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# New Mechanisam For Using Various Grades Of Geo-Polymer Concrete With The Replacement Of Fly Ash And River Sand With Robosand

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***Abstract*** *— Generally cement is used as binding material in all concrete applications. Construction is going on everywhere due to this the demand for cement is increased. One of the efforts to produce environmentally friendly concrete is to reduce the usage of Portland cement by using by-product materials, such as fly ash. It is known that production of one ton of Portland cement accounts for about one ton of carbon dioxide released to the atmosphere, as the result of de carbonation of limestone in the kiln during manufacturing of cement. A significant advance in the usage of fly ash in concrete is the development of high volume fly ash (HVFA) concrete, which partially replaces the use of Portland cement in concrete(up to 60%), while maintaining excellent mechanical properties with enhanced durability performance. Another development is geo polymer, i.e. inorganic Alumino-silicates polymer synthesized from minerals of geological origin or by- products materials, such as fly ash, rice husk ash etc., that are rich in silicon (Si) and aluminium (Al). Fly ash is abundantly available worldwide, and efforts to utilize it in concrete production are of significant interest to the concrete technologists and industry. GGBS (Ground Granulated Blast Slag) is a waste material generated in iron or slag industries have significant impact on Strength and Durability of Geopolymer Concrete. This paper gives a brief review of the development of geopolymer concrete. The factors that affect the production of geopolymer concrete such as source minerals, workability, curing time, and curing temperature are discussed in the paper. The potential use of geopolymer concrete and the future challenges are also mentioned. The Geo-polymers are comprised of alumina-silicate materials which completely replaces the Portland cement in concrete. The main objective of this project is to investigate the various grades of Geo- polymer concrete by replacing the fine aggregate with Robosand. The Mix design procedure is examined with different grades i.e., (M-30, M-35, and M-40) for Geo- polymer concrete. The compressive strength and workability of the concrete are studied for various grades of the Geo-polymer concrete.*

**Keywords** ***—Fly Ash, Geopolymer Concrete Strength, Curing, Compressive strength, Split Tensile strength, Flexural strength.***

## 1. INTRODUCTION

Construction is going on everywhere due to this the demand for cement is increased. By taking that into consideration we are using fly ash as a binding material for concrete along with alkaline solutions,

which is named as "Geo polymer Concrete". As a result of this we can reduce demand for cement and also decrease the emissions of pollutants into the atmosphere which are releasing by cement industries. During at the time of production of cement, carbon dioxide is released into atmosphere. One ton production of cement approximately release one ton of CO2 into the atmosphere. By taking that into consideration we are using fly ash as a binding material for concrete along with alkaline solutions, which is named as "Geo polymer Concrete". As a result of this we can reduce demand for cement and also decrease the emissions of pollutants into the atmosphere which are releasing by cement industries. That to fly ash is a byproduct of which is obtained from thermal power plant, and it is also the most abundant industrial waste in the environment. The use of geo polymer concrete significantly decreases CO 2 emission and reduces environmental pollution. Utilization of natural river sand is increasing day by day with an increasing of construction activities. It is becoming a scarce material now a day. It is the second major component in the concrete mix. Since it is a natural product; it has organic and inorganic matter. Organic matter if present in sand creates void cracks after setting of concrete which intern the strength of material get decrease and the permeability of concrete is also a matter if we use such sand. There were many issues rising on extraction of natural sand like decrease of underground water table which impacts on agriculture, effect on aquatic life, erosion of river banks and loss of water holding capacity are the problem associated with natural sand extraction. To overcome all these causes synthetic man made sand called manufacture sand can also be used in place of aggregates. Here in this investigation manufacture sand is utilized in place of fine aggregates. Water is not involved in the chemical reaction of Geopolymer concrete and instead water is expelled during curing and subsequent drying. This is in contrast to the hydration reactions that occur when Portland cement is mixed with water, which produce the primary hydration products calcium silicate hydrate and calcium hydroxide. This difference has a significant impact on the mechanical and chemical properties of the resulting geopolymer concrete, and also renders it more resistant to heat, water ingress, alkali–aggregate reactivity, and other types of chemical attack. In the case of geopolymers made from fly ash, the role of calcium in these systems is very important, because its presence can result in flash setting and therefore must be carefully controlled. The source material is mixed with an activating solution that provides the alkalinity (sodium hydroxide or potassium hydroxide are often used) needed to liberate the Si and Al and possibly with an additional source of silica (sodium silicate is most commonly used).The temperature during curing is very important, and depending upon the source materials and activating solution, heat often must be applied to facilitate polymerization, although some systems have been developed that are designed to be cured at room temperature.

