# Fully Replacement of Cement and Water in Geopolymer Concrete

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***Abstract* - The report presents a comprehensive summary of the extensive studies conducted on fly ash-based geopolymer concrete. Test data are used to identify the effects of salient factors that influence the properties of the geopolymer concrete in the fresh and hardened states. These results are utilized to propose a simple method for the design of geopolymer concrete mixtures. Test data of various short-term and long-term properties of the geopolymer concrete are then presented. The last part of the Report describes the results of the tests conducted on geopolymer concrete.**

***Keywords - Geopolymer Concrete, Fly Ash, Alkaline Liquid, Compressive Strength***

## I. INTRODUCTION

India produces about 70 million tons of coal ash per year from Burning about 200 million tons of coal per year for electric power generation. Coal-ash management poses a serious environmental problem for India and requires a mission-mode approach. Considerable research and development work have been undertaken across the country towards confidence building and developing suitable technologies for disposal and utilization of fly ash in construction industries. At present about 10% ash is utilized in ash dyke construction and land filling and only about 3% of ash is utilized in other construction industries. This is very much in contrast with 80% or more fly ash used in developed countries for the manufacture of concrete, cellular concrete blocks, road construction, land fill application, ceramics, agriculture, insulating concrete, recovery of metals and cenospheres and dam constructions. Currently, about one acre per MW of land is needed for ash disposal. The manufacture of geopolymer concrete, is one of causes for which the fechno clomic aspects are discussed in the following paragraphs

The global use of concrete is second only to water. As the demand for concrete as a construction material increases, so also the demand for Portland cement. It is estimated that the production of cement will increase from about from 1.5 billion tons in 1995 to 2.2 billion tons in 2010 [6].On the other hand, the climate change due to global warming has become a major concern. The global warming is caused by the emission of greenhouse gases, such as carbon dioxide (CO2), to the atmosphere by human activities. Among the greenhouse gases, $CO_2$ contributes about 65% of global warming. The cement industry is held responsible for some of the $CO_2$emissions, because the production of one ton of Portland cement emits approximately one ton of $CO_2$into the atmosphere [4].

In this respect, the geopolymer technology proposed by [4] shows considerable promise for application in concrete industry as an alternative binder to the Portland cement [5]. In terms of global warming, the geopolymer technology could significantly reduce the $CO_2$ emission to the atmosphere caused by the cement industries.

Geopolymer is a new material which is being used for construction all over the world. As a new material for construction not much of information is available on the durability of geopolymer concrete. The durability of concrete is an important requirement for the performance of the structure in aggressive environments throughout its design life period. The durability of concrete primarily depends upon its permeability characteristics. Impermeable concretes can resist the ingress of aggressive ions into the concrete and thereby reduce the damages occurring due to the deterioration of concrete and the corrosion of steel in concrete. However, there appears to be no comprehensive information of the permeability characteristics and deterioration characteristics of geopolymer concretes Moreover, for such a comprehensive understanding it is also essential that these concretes should be well designed at any particular strength.

