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COMPRESSIVE STRENGTH STUDY OF 14 MOLARITY GEOPOLYMER MORTAR

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ABSTRACT:
India is one of the Developing countries that needs to face the environmental pollution. We have many ways to reduce environmental pollution that causes by production of Portland cement and by the increasing of waste material. This paper studies the strength development in geopolymer mortar using industrial by-products. Geopolymer is the term used to represent the binders produced by polymeric reaction of alkaline liquid with silicon and aluminium as source materials. The by-product materials considered in this study are combination of GGBFS and Fly ash. The experimental program involves casting of geopolymer mortar cubes and testing them at 1 day, 3 days and 7 days for compressive strength. Different parameter considered in this study is alkaline fluid to binder ratio Keeping 14-Molarity of the alkaline liquid and the ratio of sodium hydroxide to sodium meta silicate as constant. It can be concluded that the strength increased with an increase in the quantity of GGBFS.

Key words: *Geopolymer, Alkaline solution, cement concrete, fly ash, slag, sustainable technology.*

1. INTRODUCTION

Portland cements are highly internal-energy-intensive and cause emission of green house gas CO_2 during their production. These Portland cement based conventional concretes are found to be less durable in severe environmental conditions. The contribution of ordinary Portland cement production worldwide in the emission of green house gas is approximately 7% to the total green house gas emission to the atmosphere. Therefore to preserve the global environment from the impact of cement production, it is essential to replace Portland cement with new binders which can show similar or better properties than Portland cement.

In 1978, Joseph Davidovits proposed that binders could be produced by polymeric reaction of alkaline liquids with silicon and aluminium in source materials of geological origin or bi-product materials of fly ash and rice husk ash. He termed these polymers as geopolymers. Palermo et al suggested that pozzolanos such as blast furnace slag might be activated using alkaline liquids to form a binder and hence totally replace the use of ordinary Portland cement in concrete. In this scheme the main contents to be activated are silicon and calcium in the blast furnace slag.

The geopolymers produced by combination of source materials and alkaline liquids has large potential in applications for bridges, such as precast structural elements and decks as well as structural retrofits using geopolymer fibre composites. Geopolymers is most advanced in precast applications. Other applications are precast pavers and slabs for paving bricks and precast pipes.

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The present research deals with the study of compressive strength of geopolymer mortar which is a combination of Ground Granulated Blast Furnace Slag (GGBFS) and fly ash activated by using alkaline solution of sodium hydroxide and sodium meta silicate of 14 Molarity with the ratio of NaOH:Na2SiO3 1:1.

2. MATERIALS

Materials used in this research are GGBFS obtained from JSW industries ltd. Bellary, Fly ash from VTPS, Vijayawada and sodium meta silicate and sodium hydroxide from Dutta scientific chemicals, Bangalore and the sand used in the preparation of mortars is local river sand. The chemical compositions of the materials used in this research are given in the table below. The sodium hydroxide is in flakes and pellets form and having about 98% purity. These pellets were mixed with distilled water to obtain the sodium hydroxide solution of required molarity. In the present study, the molarity of the solution is kept constant at 14M for all the experimental investigations.

Table 1: Chemical Composition of GGBFS

CONSTITUENTS	finenes (M^2/kg)	Particle Size(cumulative percent)	Insoluble Residue	Magnesia	Sulphide-Sulphur	Sulphide	Loss on Ignition	Manganese	Chloride	Glass	Moisture
PERCENT BY WEIGHT	412	94.25/100	0.23	8.73	0.54	0.29	0.17	0.06	0.010	90	0.14

Table 2: Chemical Composition of Fly Ash

CONSTITUENTS	Silica	Aluminium	Iron oxide	Manganese	Titanium oxide	Potassium oxide	Calcium oxide	Magnesium oxide	Phosphorus	Sulphur trioxide	Sodium oxide	Loss on Ignition
PERCENT BY WEIGHT	64.22	20.37	4.44	0.12	0.49	2.35	4.32	0.40	0.37	1.25	0.80	0.89

