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# EXPERIMENTAL STUDIES ON STRENGTH CHARACTERISTICS OF FLY ASH BASED GEOPOLYMER CONCRETE

**K. NAVEENA**

M. Tech, Structural Engineering (JNTU Anantapur), Assistant Professor, Department of Civil Engineering, Annamacharya College of Engineering, Rajampet, Kadapa, India

## ABSTRACT

Global warming, a well known word in the present world created by the emission of $CO_2$ into the atmosphere in various ways during the production and utilization of many materials. As a part of civil engineering we all now concrete is a key product in building structures. To prepare concrete and make it as a rock stratum, OPC plays a prominent role by improving binding properties among the other ingredients of concrete. But production of OPC causes emission of harmful gases into the atmosphere and also major consumption of natural resources. As a part of my research a step is made towards producing of concrete without using OPC as a binding material. NaOH of 8, 10, 12, 14 & 16 molarities and $Na_2SiO_3$ chemicals are used as activators with 100 % fly ash. Compressive strength properties were studied for 7, 14 and 28 days air curing after 24 hours oven curing at a temperature of $60^0$C.

**KEYWORDS:** Geopolymer Chemistry, Fly Ash-Based Geopolymer Concrete, Fine Aggregates

## INTRODUCTION

Generally in manufacturing of cement we use raw materials like Calcium Oxide, magnesium Oxide Etc, Which produces equal amount of carbon dioxide ($CO_2$) and also releasesinto the atmosphere, to avoid pollution in the atmosphere we introduced Geopolymer as a binding material in preparation of concrete. Geopolymer reduces the utilization of cement in production of concrete. Inspired by this new technique and the basic knowledge on utilization of fly ash which is abundantly available waste material in concrete making, an attempt has success full alternate for the cement concrete materials.Geopolymer binder consists of sodium pellets and fly-ash waste which are available in locally.Geopolymer materials are used here eco-friendly as-well as economical to the construction. This paper deals with study of strength properties of fly ash based geopolymer concrete having different molarities of NaOH(8, 10, 12, 14 and 16M) for a period of 7, 14, 28 days after 24 hours oven curing at a temperature of $60^0$ C.

## LITERATURE REVIEW

Geopolymer preparation that alkaline liquid as silicon aliminum of oxides by product materials as Rice husk fly ash .Because the chemical reaction that takes place in this case is a polymerization process, he coined the term ‘Geopolymer’ to represent these binders. Geopolymers are members of the family of inorganic polymers. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals, those results in a three-dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds.

## FLYASH-BASED GEOPOLYMER CONCRETE

Geopolymer materials are manufactures using the chemicals are forms silica aluminium Oxides are forming bond between the materials it involves the chemical reaction of Si-O-Al. Experimental research on the sodium pellets and sodium hydroxide are used as the alkaline solution as the preparation of geopolymer concrete with different of molarities which varies from 8 to 16 molarities concentration. In total volume of the concrete occupied 80% of aggregates. Concentrations on sodium materials are cheaper then potassium origin based components. To improve the workability of concrete adds super plasticizers as a admixtures.

### Materials Used in the Experimental Work

- **Fly Ash**

The Fly ash, which major ingredient of present work was procured from(RTPP) RayalaSeema Thermal Power Plant, Muddanur, Kadapa District, Andhra Pradesh.

- **Coarse Aggregate**

20 mm and 10 mm aggregates of uniform size are used which are procured from locally available crusher. Physical properties are tabulated below in table No: 1

**Table 1: Physical Properties of Coarse Aggregate 20mm**

| S. No | Property | Value | |
|---|---|---|---|
| | | 20mm Aggregate | 10 mm Aggregate |
| 1 | Specific gravity | 2.5 | 2.65 |
| 2 | Bulk density (compact) | 1573 Kg/cum | 1555 kg/cum |
| 3 | Bulk density (Loose) | 1423kg/cum | 1340 kg/cum |
| 4 | Fineness modulus | 7.01 | 6.95 |

### Fine Aggregate

Fine aggregate is procured from local suppliers from pandemueru river nearby to Anantapur city. Physical properties are tabulated below in table No: 2

**Table 2: Physical Properties of Fine Aggregate**

| S. No | Property | Value |
|---|---|---|
| 1 | Specific gravity | 2.648 |
| 2 | Fineness modulus | 3.06 |
| 3 | Bulk Density (compact) | 1711 Kg/cum |
| 4 | Bulk Density (loose) | 1631 kg/cum |
| 5 | Grading | Zone-II |

**Sodium Hydroxide Solution**

Sodium Hydroxide which is one of the major ingredients of geo polymer concrete. It is prepared from the sodium hydroxidepellets mixing with water 24 hours before casting has to be done. The following are the specifications of Sodium hydroxide pillets specified by SDFCL –Limited, Mumbai and this material is procured from the local laboratory chemical vendors in Anantapur. Specifications are tabulated in table 3 as given by the suppliers.