## II. METHODOLOGY

### A. *PROCESS OF GEOPOLYMER CONCRETE*

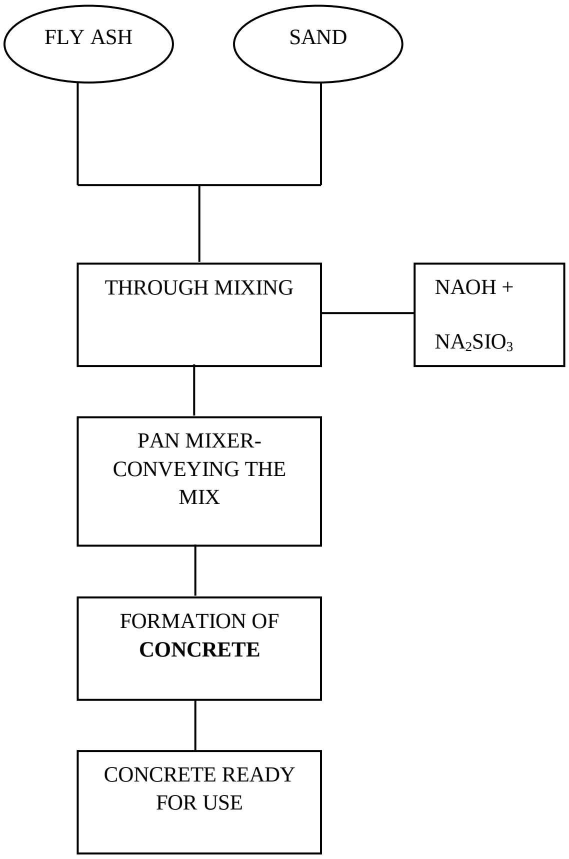


Fig – 1: Process of Geopolymer Concrete

### B. *ALKALINE LIQUIDS*

The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate [4]; [5]: [8]; [7];[8]. The use of a single alkaline activator has been reported[5].

[5] concluded that the type of alkaline liquid plays an important role in the polymerisation process. Reactions occur at a high rate when the alkaline liquid contains soluble silicate, either sodium or potassium silicate, compared to the use of only alkaline hydroxides. [8] confirmed that the addition of sodium silicate solution to the sodium hydroxide solution as the alkaline liquid enhanced the reaction between the source material and the solution. Furthermore, after a study of the geopolymerisation of sixteen natural Al-Si minerals, they found that generally the NaOH solution caused a higher extent of dissolution of minerals than the KOH solution.

### C. *MIX PROPORTIONS*

The maximum utilization of fly ash and for bonding NaOH & $Na_2SIO_3$ solution is made. Mix design for concrete is developed. In this study the mix proportion is by 1:1.75:3.5 and with addition of chemical in mole such as 8M.

### D. *PREPEARATION OF SPECIMEN*

Initially the dry weight of fly ash and dry weight of sand is measured as required. The solution is made separately according to its mole of preparation. Drily mix the fly ash and sand thoroughly and by gradually add the chemical mix up to the mix won't get de-bonded. Then the cleaned mould was place over the base plate, by using trowel, place the mortar mix inside the block and allow it to settle and make it dry finally we get the well shaped geopolymer concrete.

### E. *MATERILALS NEED TO MAKE A SINGLE CUBE*

**Ratio 1:1.75:3.5**

**TABLE - 1**

| S. No | Material | Weight gm |
|---|---|---|
| 1 | Fly ash | 400 |
| 2 | Fine aggregate | 700 |
| 3 | Course aggregate | 1400 |
| 4 | Chemical | 180 |

### F. *COMPRESSIVE STRENGTH TEST*

The specimen cured were finished mixer ,then brought to the final shape. Before placing the specimen in the compressive test machine, a steel plate of dimensions, which perfectly covers the whole area of the specimen. The specimen placed even that steel plate and one or more steel plate is placed over the specimen is placed in the longitudinal position. The load is applied gradually over the specimen. The ultimate compressive load is recorded accurately. The same procedure is adopted for all specimens. The results were tabulated. From the table charts were drawn to analyze the results.

The compressive strength of each specimen is calculated by.

Compressive strength = compressive load / effective area = …..$N/mm^2$

Average compressive strength of geopolymer concrete is **35.85 mpa**. More over its almost more ie., three times stronger than that of normal brick. And hence it is set for load bearing structure in such a good manner.

## III. RESULT ANALYSIS

### A. *GEOPOLYMER COMPRESSIVE STRENGH OF CONCRETRE*

The compressive strength of geopolymer concrete is influenced by the wet-mixing time, as illustrated by the test data plotted in Figure. The test specimens were 100x100x100 mm cube and 100 x 200mm cylinder concrete was hot air cured at $75^0$C for 24 hours and tested in compression at an age of 7 days. Totally 40concrete were casted for 1:1.75:3.5 ratios, with( 8M) morality. The curing was done by hot air curing

