*International Journal For Technological Research In Engineering*
*Volume 1, Issue 8, April-2014* *ISSN (Online): 2347 - 4718*

# WORKABILITY PROPERTIES OF GEOPOLYMER CONCRETE USING ACCELERATOR AND SILICA FUME AS AN ADMIXTURE

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***Abstract - The Paper presents extensive studies conducted on geopolymer concrete. There are salient factors that influence the properties of the geopolymer concrete in the fresh and hardened states. Geo-polymer as a replacement material for cement, by achieving more Strength & Durability & reducing the pollution inherited in atmosphere by Carbon components from the production of concrete, (& reducing the heat produced during the process of Hydration). Few chemicals are worked as a binding agent as alternative of cement, which will help to gain strength & release heat during Curing Process. In the Portland cement the big issue is that, the emission of the CO2 is more which create the global warming. By the replacement of the Portland cement, CO2 emission can stop. Right now Geopolymer is the best replacement of Portland cement so it is also known as Green concrete.***
***Index term: geopolymer, concrete, fly ash, alkaline solution, admixture (Key words)***

## I. INTRODUCTION

The term ‘‘geopolymers’’ was first introduced to the world by Davidovits of France resulting in a new field of research and technology. Davidovits explained that geosynthesis is the science of manufacturing artificial rock at a temperature below 100°C in order to obtain natural characteristics (hardness, longevity and heat stability) of rock. Geopolymers can be thus viewed as mineral polymers resulting from geochemistry or geosynthesis. However geopolymer (GP) means any aluminosilicate based binder. Geopolymer concrete is representing the various awareness about its use. In the world right now the globule warming is the biggest issue. By using the geopolymer concrete we can reduce the release of 7 to 8% of CO2 in atmosphere. That’s why geopolymer concrete is also known as Eco friendly concrete. In geopolymer concrete aluminosilicat sources are used like slag powder, fly ash, blast Furness, slag power. Right now in a various fields people like to use geopolymer concrete as a replacement of ordinary Portland cement. Geopolymer concrete can gain compressive strength at early-age. Due to the lack of knowledge of chemical nature of geopolymer concrete it’s rarely used. The GSMs should be aluminosilicate based and rich in both silicon (Si) and aluminum (Al) and thus, by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc. can form GSMs. The use of greener concrete by the partial or full replacement of cement is increasing.

## II. DESIRABLE PROPERTY OF GEOPOLYMER

Geopolymer binders are used together with aggregates to produce geopolymer concretes which are ideal for building and repairing infrastructures and for precasting units, because they have very high early strength, their setting times can be controlled and they remain intact for very long time without any need for repair. The properties of geopolymer include high early strength, low shrinkage, freeze-thaw resistance, sulphate resistance and corrosion resistance. These high-alkali binders do not generate any alkali aggregate reaction.

| COARSE AGGREGATE 20 MM | | | | |
|---|---|---|---|---|
| Sieve | **Retain gm** | **Retain %** | **Cumulative %** | **Passing %** |
| 40 | 0 | 0 | 0 | 100 |
| 20 | 611.5 | 30.57 | 30.75 | 69.25 |
| 16 | 908.5 | 45.42 | 76.17 | 69.25 |
| 12.5 | 375.5 | 18.77 | 94.94 | 23.83 |
| 10 | 104 | 5 | 99.94 | 5.06 |
| 4.75 | - | 0 | | 0.06 |

- To produce Geopolymer concrete, industrial waste should be used. (fly ash, rise husk, slag, blast Furness)
- Durability property such as resistance against attack by sulphates, acid attack
- tensile strength
- compressive strength
- flexural strength
- protection to embedded steel reinforcement
- economical
- modulus of elasticity

  

## III. MATERIALS

### A. Fly ash

Fly ash used in this study was unprocessed fly ash from torrent power plant (locally available). The whole quantity of fly ash was obtained from one batch.