3. EXPERIMENTAL PROGRAM

In this research combination of GGBFS and low calcium Fly ash is used as binder instead of ordinary Portland cement in the preparation of cement mortar. The mixture of GGBFS and fly ash is activated by using alkaline solution which is a combination of sodium hydroxide solution and sodium meta silicate solution. The solution is prepared 24 hours in advance before the use. The weight of sodium hydroxide required for preparing the solution is calculated from the molarity. The molarity is kept constant throughout the experiment i.e.,14 and the weight is calculated from the gram molecular weight of NaOH i.e., 40. The required weight thus obtained is mixed with 0.5 liter of water to obtain NaOH solution and the weight of sodium meta silicate required is calculated using the ratio of sodium hydroxide: sodium meta silicate. The ratios used in this research are 1:1. The required weight of sodium meta silicate thus obtained is mixed with 0.5 liter of water to obtain sodium meta silicate solution and the two solutions are mixed together to obtain required solution of 1 liter and kept still for 24 hrs before proceeding to the experiment.

The manufacture of geopolymer mortar is carried out using the usual methods as in case of ordinary Portland cement mortar. The required quantities are weighed for a given proportion of fluid to binder ratio and binder to aggregate ratio and the materials are mixed together in pan mixture. Dry mix is carried out for 3 minutes followed by a wet mix for about 4 minutes. The mortar thus obtained is filled in cube moulds in three layers by tamping each layer 25 times and then compacting by using vibrator. The dimensions of cube used 70.6mm×70.6mm×70.6mm. The cubes thus prepared are allowed to cure under ambient conditions.

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Fig 1: Mixing, Casting and Curing Of Geopolymer Mortar Specimens

The cube specimens prepared are allowed to self curing under ambient conditions and the compressive strength is found out after 1day, 3 days and 7 days. The cubes are tested in digital compression testing machine. Three cubes are tested at a time and the results are represented in graphs.

4. RESULTS AND DISCUSSION

In the present research the effect of amount of GGBFS on the compressive strength of geopolymer mortar is studied for different alkaline liquid to binder ratios. All the cube moulds are tested for compressive strength using the digital compression testing machine. Compressive strength of the cubes is tested at the age of 1, 3 and 7 days. The testing of the cubes and the failure pattern of the cubes are shown in the below figures.

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Fig 2: Testing In Digital Compressive Testing Machine and Failure of Samples

The results obtained are represented by the following graphs:

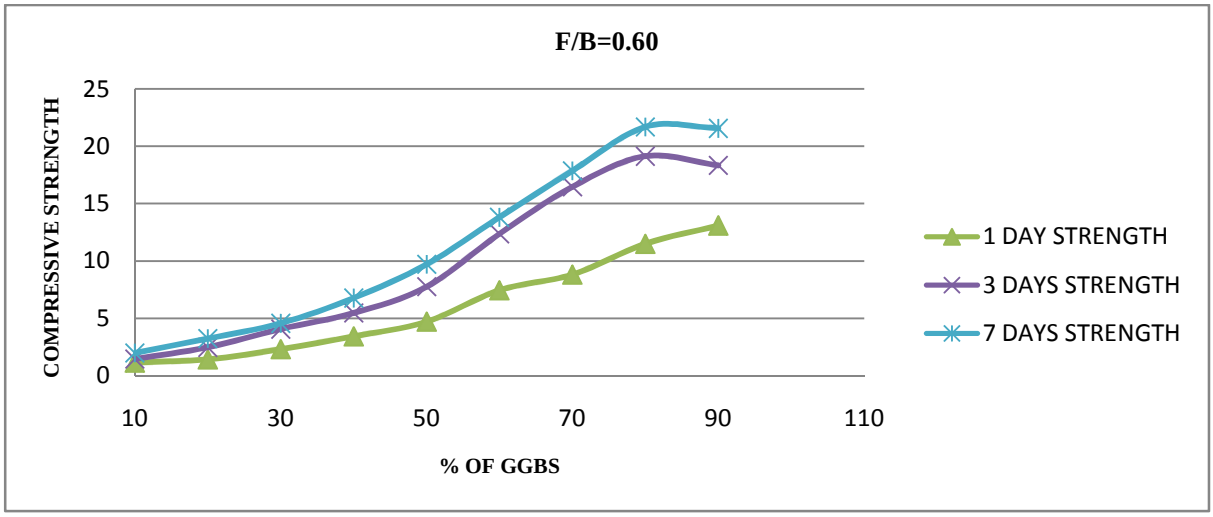

Chart 1: Variation of compressive strength with age at different percentages of GGBFS for F/B=0.60

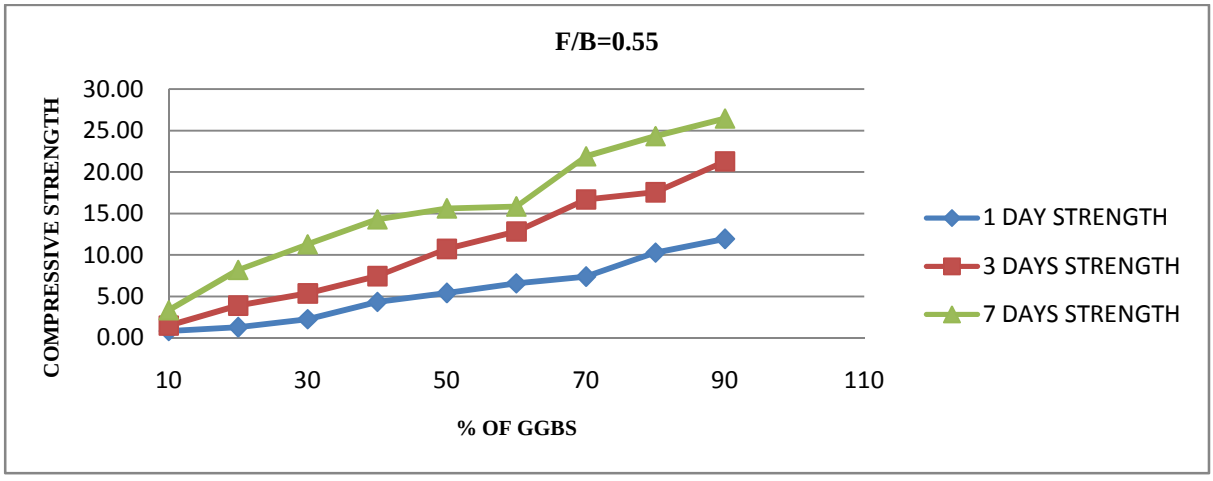

Chart 2: Variation of compressive strength with age at different percentages of GGBFS for F/B=0.55