## 2. LITERATURE SURVEY

**[1] GANAPATHI NAIDU.P et al (2012)** presented out a Study on strength properties of Geopolymer concrete with addition of GGBS. In this paper an attempt was made to study the strength properties of Geopolymer concrete using Low calcium fly ash replacing with slag in 5 different percentages. They obtained Compressive

strength of geopolymer concrete increases with increase in percentage of replacement of fly ash with GGBS was up to 28.57% of replacement of fly ash by GGBS, the setting was normal and fast setting was observed. They concluded maximum of 25% loss in compressive strength was observed when geopolymer exposed to a temperature of C for two hours.°500.

**[2] Yogendra O. Patil et al (2013)** carried out an experimental study using GGBS as partial replacement of OPC in cement concrete Experiment were made to study the compressive and flexural strength of concrete containing various % of GGBS at the age of 7, 28 and 90 days. They concluded that Increase in % of GGBS result in decrease in strength of concrete. The Optimum replacement of OPC by GGBS was 20%.

**[3] Mohemed aquib javeed et al (2015)** a carried out Studies to find out the optimum level of sustainable Geopolymer concrete with combination of manufactured sand and pond ash as a fine aggregate material replacing conventional natural river sand and using ambient curing for its strength development. It was confirmed that 60% of m-sand and 40% of pond ash as a replacement to natural sand was optimum amount in order to get a favourable strength.

**[4] Madheswaran C.K et.al (2013)** studied the variation of strength for different grades of geo polymer concrete by varying the molarities of sodium hydroxide. Different molarities of NaOH (3M, 5M, and 7M) were taken to prepare different mixes and cured in the ambient temperature. GPC mix formulations with compressive strength ranging from 15 to 52 MPa had been developed. The specimens were tested for their compressive strength at the age of 7 and 28 days. The compressive strength of GPC increased with increasing concentration of NaOH.

**[5]. Dr. Amarnath K. et al. (2015)** Study on "Flexural Behavior of Fly Ash based Reinforced Rectangular Geo-polymer Concrete Slabs", In this experimental work the flexural behavior of the rectangular geo polymer concrete slabs is studied by using fly ash and GGBS as a binder material. The proportion fly ash and GGBS used is 70% and 30% respectively. And the molarity of the Sodium hydroxide solution used is of 8M. The ratio of the Sodium silicate to the sodium hydroxide solution is 2.5. Seven rectangular slabs were casted with the overall dimension of the slab as 1300mm X 650mm with the 75mm overall thickness with aspect ratio of 2.0. The reinforcement used for these slabs of Fe 500 High Yield Strength Deformed (HYSD) bars of 8mm diameter were placed parallel to 1300mm side and 8mm dia. bars were placed parallel to the shorter sides are placed. All these slabs were tested under the 50T loading frame. For testing of the slabs support condition provided on all the sides is simply supported and the uniformly distributed load (UDL) is applied on the slab panels. The study of the load v/s deflection is noted.

## 3. RELATED WORK

**Geo-polymer binder:**

The reaction of Fly Ash with an aqueous solution containing Sodium Hydroxide and Sodium Silicate in their mass ratio, results in a material with three dimensional polymeric chain and ring structure

consisting of Si-O-Al-O bonds. This material is called as Geo-polymer binder.

**Fine aggregate (River sand replaces with Robo sand):**

The aggregate which is passing through 4.75 mm sieve is known as fine aggregate.

It is generally seen that river sands are fast disappearing from river beds due to over exploitation. This has led to a series of research efforts and soon enough with a substitute that served equally well and much better than the river sand.

Robosand was used as replacement of fine aggregate. Robosand is a product of crushed stone, here the stones are crushed into smaller granular size of river sand granules and washed to remove the fine rock dust to enhance the quality as per IS: 2386-1975.

**Coarse aggregate:**

The particles which are greater than 4.75mm are considered as coarse aggregates. We are using 12.5mm size of aggregates.

