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Experimental study: Alccofine as strength enhancer for geopolymer concrete

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ABSTRACT

Concrete is the most consumptive material after water in the world because of its strength and durability. But the production of cement depends on natural resources and emits a huge amount of carbon dioxide into the atmosphere. For the sustainable environment and to reduce the global warming caused by the carbon dioxide emitted by the cement industry new substitutes which are eco-friendly is the need of the hour. Geopolymer concrete also is known as green concrete or cementless concrete produced by 100% replacement of cement with the waste product obtained from the industries. Geopolymer concrete uses fly ash, slag, and rice husk as a binder which is a substitute for conventional concrete. In present work, the different trail mixtures with variation in Alccofine were prepared to check the workability, compressive strength and permeability of Geopolymer concrete. Variation in content of Alccofine is done as 0%, 10%, 20%, 25% and 30%. As arccosine is an admixture which is micro-fine in its structure, so it may affect the fresh and hardened properties of Geopolymer concrete. In the study, results show that with an increase in the content of Alccofine up to 25% the significant increase in the compressive strength of concrete can be gained.

Keywords— *Geopolymer concrete, Fly ash, Alccofine*

1. INTRODUCTION

Concrete is considered indispensable for growing infrastructural demand of the modern world. Concrete is the globally used material due to its versatile mechanical properties which make it the second most consumed construction material in the world. From the invention of Portland cement in 1824 to nowadays, it became an important part of the concrete. However, its accessibility and availability do not make it suitable and perfect for use. Environmental hazards related to cement manufacturing is overcoming its benefits. Production of ordinary Portland cement contributes to almost 4% of total greenhouse gas emission. Before making any bold decision to curtail the production of OPC, finding its alternate is a big challenge and in view of the encouraging results obtained from previous research. Geopolymer concrete can act as a major role supplement for Ordinary Concrete.

Alccofine is a new generation, the microfine material of particle size much finer than other hydraulic materials like cement, fly ash, silica etc. being manufactured in India. Alccofine 1203 and Alccofine 1101 are two types of Alccofine with low calcium silicate and high calcium silicate respectively.

2. MATERIALS

2.1 Coarse aggregates

Locally available coarse aggregates having the maximum size of 20 mm, and 10 mm were used in the present work. The aggregates were tested as per Indian Standard Specifications IS 383-1970. The aggregates used in testing are used in surface dry condition.

2.2 Fine Aggregate

The sand used for the experimental program was locally procured and conformed to grading zone III. The fine aggregates were tested per Indian Standard Specifications IS 383-1970. Fineness Modulus of fine aggregate = EF/100 = 250.7/100 = 2.507.

2.3 Fly ash

Alkaline solution on reaction with alumina- silicate based material developed geopolymer concrete. The fly ash, which is rich in silica and alumina, can be used as source material for GPC binder. The fly ash of class F was used as a binder for geopolymer concrete and was procured from Fly Ash Bricks Industry, Sirhind, and Punjab. It was tested for chemical and physical properties.

2.4 Super plasticizer

A super plasticizer (Galenium based), in the quantity of 2% of the mass of fly ash was used to increase the workability. Sodium silicate solution was procured in solution form. Sodium hydroxide solution and sodium silicate are mixed along with the dose of super plasticizer thoroughly at least one hour in advance to the mixing of ingredients of concrete.

2.5 Alkaline activators

For the process of geopolymerization it is only these alkaline solutions which play a significant role. The most commonly used alkaline solutions for geopolymerization process are combinations of potassium hydroxide or sodium hydroxide and potassium silicate or sodium silicate. In present work sodium silicate and hydroxide is used as an alkaline activator for geopolymerization reaction. Both the chemicals were procured from the Science Market, Ambala. Sodium hydroxide was in the form of pallets with 99 per cent purity. The morality of NaOH was taken 16M. As mixing of sodium hydroxide is an exothermic reaction so heat is evolved. In order to cool down the solution, the mixing of sodium hydroxide is done one day earlier to casting.

