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Flexural Behavior Of Fly Ash Based Geopolymer Concrete Using Alccofine

Vasanth Kumar R, Elavenil S

Abstract: ***The geopolymer concrete is a developing unconventional binder with low eco-friendly effect and possible to increase sustainability of concrete construction. The cement has been substituted by fly ash and alccofine with varying different percentages. The testing methods carried out in this paper are compression strength, split tensile strength and flexural strength. In this paper, 10M sodium hydroxide was used. The result shows that GPC (geopolymer concrete) produced with fly ash and alccofine enhances the properties. Concrete cubes, cylinder and beam samples were casted and tested to obtain mechanical and durability properties of various mixes.***

Keywords: GPC, fly ash, alccofine and alkaline activator.

I. INTRODUCTION

In the world, the extensively used material was concrete. OPC was generally used as a binder in concrete. The growing of Portland cement manufacture corresponds to influence and surroundings issues. Global warming was induced through the production of too much greenhouse gases into the air and CO_2 was certainly accountable for almost 65% of worldwide issues. The production of cement leads to production of loads of CO_2 into the air. It is important to replace the conventional concrete because it is globally stressful. GPC can be used as an alternative in place of cement because of its good performance. Geopolymer have remained first hypothesized through davidovits in the late 1970s. R.P Williams et al. The two types of fly ash used in this study was mechanical fly ash milling and raw fly ash and results were compared. Using raw fly ash, the compressive strength achieved was 180%. The strength gained using mechanical fly ash was 80%. The raw fly ash has shown better results. Faiz Uddin Ahmed et al. The class F fly ash is used in this paper. The NaOH solution used was 12M. The binder proportion of NaOH and Na_2SiO_2 was 0.60. Pradip Nath et al. The NaOH solution used was 14M. The binder proportion of NaOH and Na_2SiO_2 was 2.5. Mix 1 was substituted with fly ash. Mix 2 and 3, 90% fly ash &10% GGBS and 85% fly ash&15% GGBS. In mix 4 and 5 OPC (6% and 8%) is added. In this paper, the strength was compared between the geopolymer concrete and normal concrete. Geopolymer concrete strength is slightly greater than the conventional concrete. The strength of GPC improved when no water is added to the alkaline solution.

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* Correspondence Author (s)
Vasanth Kumar. R, M.tech (Structural Engineering), VIT Chennai, India
Dr. Elavenil. S, Professor school of Mechanical and Building sciences, Vellore Institute of Technology, Chennai, India.

Dhirendra Singhal et al. In this paper, three different moralities were used. The fly ash used was class F. 8M has achieved better compressive strength. With increase in molarity it can reduce the workability. Namshik Aha et al. Three mixes were done in this paper and quantity of fly ash, fine aggregate, NaOH solution, Na_2SiO_2 in that three mixes. The specimens were made and it is cured by oven method. S.K .Saxena et al. Six mixes were done in this paper with varying quantity of different materials. The concentration of NaOH used was 14M. Mix 1 without fly ash and in Mix 2,3,4,5 and 6 without OPC. Benny Joseph et al. In this paper, the prepared specimens were cured in the elevated temperature with different temperature. The type F fly ash was used. The ambient curing has shown better result than varying temperature. Anuja Narayanan et al. The GPC specimens were covered by a plastic sheet so that moisture will not evaporate. The ambient curing was followed for 24 hours. The specimens were cured at various temperatures. The specimens alongside mildew protected by a plastic sheets at 1200(240).

II. MATERIALS AND PROPERTIES

A. Binders

The binders used are fly ash and alccofine. Both fly ash and alccofine are obtained from local suppliers.

1. Fly Ash

The fly ash was prepared by the burning waste material or powered coal. The fly ash used in this paper was class F (low calcium fly ash).

2. Alccofine

Alccofine 1203 is white in color and it is microfine material. Alccofine is finer than the cement because of its fineness the strength of the geopolymer concrete enhanced. Alccofine develops the workability by reducing the water demand.

B. Alkaline Activators

Alkaline activators consist of NaOH and Na_2SiO_3. NaOH was prepared by dropping pellets in one litre of water in the jar and it is allowed to cool for 24 hours. The sodium hydroxide concentration is determined in terms of molarity. 10M NaOH (10x40=400gram) of NaOH solids per litre of the solution) was taken. The ratio of NaOH and Na_2SiO_3 and alkaline solution to binder ratio was taken as 2.5 and 0.45 respectively.

C. Aggregate

The different sizes of course aggregate used are 20mm and 12mm. The fine aggregate used was river sand.

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The coarse and fine aggregate properties are within the permissible limits confirming to IS 2386 and IS 383.