Later, Fly ash was used in small proportions in mass concreting for dams and other hydraulic.

| FINE AGGREGATE | | | | |
|---|---|---|---|---|
| Sieve | **Retain** | **Retain** | **Cumulative** | **Passing** |
| 10 mm | 0 | 0 | - | 100 |
| 4.75 | 6 | 3 | 3 | 97 |
| 2.36 | 38 | 19 | 21 | 79 |
| 1.18 | 54 | 27 | 48 | 52 |
| 600 | 31 | 15.5 | 63.5 | 36.5 |
| 300 | 43 | 21.5 | 85 | 15 |
| 150 | 10 | 5 | 90 | 10 |
| Pan | 20 | 10 | 100 | 0 |

The chemical composition of fly ash given in Table was obtained

### B. Course Aggregates & Fine aggregate

Locally available crushed stones of 10 mm and 20 mm aggregates were used as coarse aggregates. Local river sand was used as fine aggregate in the concrete mixtures. The test result for fine and course aggregate are as under.

Table 1: Sieve analysis of fine aggregate

| COARSE AGGREGATE 10 MM | | | | |
|---|---|---|---|---|
| Sieve | **Retain** | **Retain** | **Cumulative** | **Passing** |
| 12.5 | 16 | 0.8 | 0.8 | 99.2 |
| 10 | 212 | 10.6 | 11.4 | 88.6 |
| 4.75 | 1445 | 72.25 | 83.65 | 16.35 |
| 2.36 | 308 | 15.4 | 99.05 | 0.95 |

Table 2: Sieve analysis of coarse aggregate 10 mm

Table 3: Sieve analysis of coarse aggregate 20 mm

### C. Alkaline Solution as binder materials

The alkaline liquid used was a combination of sodium silicate solution and sodium hydroxide solution. The sodium silicate solution (Na2O= 13.7%, SiO2=29.4%, and water=55.9% by mass) was purchased from a local supplier in bulk. The sodium hydroxide (NaOH) in flakes or pellets from with 97%-98% purity was also purchased from a local supplier in bulk. The NaOH solids were dissolved in water to make the solution. Water, which was used to prepare NaOH solution, was tap water. The sodium hydroxide pellets were prepared one to two days prior to the concrete batching to allow the exothermically heated liquid to cool to room temperature. The sodium silicate and sodium hydroxide were mixed just prior to the concrete batching. This was a different process than had been employed previously at Curtin University where the two alkaline liquids were mixed 24 hour prior to casting. A number of alkaline liquids when combined were observed to harden upon mixing making them unusable. Subsequently, the two alkaline liquids were mixed together only on the day of casting and stored in a sealed container until required. Geopolymer concrete is manufactured by replacing cement fully with processed low calcium fly ash which is chemically activated by alkaline solutions like sodium silicate and sodium hydroxide.

### D. Admixture

*Accelerator*

Accelerators speed up the hydration (hardening) of the concrete. Typical materials used are CaCl2 (Calcium chloride), Ca(NO3)2 (Calcium nitrate) and NaNO3 (Sodium nitrate). However, use of chlorides may cause corrosion in steel reinforcing. It is a specially formulated for combined action as water reducing agent with acceleration in setting time. When added to the concrete mix it gives a good workability & help to set faster than regular conventional concrete in the fresh state and high early and ultimate strengths in the hardened state.

*Properties of Accelerator*

- It reduces initial set 2- 3 hrs, depending on the dose.
- It sets fast hence high early and ultimate compressive strength concrete.
- Reduces water up to 5-8% without affecting the workability.
- Increases workability at a given w/c ratio, easy compaction hence eliminates honeycombing.
- Provides highly cohesive concrete mix & reduces the chance of bleeding & segregation.
- Makes concrete less permeable and hence improves the durability.
- Chloride free hence suitable for RCC.

### E. Plasticizer

The super plasticizer was added in proportion to the fly-ash in the mix by mass. The addition of super plasticizer improved the workability of the fresh concrete but had very little effect on the compressive strength up to about two percent of this admixture to the mass of fly ash. Beyond this value, there is some degradation of the compressive strength.
Compressive strength of geopolymer concrete does not vary with age, and curing the concrete specimens at higher temperature and longer curing period will result in higher compressive strength. Furthermore, the commercially available Naphthalene-based super plasticizer improves the workability of fresh geopolymer concrete. The start of curing of geopolymer concrete at elevated temperatures can be delayed at least up to 60 minutes without significant effect on the compressive strength.