2.6 Alccofine

Alccofine is a mineral admixture produced by Ambuja Cement Ltd. Alccofine 1203 is a specially processed product based on Copper Slag of high glass content with high reactivity obtained through the process of controlled granulation. It is one type of super-pozzolanic material which reduces the permeability in concrete and creates dense packing in concrete and ultimately reduces the water content and increase the compressive strength of concrete. Alccofine 1203 was procured from Ambuja Cement Ltd Goa.

3. MIX DESIGN

The mix design of geopolymer concretes with fly ash was done in reference to the proposed design mix by the researchers as no specified guidelines are available from Indian Standards. The mix design was finalised by taking 3 trials. The mix with fly ash content of 400kg/m^3 gives the required strength for M30 grade. Similar to that of conventional concrete, coarse and fine aggregates were taken approximately 75-77% by mass of the entire mixture. The concentration of the NaOH solution was 16M so as to achieve better compressive strength. 2% Naphthalene Sulphonate based superplasticizer was used to improve the workability of fresh geopolymer mix. Alkaline liquid (NaOH + Na_2SiO_3) to fly ash (AL/FA) ratio was taken 0.46. Further Na_2SiO_3 is 2.5 times NaOH. Alccofine is added in addition by mass and as a percentage of Fly Ash. The exact mix proportion of geopolymer concrete mixes is given in table.1. The different mixes were made as follow:

Table 1: Mix proportions (in Kg) for one cubic meter of GPC

Mix Designation	Fly Ash (Kg)	Coarse Aggregates (Kg)		Fine Aggregate (Kg)	Alccofine (percentage of fly ash) (%)	Quantity of Alccofine (Kg)	NaOH (Kg)	Na_2SiO_3 (Kg)	Water(Kg)
		20 mm	10 mm						
MA0	400	632	632	540	0%	0	52.58	131.45	27.07
MA10	400	632	632	540	10%	40	52.58	131.45	27.07
MA15	400	632	632	540	15%	60	52.58	131.45	27.07
MA20	400	632	632	540	20%	80	52.58	131.45	27.07
MA25	400	632	632	540	25%	100	52.58	131.45	27.07
MA30	400	632	632	540	30%	120	52.58	131.45	27.07

4. RESULTS AND DISCUSSIONS

4.1 Workability

4.1.1 Slump cone test: This is an important test for finding out the workability of Geopolymer concrete. As the quantity of admixture is increased so the change in slump value was expected. So to find the effect of Alccofine on slump value, Slump cone test is conducted on all mixes.

Table 2: Slump Test Results

Mix Designation	Alccofine	Slump Value in mm
MA0	0%	20
MA10	10%	55
MA15	15%	62
MA20	20%	70
MA25	25%	72
MA30	30%	75

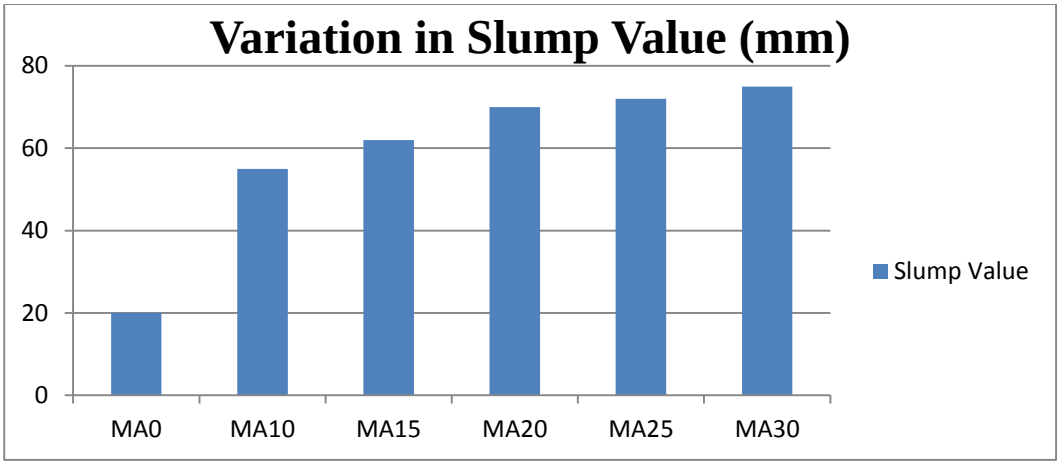

Fig. 1: Variation in Slump Value (mm)