Table 1: Physical properties of various materials

Property	River sand	12.5mm aggregates	20mm aggregates
Specific gravity	2.6	2.75	2.75
Water absorption (%)	1.82	0.53	0.35
Crushing value (%)	-	22.25	15.56
Bulk density (kg/m^3)	1755	1460.75	1480.87

Table 2: Physical Properties of Aggregate

Property	Fly ash	Alccofine	Na_2SiO_3	NaOH
Form	Fine powde r	Microfine	Viscous liquid	Flaky pellets
Colour	Grey	White	Yellowish	White
Specific gravity	2.10	2.82	1.50	1.44
Bulk density (kg/m^3)	1520	1325	5674	3460

III MIX PROPORTION

In this paper, four different concrete mix proportions were made. The mix 1 (fly ash 95% and alccofine 5%), mix 2 (fly ash 90% and alccofine 10%), mix 3 (fly ash 85% and alccofine 15%) and mix 4 (fly ash 80% and alccofine 20%)

IV RESULTS AND DISCUSSION

A. General

Materials	Quantity(kg/m^3)			
	Mix 1	Mix 2	Mix 3	Mix 4
Fly ash	393.10	372.41	351.72	331.03
Alccofine	20.68	41.38	62.06	82.75
F.A	720	720	720	720
C.A	1080	1080	1080	1080
NaOH	53.2	53.2	53.2	53.2
Na_2SIO_3	133.01	133.01	133.01	133.01

This chapter deals with the experimental work carried out to determine the mechanical and durability properties of geopolymer concrete specimens under various tests, after desired curing periods. **Table 3: Mix proportion**

B. Mechanical properties

The mechanical properties involved determination of strength by carrying out compression test, split tensile test and flexural test.

1. Compressive strength test

The size of the cube specimen is 150x150x150 mm. The specimen is placed between base plate and load is applied across the longitudinal section of the specimen. Figure 1 shows the experimental setup of specimen under compression test. Table 4 shows the compressive strength value of various mixes at 7 and 28 day.

Figure 1: Experimental setup for compression test

Table 4: Compressive strength of various mixes

Mix	7 day Mpa	28 day Mpa
1	13.98	26.61
2	25.38	37.34
3	44.51	53.22
4	46.15	64.67

2. Split tensile strength test

The specimens were tested in compression testing machine of 2000 KN capacity. The specimen is placed between base plate and load is applied across the longitudinal section of the of the specimen. Figure 2 shows the experimental setup of specimen Under compression test. Table 5 shows the compressive strength value of various mixes at 7 and 28 day.

Figure 2: Experiment setup for split tensile test.

Table 5: Split tensile strength of various mixes

Mix	7day Mpa	28 day Mpa
1	1.85	2.96
2	1.96	3.34
3	2.24	3.96
4	2.56	4.51

3. Flexural strength test

The size of beam specimen is 150x150x700. Four beams were casted and three points bend method beam test is done to determine the flexural strength properties of geopolymer concrete mixes. The figure 3 shows geometry of the beam specimen. Figure 4 shows the experimental setup of specimen under flexural strength test. The figure 5 shows the force- displacement curves for different mix. Table 6 shows the compressive strength values of various mixes at 28 day.

Figure 3: Geometry of the specimen

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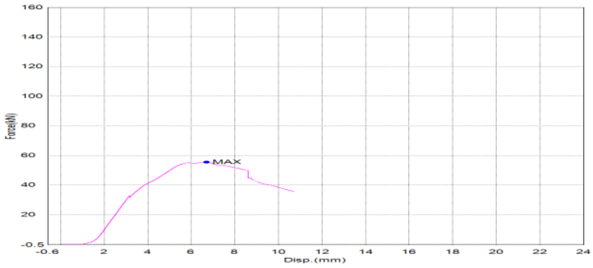
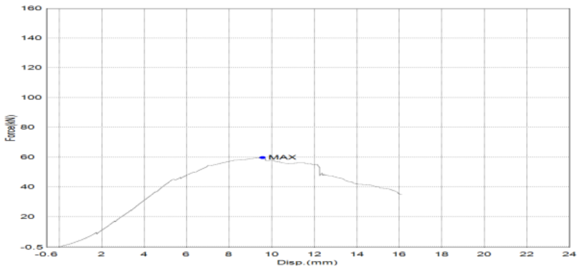
Figure 4: Experimental setup for flexural strength test

Table 6: Flexural strength of various mixes

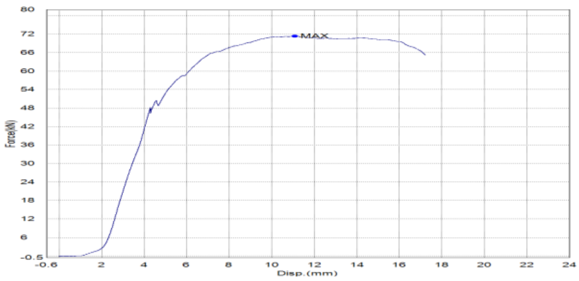
Mix	Ultimate load KN	Maximum stress N/mm^2	Maximum displacement mm
1	55.38	13.54	6.69
2	59.81	14.62	9.56
3	71.39	17.45	11.09
4	101.33	24.77	6.77