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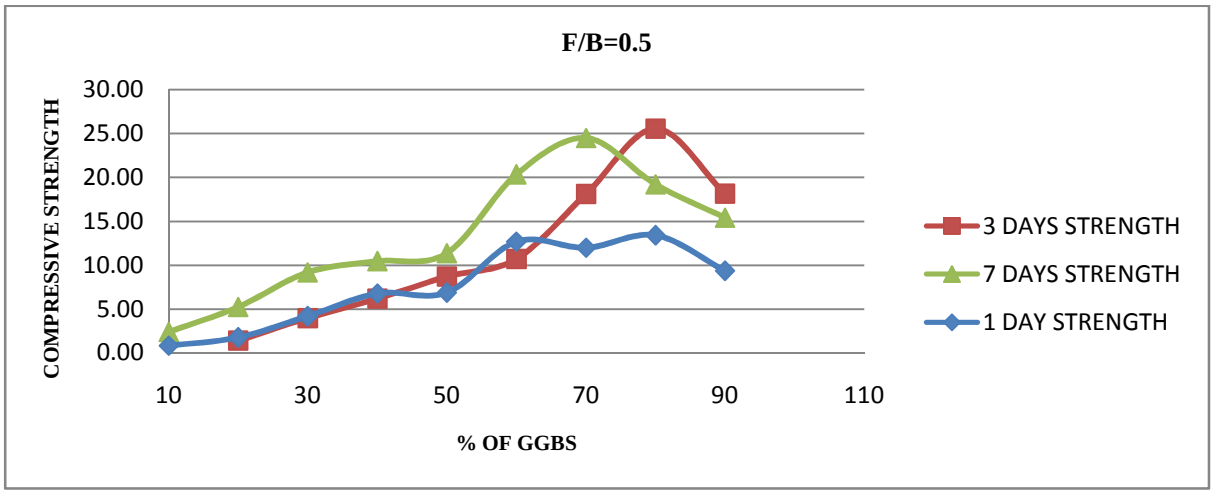

Chart 3: Variation of compressive strength with age at different percentages of GGBFS for F/B=0.50

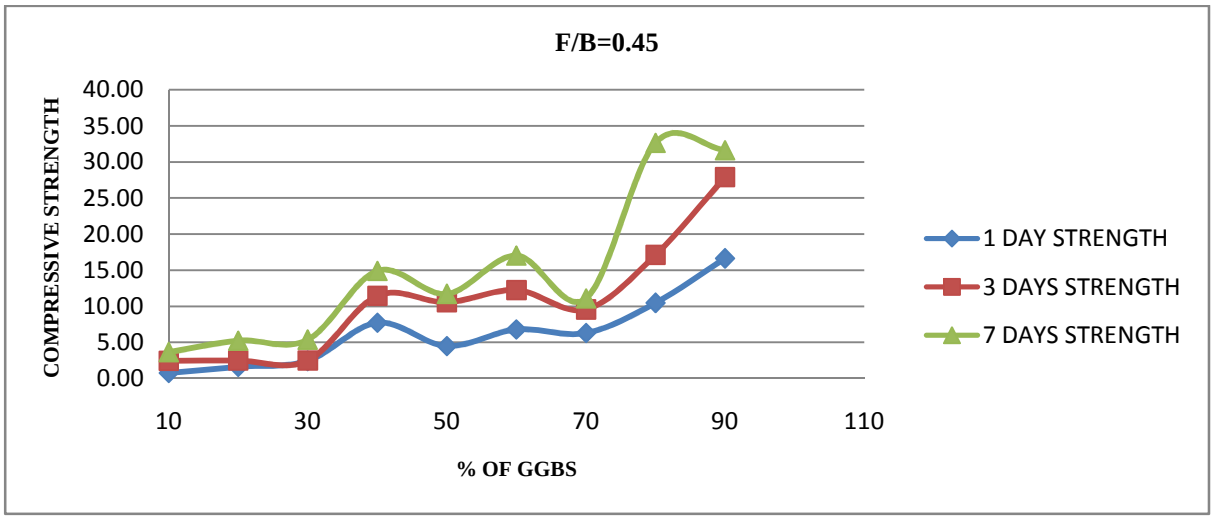

Chart 4: Variation of compressive strength with age at different percentages of GGBFS for F/B=0.50

