# THE DEVELOPMENT OF COMPRESSION STRENGTH OF FLY ASH AND GGBS BASED GEOPOLYMER MORTAR

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## ABSTRACT

*Geopolymer mortar was prepared using fly ash, GGBS and alkaline activators such as sodium silicate and sodium hydroxide.This paper investigate compression strength of geopolymer mortar for 12M sodium hydroxide, sodium silicate to sodium hydroxide ratio was taken 2.5 and fly ash was replaced by GGBS from 10% to 90%.The specimen was cured in ambient curing. The compression test was carried out at 7 and 28 days for each combination of geopolymer mortar. Compressive strength increases with an increase in the quantity of GGBS.It can be concluded that the results of geopolymer mortars are high when compared with conventional mortars in terms of strength.*

***Keywords—Fly ash, GGBS, geopolymer, alkali activators.***

## I. INTRODUCTION

Portland cement is widely used in concrete industry since many decades ago in the world, however it releases green house gases, i.e. carbon dioxide (CO2), into the atmosphere during manufacture of cement. Geopolymer method is the one of the new technologies to reduce the use of Portland cement in concrete. Fly ash reacts with alkaline solutions to form a cementitious material, fly ash based geopolymer concrete does not emit carbon dioxide into the atmosphere when compare to normal cement concrete[3].

And also the demand for Portland cement is increasing day by day and hence, efforts are being made in the construction industry to replace cement materials and developing alternative binders in concrete, the application of geo-polymer technology is one such alternative method.There are two main constituents of geo-polymers concrete, one is thesource materials and another one is the alkaline liquids. The source materials for geo-polymers based on alumina-silicate should be rich in silicon (Si) and aluminium (Al). These material could be natural minerals such as kaolinite, clays, etc. and by-product materials such as fly ash, silica fume, slag, rice husk ash, red mud, etc. could be used as source materials. The choice of the source materials for making geo-polymers depends on following factors such as availability, cost, type of application, and specific demand of the end users.The most common alkaline liquid used in geo- polymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate.

Geopolymerization is the process of dissolution of alumina and silica oxide and activate by alkaline activator. Incorporation of low cost inert filler or aggregate is widely used in the production of mortar and concrete for Portland cement (OPC) binder .Thus, the addition of natural aggregate into geopolymer is not only enhancing the strength but promising high durability and also reducing drying cracking. Instead of functioning as low cost filler in the Portland cement. mortar and geopolymer mortar, it helps to control the workability of the mixtures in order to suit for the certain application Fly ash based geopolymer mortar described in this paper is a combination of fly ash and sand with sodium hydroxide and sodium silicate as an alkaline activator[2].

## II. LITERATURE REVIEW

Hardjito et al (2004), Geopolymers are environmental friendly materials which do not emit green house gases during polymerisation process. Besides, they need only moderate energy to produce. Geopolymers are made from source materials with silicon (Si) and Aluminium (Al) content, thus they can be made using fly ash, waste-product of coal-fired power station, as the source materials[3].

Davidovits(1999), Furthermore, geopolymer possesses excellent mechanical properties which does not dissolve in acidic solution and does not generate any hazardous alkali-aggregate reaction even with alkali content as high as 9.2%[3].

P. Chindaprasirt et al (2006),Optimum curing temperature of 60 °C was suggested for the study of the geopolymer mortar with small 50 mm cube size. This suggestion is based on the fact that smaller cube is having higher surface area-to-volume ratio compared to larger cube. Which, as a result, the smaller cube is more vulnerable to the high curing temperature and would experience loss of moisture during curing compared with the larger samples[3].

Banda Rohit Rajan et al (2015), binder prepared using the source materials such as Fly Ash and Ground Granulated Blast Furnace Slag (GGBS) without using any conventional cement have been investigated.They used various combinations of fly ash and GGBS considered are 90% & 10%, 80% & 20%, 70% & 30%. The ratio of Na2SiO3 /NaOH is taken as 2 and 2.5 and the alkaline liquid to binder ratio as 0.45. They finally conclude geopolymer mortarsmade with Na2SiO3 /NaOH ratio as 2.5 & alkaline liquid to binder ratio as 0.45 produces higher strength.

