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AN EXPERIMENTAL STUDY ON FLY-ASH AND STEEL SLAG POWDER BASED GEOPOLYMER CONCRETE

D. logeshwari[1], B. Kiruthika[2].

[1]*PG Student, ME-Structural engineering, Dept.of civil engineering, Paavai Engineering College*
[2]*Assistant professor, Department of civil engineering, Paavai Engineering college, Namakkal, Tamilnadu, India.*

Abstract - *In this construction world, Geopolymer concrete is a special concrete which doesn't requires the Ordinary Portland Cement and also reduces the emission of carbon-di-oxide. Geopolymer Concrete (GPC), an ecofriendly material is being used as an alternative to Ordinary Portland Cement Concrete in many areas. The Geopolymer Concrete is made up of industrial by-products (which contains more Silica and Alumina) and activated with the help of Alkaline solution (combination of sodium hydroxide & sodium silicate or potassium hydroxide & potassium silicate). Geopolymer concrete makes 90% utilization of fly ash and 10% utilization of steel slag powder in concrete along with alkaline solutions, as a binder. The specimens are casted for 10M, 14M and 16M of NaOH and alkaline to fly ash + steel slag powder with using superplasticiers.Hardened properties: The compressive strength, flexural test, spilt tensile strength of specimens are casted and testing as compared to 10M, 14M and 16M at 7, 14 and 28 days.*

Keywords: **Class F Fly ash, Geopolymer mortar, Alkaline activators, Sodium Silicate, Molarities Etc.,**

1. INTRODUCTION

Geo-polymer was first introduced by Davidovits (1991). Geo-polymer mortar does not contain Ordinary Portland Cement (OPC) instead binding material is made by reaction with alkali liquid with the source material rich in alumina and silica. Silica and alumina rich materials such as fly ash, steel slag, GGBFS and metakaolin are commonly used to make geo-polymers which promote excellent behavior and property. Geo-polymers depend on thermally activated natural or industrial by-products to produce source of Si and Al. Si and Al dissolved in the alkaline activating solution and polymerizes into molecular chains and becomes the binder. The ultimate structure of the geo-polymer depends on the ratio of Si to Al. The combination of sodium silicate (Na_2SiO_3) and sodium hydroxide (NAOH) has been widely used as the alkaline activator to produce geo-polymer. Instead, potassium hydroxide and potassium silicate solution can also be used. But sodium is economical and widely used material as of now.Geo-polymer products have high compressive strength, resistance to steel corrosion, low permeability and high durability. Fly ash is the major material approached as the source material of geo-polymer due to its commercial and performance advantage. It is the waste material or residue produced by the combustion of coal.

2. OBJECTIVE OF PRESENT STUDY

1. As geopolymer concrete as consume less amount of water when compared to conventional concrete, so we used self curing method.

2. While using geopolymer concrete, different types of industrial byproduct such as class f fly ash, GGBS, Steel slag, alkaline solution etc., as used as binder material.

3. When geopolymer concrete were used, it will reducing carbon di oxide emission level into the atmosphere but conventional concrete produce more co_2 emission level.

4. The objective of present investigation is to study the properties of geopolymer concrete along with different proportion of molarities concentration.

2.1 SUMMARY OF LITERATURE COLLECTION

According to **SMITA SINGH(2016),** from his results shows, that red mud had been the potential source material in geopolymer concrete such as fly ash , rice hush,GGBS by using ambient temperature curing method. and finally this experimental shows good strength and well desirable stetting time while they should been grinding Red mud and fly ash in 45µ.

SUMAJOUW et.al (2006) studies revealed that the behavior of fly ash based geopolymer concrete at study of slender reinforced column. In his experimental has shows class f fly ash based geopolymer concrete reinforced column gases excellent potential for precast industry.

