.

Loads(KN)	Stress(Mpa)
10	4
9.5	3.8
8	3.2
Average= 9.16	Average= 3.67

Average flexural strength of geopolymer concrete comes out 2.56 Mpa when alkaline liquid to fly ash ratio is 3.5 and fly ash, aggregates are used in the following ratio:

Fly ash : fine aggregate : coarse aggregate
1 : 1.5 : 3

8.4 Testing of cylinders

After the proper mixing workability of mix is determined by slump test. Slump value of the mix comes out 76mm which comes in medium workable range. Cylinders are heat cured for 24 hours. After 24 hours cylinders are removed from mould and taken out from oven. After 24 hours of high temperature curing cylinders are kept in open air for 6 days at room temperature. After 7 days of casting cylinders are tested on CTM. Loading arrangement is as shown in fig 3.

Fig 4: Loading arrangement for Split Tensile Strength Test.

8.5 Before failure after failure

Cylinder testing for split tensile strength.

Table 6:Tensile strength of geopolymer concrete.

Loads(KN)	Stress(Mpa)
170	2.4
185	2.61
190	2.68
Average= 177	Average= 2.56

Average tensile strength of geopolymer concrete comes out 2.56 Mpa.

IX. CONCLUSIONS

Based on the experimental work reported in this study, the following conclusions are drawn:

- GPC M20 can be formed using a nominal mixture of 1.5:1 (fly ash: fine aggregate: coarse aggregate) and an alkaline liquid stabilizer to achieve an ash ratio of 0.35.
- The concentration of sodium hydroxide increases.
- Increase the amount of lye to reduce the proportion of fly ash.
- GPC reaches its final strength within 7 days, four times faster than regular cement. In 3 days, there are more than 50% power.
- The optimum strength ratio between sodium citrate and sodium hydroxide is 2.5. This ratio is lower than 2.5 or higher of the force.
- High temperatures (about 600 ° C) are necessary for strength development.
- When immersed in an acidic solution, the strength of GPC will decrease. The low alkali acid cube shows a high drop in ash content compared to the base-high cube.
- GPC penetration is very low. The permeability increases as the alkaline fluid increases, and the ash ratio increases.

- Increase the working capacity of the ash ratio as the alkaline liquid increases. Mixed with lye, the fly ash ratio is very harsh 0.3.

X. FUTURE SCOPE

An attempt has been made to carry out a feasibility of geopolymer concrete instead of ordinary Portland cement. Various tests were performed on geopolymer blocks as a part of study like compressive strength test, slump test etc. Due to lack of sufficient time tests like drying shrinkage test, creep test, chemical tests etc. which requires time on a large scale becomes the future scope of work. Though a resultof thisdata can affect the performance of geopolymerconcrete, butat present a compressive strength result is sufficient to prove the suitability of geopolymer concrete on the field as a trial basis.

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