4.1.2 Compressive Strength Test Results

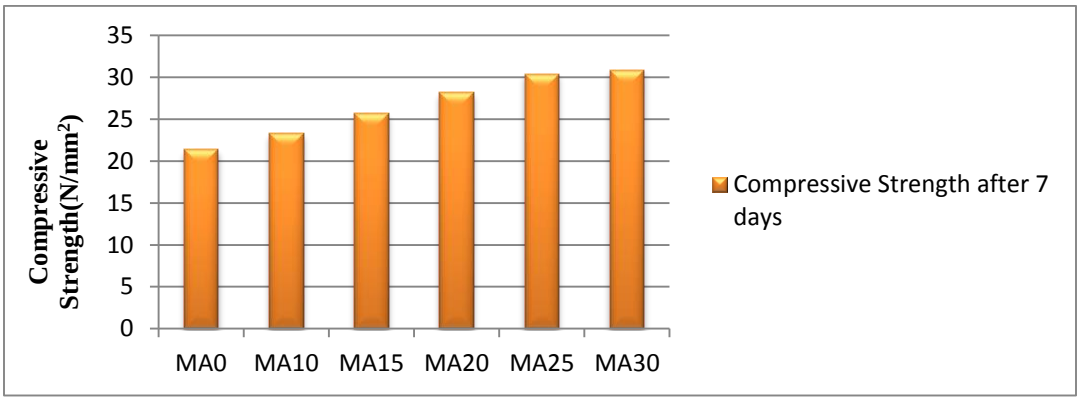

Fig. 2: Compressive Strength test results after 7 days

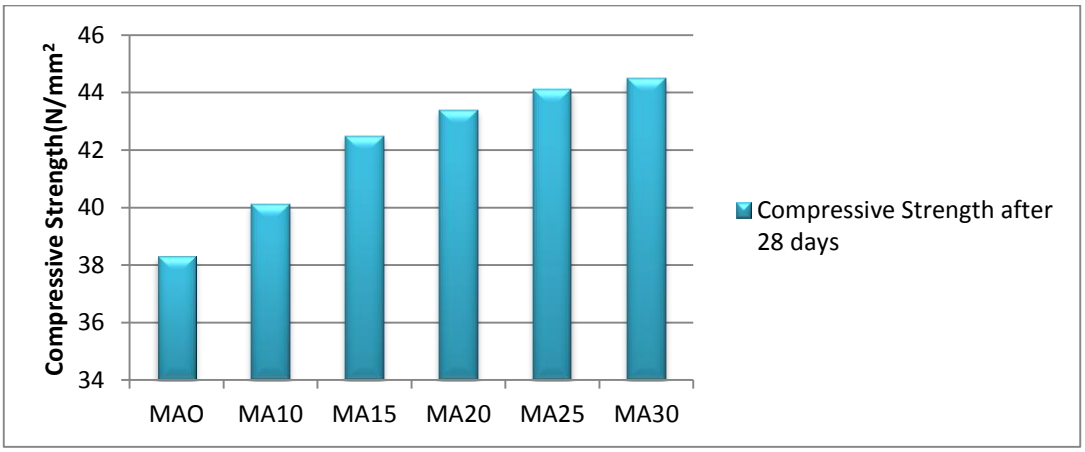

Fig. 3: Compressive Strength test results after 28 days

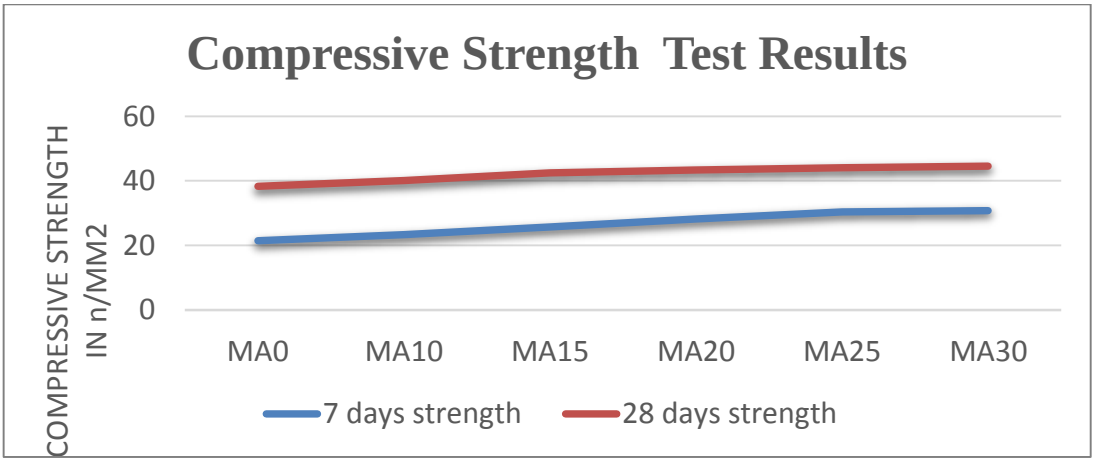

Fig. 4: Compressive Strength test results

4.1.3 Effect of Alccofine Content on Permeable Voids

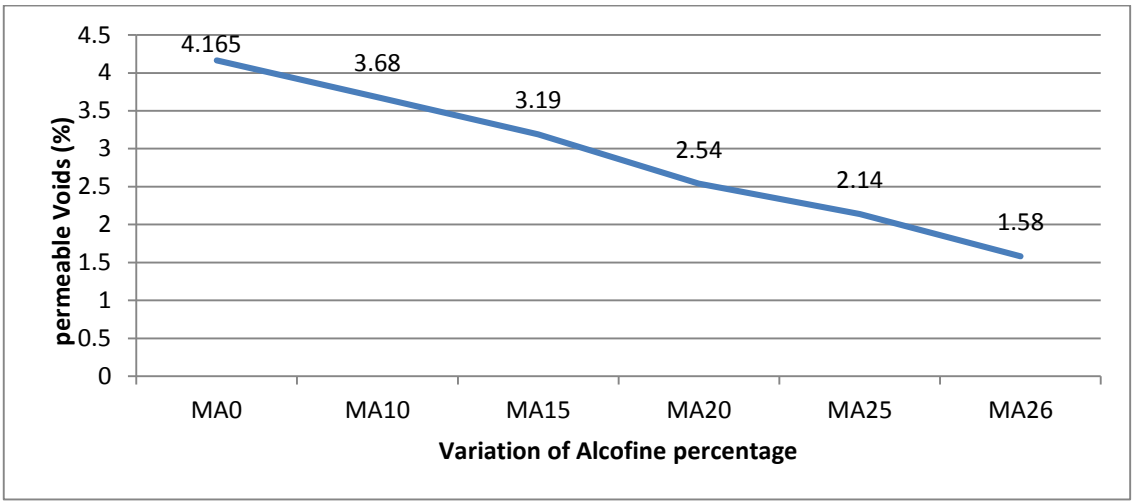

Fig. 5: Effect of Alccofine Content on Permeable Voids

5. CONCLUSIONS

The following conclusions are drawn from this study:

(a) From the results of the study, it is clear that alccofine increases strength as well as workability of geopolymer concrete.
(b) With the increase in the content of alccofine up to 25%, compressive strength increases.
(c) There is no such considerable increase is observed at 30% alccofine.
(d) Geopolymer concrete requires no water curing.
(e) The addition of Alccofine enhanced the compressive strength of GPC significantly due to its unique structural properties like higher specific area which have filled the micro pores in GPC, which is one of the prominent reasons for achieving denser concrete. Higher calcium oxide content in Alccofine is also responsible for accelerating the polymerization process.
(f) Approximate 15% reduction in permeable voids on the addition of 5% alccofine. Result obtained indicates that water absorption and permeability in terms of depth of penetration are decreased due to an ultra-fine particle size of alccofine, it captures the micro pores in concrete which further improves the durability of GPC.
(g) An inverse relationship exists among compressive strength and permeable voids. Thus a reduction in permeable voids results in an increase in compressive strength.

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