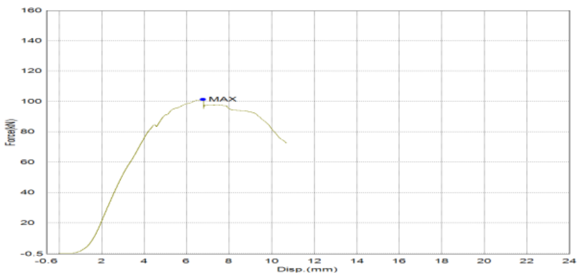
a) Mix 1



b) Mix 2



c) Mix 3



d) Mix 4

Figure: 5 Force-displacement curves for different mix

C. Durability properties

1. Chloride attack test

Chloride attack is the primarily cause of corrosion of reinforcement. Calcium chloride and sodium chloride leaches calcium hydroxide and cause concrete disintegration. For the chloride attack, samples were immersed in 5% of NaCl solution. Before immersing, dry weights of the specimens are to be noted. After particular days, take out the specimens and keep it for drying. Weigh the specimens and check the variation in the weights. Also check the compressive strength and find the percentage change in the compressive strength of the sample. The figure 6 shows the tested samples of chloride attack.

Figure 6: Tested specimens of chloride attack

Table 7: Chloride attack

Mix	Compressive Strength N/mm^2			% Loss of weight		
	28 days	56 days	90 days	28 days	56 days	90 days
1	21.56	19.11	17.31	1.89	1.99	2.33
2	32.67	29.26	26.91	1.85	2.01	2.55
3	51.33	49.65	46.95	0.75	1.23	1.53
4	62.75	58.01	56.56	0.90	1.54	1.84

2. Sulphate attack test

Sulphate attack can happen in two ways-internal and external attacks. External sulphate attack can happen through environments like soil, water which penetrates to concrete structures. Internal sulphate attack can happen either by high sulphate content or from aggregate contaminated with gypsum. The specimen after curing were weighed and noted as the initial weight of the specimens. Then, the samples were immersed in the 5% of sodium sulphate solution. After 28, 56 and 90 days, specimens were taken out from the solution and allow it to dry. Check the weight of the sample as final values of specimen. Also, compressive strength and compare it with initial compressive strength. Figure 7 shows the tested samples of sulphate attack.

Figure 7: Tested specimens of sulphate attack

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Table 8: Sulphate attack

Mix	Compressive Strength N/mm²			% Loss of weight		
	28 days	56 days	90 days	28 days	56 days	90 days
1	22.78	20.21	17.45	1.79	1.89	2.12
2	33.26	31.36	29.61	1.50	1.62	1.99
3	52.47	48.54	47.11	1.13	1.55	1.75
4	61.85	59.15	57.77	1.26	1.87	2.06

3. Acid attack test

Some chemical environments can deteriorate the concrete even if it is a high quality concrete. Sulphuric acid can be formed by sulphurous gases which forms during combustion React with moisture and forms sulphuric acid. Also, the bacteria present in the sewage converts into sulphuric acid. During the reaction of sulphuric acid with concrete, calcium sulpho-aluminate will forms and it crystallise and causes expansion and disruption of concrete. For acid attack test, three specimens of cubes 150mmx150mmx150mm after curing was taken note the initial weights of the cubes before immersing in the solution. Samples were immersed in the solution of 5% of sulphuric acid. The PH of 3 was maintained throughout the test. After 28, 56 and 90 days, specimens have to keep for 1 day for drying. After drying, check the weight of the samples and also, the compressive strength of the samples by testing it in compressive testing machine.

Figure 8: Tested specimens of acid attack

Table 9: Acid attack

Mix	Compressive Strength N/mm²			% Loss of weight		
	28 days	56 days	90 days	28 days	56 days	90 days
1	19.74	17.62	15.33	2.77	3.21	3.51
2	31.59	27.54	25.15	2.84	3.03	3.12
3	50.26	47.99	45.48	2.21	2.88	2.95
4	60.84	58.32	55.62	2.75	3.33	3.65

V. CONCLUSION

- The maximum compressive strength and split tensile strength of the geopolymer concrete of 64.67Mpa and 4.51Mpa respectively was obtained with 80% fly ash and 20% alccofine.
- Geopolymer Mix 4 with 80%fly ash and 20% alccofine shows maximum ultimate load of 101.33KN.
- The 28 days strength of geopolymer of mix 3(fly ash 85% and alccofine 15%) and mix 4(fly ash 80% and alccofine 20%) was improved due to hydration in addition of polymerization.
- Geopolymer concrete of mix 4(fly ash 80% and alccofine 20%) has shown better resistance to chloride attack, sulphate attack and acid attack.

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AUTHORS PROFILE

Vasanth Kumar R, Student of final year M.tech, VIT Chennai, 600117, India

Dr. S. Elavenil is working as a professor in school of Mechanical and Building sciences, Vellore Institute of Technology, Chennai, India. She obtained the Ph.D degree in Dynamic response of plates under impact loading in 2006 from Anna University and M.E degree in Structural Engineering in 1994 from NIT Trichy, India. She did B.E degree in Civil Engineering from PSNA college of Engineering, Dindugal, India. She published more than 60 papers in the National and International journals. She has published 3 books. Her research interest includes Finite Element Method, Fibre reinforced concrete, Structural Dynamics and Earthquake Engineering.

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