**Table 3: The Specifications of NaOH Pellets**

| Purity | 97%( Assay) |
|---|---|
| Na2co3 | 2% |
| Cl | 0.01% |
| SO4 | -0.01% |
| $SiO_2$ | 0.02% |
| Zinc | -0.02% |
| $PO_4$ | 0.00% |
| Aluminium(Al) | 0.00% |

**Sodium Silicate Solution**

Sodium Silicate Solution in Alkaline Grade are supplied by Astrra Chemicals,11, Moores Road, Thousand Lights, Chennai – 600. Specifications are tabulated in table 4 as given by the suppliers.

**Table 4: Specifications of Sodium Silicate Solutions**

| Specific Gravity (30°C) | 1.46 To 1.50 |
|---|---|
| Viscosity (30°C) (By B4 Cup) | 40 sec To 80 sec |
| Na2O % | 13.5 To14.5 |
| SiO2 % | 27.0 To29.0 |
| Weight Ratio | 1:2.00 To 1:2.40 |
| Mole Ratio | 1:2.06 To1:2.47 |

- **Water**

Potable water is used for making of NaOH solution and in preparation of fresh concrete.

- **Super Plasticizer**

Commercial available super plasticizer was used to improve workability properties at fresh stage of geo polymer concrete.

**Mix Design of Geo Polymer Concrete**

The following are the adopted design Parameters of the Mix design of the Geo Polymer Concrete

| Unit Wt of Concrete is Assumed as | | 2400 kg/cum |
|---|---|---|
| Mass of Aggregate is taken as 77% of concrete | = | 1848 Kg/cum |
| Mass of Coarse Aggregate as 65% of Total Aggregate | = | 1201 Kg/cum |
| Mass of Fine Aggregate as 35% total Aggregate | = | 646.80kg/Cum |
| Mass of 20 mm aggregate as 70% of Coarse Aggregate | = | 841 kg/cum |
| Mass of 10mm Aggregate as 30% of Coarse Aggregate | = | 360 g/cum |
| Mass of Alkali Liquid +Fly Ash | = | 552 kg/cum |
| Assumed Alkali Liquid to Fly ash Ratio as 0.35Fly Ash | = | 408 kg/cum |
| Alkali Liquid | = | 143 kg/cum |
| Ratio of Sodium Silicate to Sodium Hydroxide | = | 2.5 = 41 kg/cum |
| Sodium Hydroxide pillets wt for 8 Molarity is | = | 26.2% = 10.74 kg/cum |
| water in this solution | = | 30.26 kg /cum |
| Sodium Silicate Solution | = | 102 kg |
| Water to Fly Ash Ratio | = | 0.33 |
| Water to geo polymer solids Ratio | = | 0.3 |
| Commercial Available super plasticizer is adopted as 1.5% of Fly ash by wt | | |

**Experimental Program**

**Preparation of Fresh Geopolymer Concrete**

The geopolymer mix consists of sodium hydroxide pellets were dissolved in water, make solution before the preparation of cube casting. The sodium hydroxide and the sodium silicate solutions were mixed together with super plasticizer then added to the dry materials and mixed throughly. After performing workability tests i.e. Vee – Bee and compaction factor, the fresh concrete was cast into the moulds of size 150x150x150 mm for compressive strength and cylinders of size 150 mm dia and 300 mm for split tensile strength.immediately after mixing, in three layers and allowed to compaction by using vibrating table. After casting, the specimens were cured in oven at 60°C for 24 hours and left to air cooling for 7, 14 and 28 days.

**Testing of Specimens**

Both cubes and cylinders casted were tested by using compression testing machine after 7, 14 and 28 days.

## RESULTS AND DISCUSSIONS

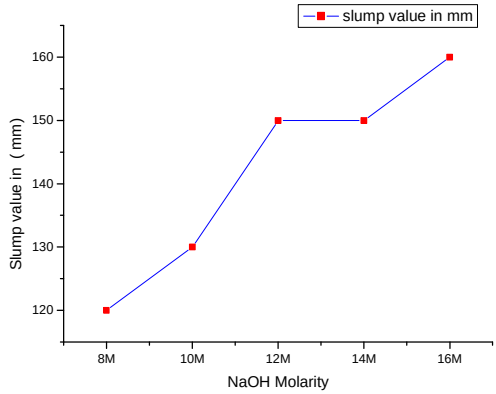
Based the Experimental investigations carried out on fly ash based geopolymer concrete with variations in molarities from 8M to 16 M, the concluded data can be presented in the following discussion.

**Fresh Properties**

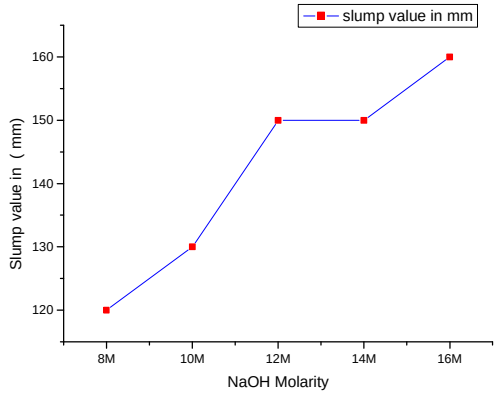
The workability tests such as Slump tests were conducted on fresh concrete mixes with different NaOH molarities are tabulated in table 5 below and graphical represented in graph 1& 2. It is observed that, the slump value is increases up to 12M and constant thereafter. But compaction factor is showed a constant increase with increase in NaOH molarities.