3. MATERIAL COLLECTION

3.1 STEEL SLAG

Table 3.1 Properties of steel slag

S.No	Properties	Test results obtained
1	Specific gravity	3.09
2	Fineness modulus	4.087
3	Bulk density	1447.58 kg/m^3

3.2 FLY ASH

Table 3.2 Properties of fly ash

S.No	Properties	Test results obtained
1	Specific gravity	2.23

3.3 M-SAND

Table 3.3 Properties of M-sand

S.No	Properties	Test results obtained
1	Specific gravity	2.48
2	Total water absorption	1.35 %
3	Fineness modulus	6.682

3.4 TRANSPARENT INSULATOR DISC CERAMICS WITH COARSE AGGREGATE(20mm)

Table 3.4 Properties of coarse aggregate(20mm) and transparent insulator disc ceramics(20mm)

S.No	Properties	Coarse aggregate	ceramics
1	Specific gravity	2.48	2.70
2	Crushing value	15.80%	16.5%
3	Impact value	18.00%	28.00%

3.5 ALKALINE SOLUTION

In geo-polymerization, alkaline solution plays an important role. Sodium hydroxide solution and sodium silicate gel mixed together to get alkaline solution. Generally, NaOH is available in the market in the form of pellets or flakes form with 96% to 98% purity where the cost of the product depends on the purity of the material. The solution of the sodium hydroxide was formed by dissolving it in water based on the molarities required. It is recommended that the NaOH solution should be made 24 hours before casting and should be used with 36 hours of mixing the pellets with water as after that it is converted to semi-solid state. Na_2SiO_3- Sodium Silicate Solution in the liquid form.

4. EXPERIMENTAL SETUP

4.1 COMPRESSIVE STRENGTH TEST

Tab.no:3.5: Results for Compressive strength For Geopolymer Concrete

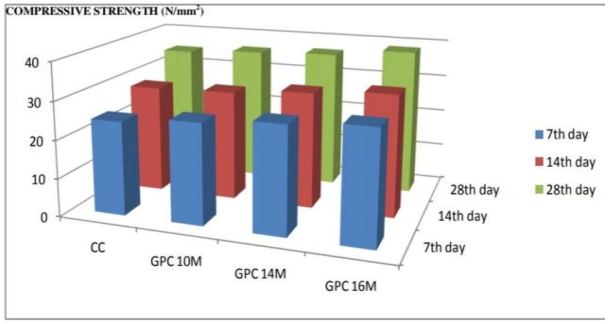
Mix	Molarity of NAOH solution	Curing method	Compressive strength (N/mm^2)		
			7 Days	14 Days	28 Days
M1	10M	Ambient curing	25.80	28.90	35.19
			26.43	29.42	35.96
			26.68	28.46	36.60
		Average	**26.30**	**28.92**	**35.90**
M2	14M	Ambient curing	27.04	29.68	38.81
			28.01	31.01	39.02
			28.81	31.92	38.01
		Average	**27.95**	**30.54**	**36.61**
M3	16M	Ambient curing	28.86	30.49	36.98
			29.07	31.18	35.67
			30.04	32.12	37.12
		Average	**29.32**	**31.26**	**38.59**

When molarity increases, the viscosity of the solution increases with increase in the compressive strength. As molarity increases, compressive strength also increases up to 18M and beyond that the strength value decreases. By optimizing the molarities, 16M has given better strength value with increasing workability as shown in table 3.5

Table no: 3.6 Results Of Cc

Mix	Compressive Strength For Conventional Concrete (N/mm^2)		
	7 Days	14Days	28 Days
M1	24.6	28.5	34.80
M2	26.80	30.3	37.67
M3	27.11	33.40	36.86
AVERAGE	**26.11**	**30.74**	**36.44**

Graph.No:1.1 Graphical Representative Of Compressive Strength CC Vs. GPC



4.2 SPILT TENSILE STRENGTH RESULT

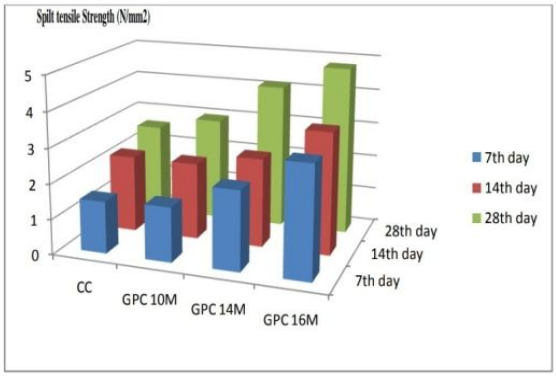
Tab.No.3.7 Spilt Tensile Results Of Geopolymer Concrete (GPC)