## III. MATERIALS

### 3.1 Fly ash

Fly ash, also known as "pulverised fuel ash" in the united kingdom. Fly ash is one of the waste product material, It is generated from thermal power plant. In modern cold fire power plant, fly ash is generally captured by electrostatic prepitators or other particle filtration equipment before the fuel gases reach the chimneys. Two classes of fly ash are defined by ASTM C618: class f fly ash and class c fly ash. The difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. In this paper class f fly ash used and collected from mattur dam.

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### 3.2 Ground granulated blast furnace slag

GGBS is obtained by quenching molten iron slag (a by-product of iron and steelmaking) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder. The chemical composition of a slag material varies depending on the composition of the raw materials in the iron production process. In this project GGBS collected from JSW cement limited.

### 3.3 Sodium silicate

Sodium silicate has a widely uses, including the formulation of cement, passive fire protection, textile and lumber processing, manufacture of refractory ceramics, as adhesives and in the production of silica gel. In industry, the various grades of sodium silicate are characterized by their $sio_2$:$na_2o$ weight ratio (which can be converted to molar ratio by multiplication with 1.032). The ratio can vary between 2:1 and 3.75:1. Grades with ratio below 2.85:1 are termed alkaline. Those with a higher $sio_2$:$na_2o$ ratio are described as neutral.

### 3.4 Sodium hydroxide

Sodium hydroxide (NaOH with 98% purity) flake form is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemica burns. It is highly soluble material in water, and readily absorbs moisture and carbon dioxide from the air. Sodium hydroxide is used in many industries like in the manufacture of pulp and paper, textiles, drinking water, soaps and detergents, and as a drain cleaner.

### 3.5 Superplasticizer

Superplasticizers also known as high range water reducers. CERAPLAST 300 is used in this project. It is a high-grade superplasticizer based on Naphthalene, highly recommended for increased workability and high early and ultimate strengths of concrete.

## IV. MIX DESIGN

The experiments were carried out for optimising the maximum strength. Sodium Hydroxide of 12 molar was used for making alkaline activator solution with sodium silicates liquid. Both the chemicals were well mixed together and then added in the dry mix of fly ash, GGBS and fine aggregate. For 12 M, 12X40=480 gms of NaOH solids dissolve one litre of water. In this paper 354gms of NaOH flake dissolve in 646 ml of water, binder 0.074kg, M-sand is 0.222kg, sodium silicate is 0.0177kg, superplasticizer is 0.001 for one mould.

## V. TEST SPECIMEN AND CURING DETAILS

For casting the cubes of 50mmX50mmX50mm size were used. Immediately after casting, the test specimens were covered with plastic film to minimize the water evaporation. After 1 day of casting the cubes were kept for temperature curing at $60^oC$ for 24 hrs. Then cubes were left in ambient temperature up to testing at 7 and 28 days.

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## VI. COMPRESSION TEST RESULT

Fig. 1 and Fig. 2 shows the compressive strength of fly ash based geopolymer mortar for 12M and sodium silicate to sodium hydroxide ratio was 2.5. The strength was increasing when GGBS content was increased. GGBS content was increased from 10% to 90%. The compressive test result taken for 7 and 28 days. The strength value was determined as the average of three specimens. The formula is ,Compressive strength = failure load/loaded area.