**Table 5: Workability Values for Different Molarities of NaOH from 8M to 16 M**

| S. No | Molarity of NaOH | Slump Value | Compaction Factor |
|---|---|---|---|
| 1 | 8M | 120 | 0.91 |
| 2 | 10M | 130 | 0.91 |
| 3 | 12M | 150 | 0.92 |
| 4 | 14M | 150 | 0.93 |
| 5 | 16M | 160 | 0.94 |




**Graph 1: Naoh Molarities vs Slump Values Obtained at Fresh Stage of Fly Ash Based Geopolymer Concrete**




**Graph 2: NaOH Molarities vs Compaction Factor Values Obtained at Fresh Stage of Fly Ash Based Geopolymer Concrete**

## STRENGTH CHARACTERISTICS

### Compressive Strength

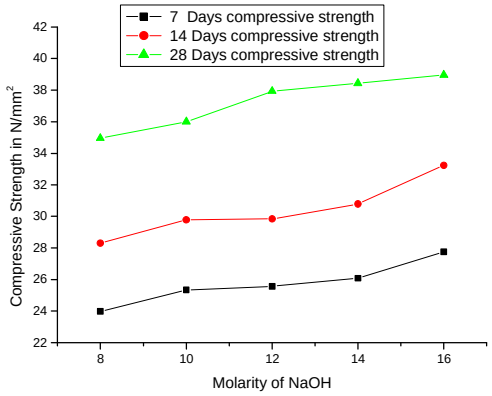
The Compressive strength and split tensile strength is noticed that increase in NaOH Molarities and curing period, observed Values are tabulated in Table No.6 & 7. and represented graphically in Graph No.3 & 4 below.

**Table 6: Compressive Strength of Cubes for Different Molarities**

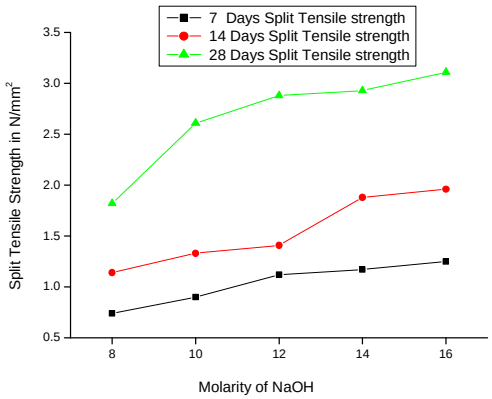
| S.No | Molarities of NaOH | Compression Strength of Cubes in Mpa | | |
|---|---|---|---|---|
| | | 24 Hours Oven Curing at $60^0$ C + 7 Days Air Curing | 24 Hours Oven Curing at $60^0$ C + 14 Days Air Curing | 24 Hours Oven Curing at $60^0$ C + 28 Days Air Curing |
| 1 | 8 M | 23.99 | 28.31 | 34.96 |
| 2 | 10 M | 25.33 | 29.78 | 36 |
| 3 | 12 M | 25.57 | 29.84 | 37.93 |
| 4 | 14 M | 26.09 | 30.79 | 38.43 |
| 5 | 16 M | 27.76 | 33.24 | 38.96 |

**Table 7: Split Tensile Strength of Cylinders of Different Molarities**

| S.No | Molarities of NaOH | Split Tensile Strength of Cylinders in MPa | | |
|---|---|---|---|---|
| | | 24 Hours Oven Curing at $60^0$ C + 7 Days Air Curing | 24 Hours Oven Curing at $60^0$ C + 14 Days Air Curing | 24 Hours Oven Curing at $60^0$ C + 28 Days Air Curing |
| 1 | 8 M | 0.74 | 1.14 | 1.82 |
| 2 | 10 M | 0.9 | 1.33 | 2.61 |
| 3 | 12 M | 1.12 | 1.41 | 2.88 |
| 4 | 14 M | 1.17 | 1.88 | 2.93 |
| 5 | 16 M | 1.25 | 1.96 | 3.11 |




**Graph 3: Naoh Molarities vs Compressive Strength of Standard Cubes For 7, 14 and 28 Air Curing Days After 24 Hours of Oven Curing At 600C**




**Graph 3: Naoh Molarities vs Split Tensile Strength of Standard Cylinders for 7, 14 and 28 Air Curing Days After 24 Hours of Oven Curing At 600C**

## CONCLUSIONS

Based on the results obtained from this study, the following Conclusions seems to be valid.

- The increase in molarities of NaOH from 8M to 16 M causes increase in Slump value .

- The increase in NaOH Molarities from 8M to 16 M and curing period, the compressive strength of Geopolymer concrete cubes is increased.
- The increase in NaOH Molarities from 8M to 16 M and curing period, the Split tensile strength of Geopolymer concrete Cylinders is increased.
- Finally, it can be concluded that the increase in NaOH Molarities from 8M to 16 M and curing period of 7, 14 and 28 days air cooling increase in strength is observed.

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