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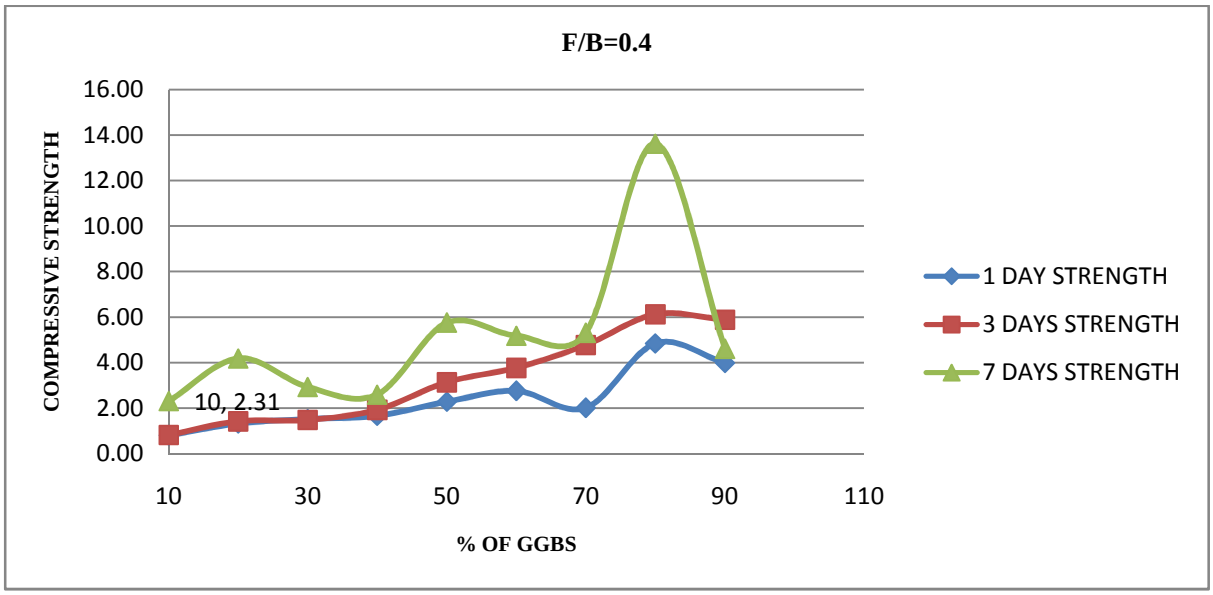

Chart 5: Variation of compressive strength with age at different percentages of GGBFS for F/B=0.40

From the above results it can be said that the compressive strength increased with the increase in percentage of GGBFS for various fluid to binder ratios. The maximum strength is obtained at F/B of 0.45. the 1 day, 3 days and 7 days strength for F/B=0.45 are 16.63MPa, 27.90MPa and 32.67MPa at 90%, 90% and 80% GGBFS respectively. From this we can say that optimum polymerisation is carried out for F/B of 0.45. If the F/B ratio is further decreased to 0.4 then the maximum strength obtained in this case is 13.63MPa for 7 days at 80% of GGBFS which is quite less than the value obtained for previous case. Hence it can be observed that at a decreased ratio of fluid the reaction is not taking place. The decreased ratio is insufficient to activate the source materials and hence there is no proper strength for a decreased fluid to binder ratio. The maximum strengths obtained for 7 days for other fluid to binder ratios of 0.6, 0.55 and 0.5 are 21.7MPa, 26.48MPa and 24.5MPa for 80%, 90% and 70% GGBFS respectively. Hence we can say that the optimum ratio of F/B to obtain maximum strength is 0.45.

5. CONCLUSION

The following conclusions can be drawn from the present experimental investigations:

- Materials like GGBFS and fly ash can be used to replace ordinary Portland cement. These can be used as binder by activating with alkaline solution.
- The compressive strength increased with an increase in GGBFS content and the maximum compressive strength is obtained for 7 days i.e. 32.67MPa at 80% GGBFS for F/B of 0.45.
- At all the proportions, compressive strength increased with an increase in age which shows that reaction continues under ambient conditions.
- The compressive strength is increased with decrease in F/B from 0.6 to 0.45 but the compressive strength decreased with further decrease in F/B from 0.45. hence 0.45 can be taken as optimum value for high strengths.

Thus, geopolymer mortar specimens shows better properties and the compressive strength increased with an increase in age. By developing methods for obtaining the chemicals at cheap cost can help to spread the practise of using environmental friendly and durable geopolymer structures.

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