Mix	Morality of NAOH solution	Curing method	Compressive strength for GPC (N/mm²)		
			7 days	14 days	28 days
M1	10M	Ambient curing	1.05	1.67	2.09
			1.97	2.08	3.10
			1.63	2.82	3.67
		Average	**1.55**	**2.19**	**2.97**
M2	14M	Ambient curing	2.10	2.54	4.41
			2.14	2.14	4.23
			2.51	2.93	4.05
		Average	**2.25**	**2.53**	**4.13**
M3	16M	Ambient curing	2.97	3.15	4.47
			3.02	3.44	4.95
			3.51	3.84	5.01
		Average	**3.16**	**3.47**	**4.81**

Tab.No: 3.8 Spilt Tensile For Conventional Concrete(Cc)

MIX	Spilt tensile Strength for conventional concrete (N/mm2)		
	7Days	14 Days	28 Days
M1	1.40	2.16	2.56
M2	1.46	2.26	2.67
M3	1.60	2.36	2.70
Average	**1.48**	**2.26**	**2.643**

Graph.No:1.2 Graphical Representatives Of Spilt Tensile Strength CC Vs GPC



4.3 FLEXURAL STRENGTH TEST RESULT

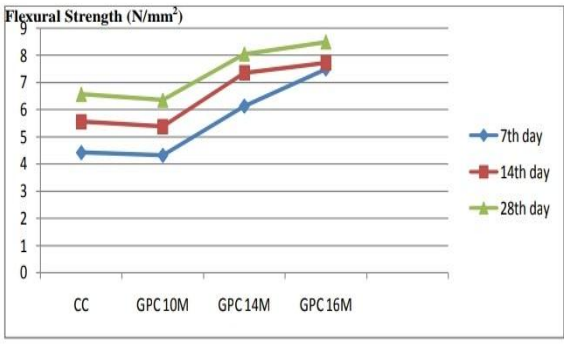
Table no:3.9 Flexural Results for Geopolymer Concrete

Mix	Molarity of NAOH solution	Curing method	Compressive strength For GPC (N/mm²)		
			7 days	14 days	28 days
M1	10M	Ambient curing	4.57	5.15	5.08
			4.09	5.06	5.65
			4.29	5.93	5.63
		Average	**4.31**	**5.38**	**5.45**
M2	14M	Ambient curing	6.16	7.18	7.55
			6.02	7.39	8.60
			6.21	7.50	8.00
		Average	**6.12**	**7.35**	**8.05**
M3	16M	Ambient curing	7.01	7.49	8.14
			7.57	7.87	8.37
			7.91	7.80	8.98
		Average	**7.49**	**7.72**	**8.49**

Table.no:3.10 Flexural Test Results For Conventional Concrete(Cc)

MIX	Flexural Strength For Cc (N/mm²)		
	7Days	14 Days	28 Days
M1	4.05	5.45	6.12
M2	4.34	5.97	6.61
M3	4.86	5.23	6.92
AVG	**4.41**	**5.55**	**6.56**

Graph. No: 1.3 Graphical Representative Of flexural strength CC vs GPC



For Geo-polymer mortar prism, Flexural strength test has been done. In this testing, single point load has been given by placing place on the prism at the centre and the test results were discussed.

CONCLUSION

- Based on the observation from the literature review, the binder to steel slag ratio is identified.
- For conventional concrete, OPC 53 grade concrete was used in this project and M_{30} mix design was used.
- For preparation of alkaline solution, Sodium hydroxide flakes and sodium silicate gel have been used for bonding purpose.
- Alkaline molarity is identified from the optimization process and molarity 16M gives better strength.
- In these experimental shows, flexural and spilt tensile strength was gave better strength but compressive strength is not gave better strength compared to other two strength.
- The maximum compressive strength of geopolymer concrete is 38.59 N/mm² at 28 days for 16 MOLARITY while comparing to other molarity like 10M, 14M.
- The spilt tensile strength of geopolymer concrete was high strength compared to conventional concrete at 7days, 14days and 28 days.
- While high molarity of NaOH was increased with strength of specimen also increased.
- The maximum flexural strength of geopolymer concrete is 8.49 N/mm² at 28 days for 16MOLARITY while comparing to other molarity like 10M, 14M.
- Geopolymer concrete strength will be get good result at 28 days because we compared to compressive strength of specimen result value.
- Spilt tensile strength of geopolymer concrete is GRADUALLY increased with respect to molarity
- The strength of specimen is increased while aging of the specimens.
- While when molarity ratio is increased, it also increasing the strength of the specimens.
- Cubes are casted for different molarity proportion and sunlight lab curing has done for optimization.

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