**Water:**

Water is not involved in the chemical reaction of geo polymer concrete and instead water is expelled during curing and subsequent drying. Only water can be used in preparation of alkaline activator solutions. It can be considered only for the mixing of the geo polymer concrete.

**Parameters considered for mix proportioning of geo polymer concrete:**

**Geo polymer binder:**

Low calcium class F (ASTM CLASS F) fly ash is used.

The concentration of alkaline activator solution is 12M.

For 12M, 12*40=480 Grams of sodium hydroxide dissolved in 1000ml of water.

Solution to fly ash ratio=0.35.

Sodium hydroxide to sodium silicate ratio=1:2.5

**Robosand:** The following table represents the properties of Robosand.

| ***Properties*** | ***Observations*** |
|---|---|
| *Fineness modulus* | *2.52* |
| *Specific gravity* | *2.76* |
| *Bulk density* | *1688 kg/m$^3$* |

**Coarse aggregate:** The following table represents the properties of coarse aggregates.

| ***Properties*** | ***Observations*** |
|---|---|
| *Fineness modulus* | *6.83* |
| *Specific gravity* | *2.61* |
| *Bulk density* | *1530 kg/m$^3$* |

**Preparation of Geo polymer Concrete Mixes:**

Preparation of geo polymer concrete is similar to that of cement concrete. The fly ash,

Robo sand, coarse aggregates were mixed in dry state. Then add prepared mixture solution of sodium hydroxide and sodium silicate along with extra water based on water-to-geo polymer binder ratio and mix thoroughly for 3–4 min so as to give homogeneous mix.

It was found that the fresh fly ash based geo polymer concrete was viscous, Cohesive and dark in color. After making the homogeneous mix, workability of Fresh geo polymer concrete was measured by flow table apparatus as per IS 5512-1983 and IS 1727-1967. Concrete cubes of side 150 mm& cylinders of 300mm long&100 mm diameter are casted in three layers. Each layer is well compacted by tamping rod of diameter 16 mm. All cubes& cylinders were place on table vibrator and vibrated for 2 min for proper compaction of concrete. After compaction of concrete, the top surface was levelled by using trowel.

After 24 h of casting, all cubes were de moulded and then placed in an oven for thermal curing (The curing is at $60^0$c for 24hrs). To avoid the sudden variation in temperature, the concrete cubes were allowed to cool down up to room temperature in an oven. Three cubes & cylinders were cast and tested for compressive strength& split tensile strength for each curing period.

## 4.NECESSITY OF GEOPOLYMER CONCRETE

Construction is one of the fast growing fields worldwide. As per the present world statistics, every year around 260, 00, 00,000 Tons of Cement is required. This quantity will be increased by 25% within a span of another 10 years. Since the Lime stone is the main source material for the ordinary Portland cement an acute shortage of limestone may come after 25 to 50 years. More over while producing one ton of cement, approximately one ton of carbon di oxide will be emitted to the atmosphere, which is a major threat for the environment. In addition to the above huge quantity of energy is also required for the production of cement. Hence it is most essential to find an alternative binder. The Cement production generated carbon di oxide, which pollutes the atmosphere. The Thermal Industry produces a waste called flyash which is simply dumped on the earth, occupies larges areas. The waste water from the Chemical Industries is discharged into the ground which contaminates ground water. By producing Geopolymer Concrete all the above mentioned issues shall be solved by rearranging them. Waste Fly Ash from Thermal Industry + Waste water from Chemical Refineries = Geo polymer concrete. Since Geopolymer concrete doesn't use any cement, the production of cement shall be reduced and hence the pollution of atmosphere by the emission of carbon di oxide shall also be minimized.

**Constituents of Geopolymer concrete:**

- Fly Ash- rich in Silica and Aluminium
- Sodium Hydroxide or Potassium Hydroxide
- Sodium Silicate or Potassium Silicate

**Properties of Geopolymer Concrete:**

The superior properties of Geopolymer concrete,

- sets at room temperature
- Non toxic, bleed free
- long working life before stiffening
- Impermeable

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 higher resistance to heat and resist all inorganic solvents
 higher compressive strength