### *B. DISCUSSION BASED ON CONCRETRE TEST RESULTS*

The compressive strength significantly increased as the wet-mixing time increased. Hot air curing of low-calcium fly ash-based geopolymer concrete is generally recommended. Hot air curing substantially assists the chemical reaction that occurs in the geopolymer paste. Both curing time and curing temperature influence the compressive strength of geopolymer concrete Longer curing time improved the polymerization process resulting in higher compressive strength. The rate of increase in strength was rapid up to 24 hours of curing time; beyond 24 hours, the gain in strength is only moderate. Therefore, steam-curing time need not be more than 24 hours in practical applications. Higher curing temperature resulted in larger compressive strength. When the wet-mixing time is increased from 4 minutes to 16 minutes, the above compressive strength values may increase by about 20%.The unit-weight of concrete primarily depends on the unit mass of aggregates used in the mixture. Tests show that the unit-weight of the low-calcium fly ash-based geopolymer concrete is similar to that of fly ash concrete.8M grade concrete showed better compressive strength compare to other molarities. Hot air curing gives good result compare to other curing. Adequate curing of geopolymer concrete will yield good strength in other grades too. The compressive strength and the workability of geopolymer concrete are influenced by the proportions and properties of the constituent materials that make the geopolymer paste. Higher concentration (in terms of molar) of sodium hydroxide solution results in higher compressive strength of geopolymer concrete. Higher the ratio of sodium silicate solution-to-sodium hydroxide solution ratio by mass, higher is the compressive strength of geopolymer concrete. As the $H_2O$-to-$Na_2O$ molar ratio increases, the compressive strength of geopolymer concrete decreases.

### *C. COMPRESSIVE STRENGTH OF CUBE (GEOPOLYMER) – 8 MOLE*

**TABLE - 2**

| S.No | SPECIMEN SIZE (mm) | WEGHT (gm) | LOAD (KN) | COMPRESSIVE STRENGTH (mpa) |
|---|---|---|---|---|
| 1. | 100x100x 100 | 2405 | 356 | 35.6 |
| 2. | 100x100x 100 | 2356 | 348 | 34.8 |
| 3. | 100x100x 100 | 2368 | 362 | 36.2 |

### *D. COMPRESSIVE STRENGTH OF CUBE (NORMAL CONCRETE)*

**TABLE - 3**

| S.No | SPECIMEN SIZE (mm) | WEGHT (gm) | LOAD (KN) | COMPRESSIVE STRENGTH (mpa) |
|---|---|---|---|---|
| 1. | 100x100x 100 | 2330 | 195 | 19.5 |
| 2. | 100x100x 100 | 2345 | 192 | 19.2 |
| 3. | 100x100x 100 | 2328 | 189 | 18.9 |

**BAR CHART**

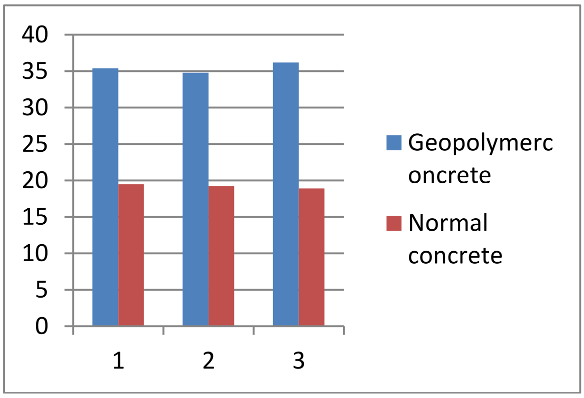


Fig – 2 : Comparison cube

**GEOPOLYMER Vs NORMAL CONCRETE**

### *E. RESULT*

The compression strength of geopolymer cube is higher then the normal cube is shown in figure 2.

## IV. CONCLUSION

From the experimental investigation made it was found that, Geopolymer concrete manufactured with low calcium fly ash with ratios **1:1.75:3.5** and 8 mol solution geopolymer concrete attained the maximum strength which was better than the ordinary concrete. Adequate high curing temperature ($60^0$c – $80^0$c) and adequate curing time (minimum 24 hrs) will give better result. The geopolymer concrete with hot air curing at $75^0$c increase 5-10% more strength when compare to geopolymer concrete without hot air curing. Workability which influences the properties of the fresh concrete and compressive strength which influences the properties of the hardened concrete have been identified. Low-calcium fly ash-based geopolymer concrete has excellent compressive strength and is suitable for structural applications. The reason of increased compressive strength of geopolymer concrete is the chemical reaction due to substantially fast polymerization process and aging of the alkaline liquid. Geopolymer binders have emerged as one of the possible alternative to OPC binders due to their reported high early strength.

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