  

## IV. MIX DESIGN

| Characteristics | Fly ash (%wt) |
|---|---|
| Silica | 55-65 |
| iron oxide | 5-7 |
| aluminum oxide | 22-25 |
| calcium oxide | 5-7 |
| magnesium oxide | <1 |
| titanium oxide | <1 |
| Phosphorous | <1 |
| Sulphates | 0.1 |
| alkali oxide | <1 |

Table 4: Chemical composition of Fly ash

| Physical properties | Properties of fly ash used | Properties of fly ash according to IS 1320-1981 |
|---|---|---|
| Specific gravity | 2.51 | - |
| Initial setting time | 120 minutes | - |
| Final setting time | 280 minutes | - |
| Fineness specific surface in m2/ kg min | 320 | 340 |
| Lime reactivity Avg compressive strength | 4.00 | 6.200 |

Table 5: Physical Properties of low calcium class F Fly Ash

| Materials for M30 | As per normal mix design | Using with silica fume (kg/m3) | Using admixture– plasticizer (kg/m3) | Using admixture – accelerator (kg/m3) |
|---|---|---|---|---|
| | **G1** | **G2** | **G3** | **G4** |
| Fly ash | 550 | 388 | 550 | 550 |
| Fine aggregate | 600 | 600 | 600 | 600 |
| Course aggregate 10mm | 419 | 419 | 419 | 419 |
| Course aggregate 20mm | 419 | 419 | 419 | 419 |
| Alkaline solution | 336 | 336 | 336 | 336 |
| Silica fume | - | 162 | - | - |
| Plasticizer | - | - | 11.85 | - |
| Accelerat or | - | - | - | 17.43 |

Table 6: Mix design of M 30 concrete

## V. EXPERIMETNTAL PROGRAM

### *A. Slump test*

To determine the workability of concrete mix by slump test conducted by as per IS 1199-1959. The internal surface of the mould thoroughly cleaned and freed from superfluous moisture than mould placed on a smooth, horizontal, rigid and nonabsorbent surface. The mould was filled in four layers, each approximately one-quarter of the height of the mould. Each layer was tamped with twenty-five strokes of the rounded end of the tamping rod. The bottom layer tamped throughout its depth. After the top layer has been rodded, the concrete was struck off level with a trowel or the tamping rod, so that the mould is exactly filled. The mould removed from the concrete immediately by raising it slowly and carefully in a vertical direction. This allows the concrete to subside and the slump shall be measured immediately by determining the difference between the height of the mould and that of the highest point of the specimen being tested.
The test results are given in table 7.

| Sr no. | Mix proportion | slump |
|---|---|---|
| 1 | G1 | 78 mm |
| 2 | G2 | 70mm |
| 3 | G3 | 86 mm |
| 4 | G4 | 75 mm |

Table 7: Result of slump test

### *B. Compaction factor test*

The concrete was placed gently in upper hopper, using the hand scoop. The hopper was filled level with its brim and trap door was opened so concrete falls in to lower hopper. Than the trapdoor of second hopper was opened and concrete was allowed to fall in cylinder. The excess concrete above the top of cylinder was removed by towel. The weight of concrete was measured and compare that with the weight of concrete was fully compacted in same cylinder and the ratio of both known as compaction factor.
Result of compacting factor test is given in table 8.

| Sr. no. | Mix proportion | C.F. |
|---|---|---|
| 1 | G1 | 0.65 |
| 2 | G2 | 0.62 |
| 3 | G3 | 0.73 |
| 4 | G4 | 0.68 |

Table 8: Result of Compaction factor test

## VI. CONCLUSION

- Increase in proportion of silica fume, it gives a less workability.
- More workability can achieve by increase in proportion of plasticizer.
- Due to effect of the accelerator the geopolymer concrete setting time decreased and due to that effect the concrete slump will be minimum and the

  

workability will become less.

- Geopolymer concrete use as an alternative of Portland cement and it reduce the $CO_2$ emission in the world so it can be said that it helps to the nature that's why Geopolymer concrete represent as a "Green concrete" and also as a "Eco-friendly concrete".
- Due to use of the industrial waste, Geopolymer concrete also play a role as an economical product and it also affect the cost of the geopolymer concrete.

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