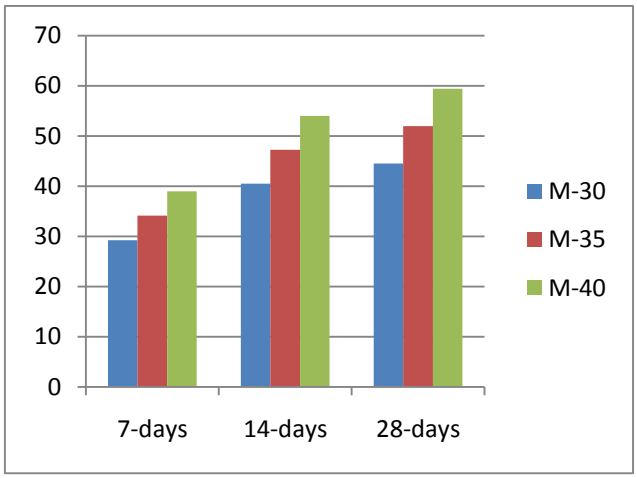
Compressive strength of Geopolymer concrete is very high compared to the ordinary Portland cement Concrete. Geopolymer concrete also showed very high early strength. The compressive strength of Geopolymer concrete is about 1.5 times more than that of the compressive strength with the ordinary Portland cement concrete, for the same mix. Similarly the Geopolymer Concrete showed good workability as of the ordinary Portland Cement Concrete.

**Limitations:** The followings are the limitations
 bringing the base material fly ash to the required location
 High cost for the alkaline solution
 Safety risk associated with the high alkalinity of the activating solution.
 Practical difficulties in applying Steam curing / high temperature curing process

Considerable research is ongoing to develop geopolymer systems that address these technical hurdles.

| ***Properties*** | ***M-30*** | ***M-35*** | ***M-40*** |
|---|---|---|---|
| *Workability in terms of flow (%)* | 29.17 | 44.15 | 61.61 |
| *Degree of workability* | medium | medium | high |
| *Passing ability(L-Box)* | 0.86 | 0.92 | 0.95 |

**Graph for comparison of compressive strengths:**

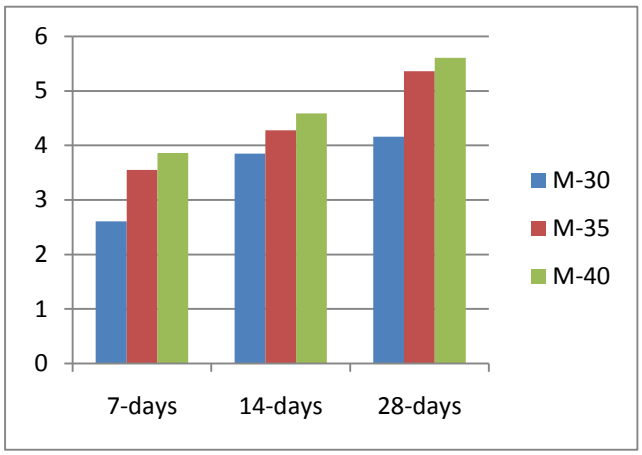



Graph represents the compressive strength for various grades.

**Graph for comparison of split tensile strengths:**

## 5. EXPERIMENTAL RESULTS

**Test results of workability:**




Graph represents the split tensile strength for various grades.

## CONCLUSION

- Due to the production of geo polymer concrete, the cement production will reduce. So the production of carbon dioxide will reduce which will cause the green house effect.
- In the production of geo polymer binder, the materials like fly ash (waste material from thermal industries) & sodium hydroxide & sodium silicate (waste water from chemical refineries) can be utilized.
- The compressive strength is 1.5 times more than the ordinary concrete.
- With the use of Robo sand, the compressive strength is increases by 30 %( approx.)
- The geo polymer concrete is cheaper, eco-friendly, greater durability& having greater workability.
- Study on the addition of various fibers in geopolymer concrete and their effect on enhancement of strength.
- Achieving ultra-high strength geopolymer concrete by the addition of silica fume, quartz sand and quartz powder.

**FUTURE SCOPE:**

1. The Geo-polymer concrete is eco-friendly than other conventional type of concrete due to complete replacement of normal sand with M-sand.
2. The replacement of M-sand reduces the hydration and also shows increase in the value of compressive strength for 5M and 10 M by 4.08% and 9.51% also shows increase in the value of Split tensile strength for 5M and 10 M by 9.2% and 4.5% respectively.
3. It is evident from the results that higher the concentration of NaoH, higher is the compressive strength of geopolymer concrete.

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Good Teachers are worth more than thousand books, we have them in Our Department.

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