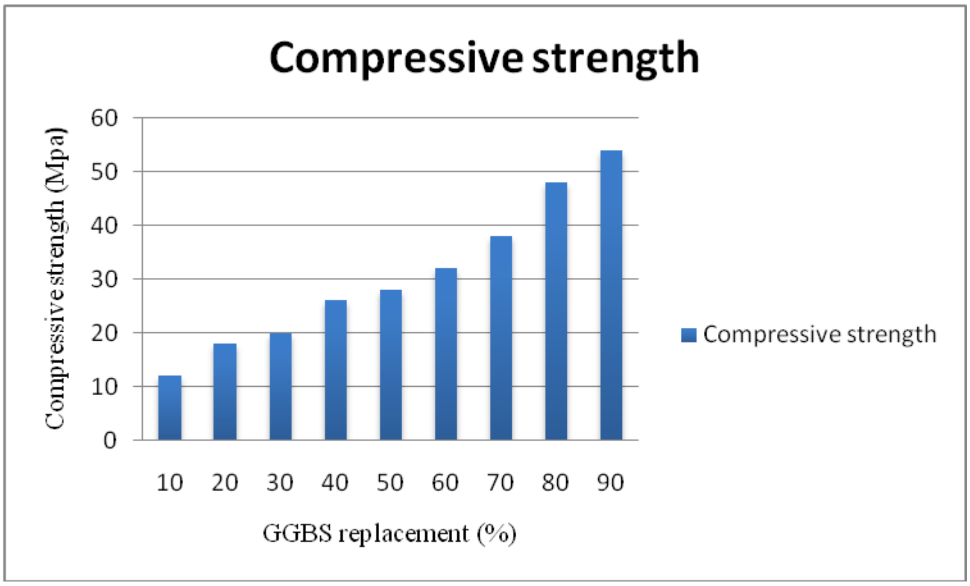


Fig 1.Compressive strength result for 7days ambient curing.

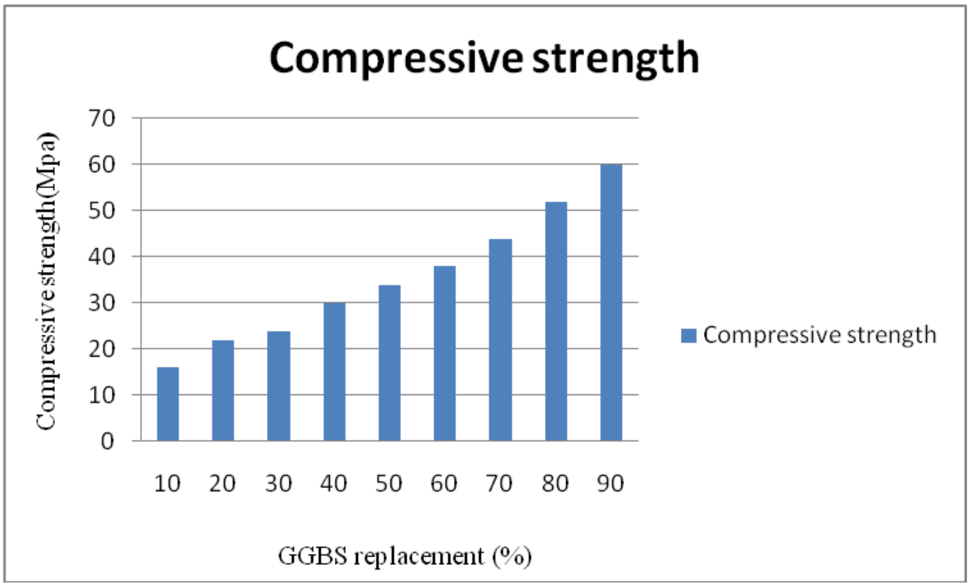


Fig 2.Compressive strength result for 28 days ambient curing.

## VII. CONCLUSION

1. From this result geopolymer mortar can obtain good strength in 28 day in ambient curing conditions.

2. Compressive strength increases when increasing GGBS content from 10% to 90% for 12M .

3. Geopolymer concrete made with fly ash,GGBS without using cement. Geopolymer concrete does not emit carbon dioxide into the atmosphere.

4. 18% to 30% economy is achieved in geopolymer mortar when compared to cement mortar[1].

5. Fly ash is a waste material obtained from thermal power plant, GGBS is obtained by quenching molten iron slag (a by product of iron). Both waste material are utilize for construction work successfully.

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