

Evaluation of Strength and Durability of Geo Polymer Concrete

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Abstract— It is important to durable of structure and reduce CO₂ emission through the greater use of substitute for Cement. The use of supplementary cementitious materials as partial replacements for the cement in concrete will play a significant role with respect to the environmental control of greenhouse effects and global temperature reduction. The development of geopolymer concrete (GPC), processing of geopolymer using fly ash, GGBS in combination with sodium hydroxide and sodium silicate solutions, offers a promising alternative to ordinary portland cement concrete. This study compares the different ratios of fly ash to GGBS where, 50:50,60:40,40:60 ratios and differing the molarities of alkaline solutions which are 8M,10M and 12M and comparing the strengths of the above ratios and conducting durability characteristics of fly ash and GGBS based geopolymer concrete by conducting test procedures like acid attack test

Keywords— Geo polymer concrete, Fly ash, GGBS, Durability

I. INTRODUCTION

In this modern world ,the most used raw material for construction of buildings these used material in concrete is normally manufactured mixing the ingredients such as cement , fine aggregate, coarse aggregate and water , mineral admixtures for the concrete nowadays such as ,fly ash, GGBS and also usage of super plasters for improving strength of concrete. The materials used for concrete manufactures such as fine aggregates are found in nature but the materials like cement has to be manufactured by using the various raw materials for the manufacture of cement is energy consuming process and also it produces large amount of green house gases like carbon dioxide etc which will affects the global warming hence to reduce the use of the cement in concrete the researchers started their research[2] . in the year 1978 , Davidovits proposed that the binder can be obtained by using the alkaline solution in the concrete by using the alkaline solution in the concrete the polymerization process will occur in the concrete and creates the bond between the concrete hence this concrete is called as geopolymer concrete .instead of cement we can use other cementitious materials like fly ash , ground granulated blast furnace slag and metallurgical slag these are the admixtures which are obtained due to the industrial wastes and which also reduces the pollution of the environment. [1]The geopolymer concrete is to be such that it should obtain high strength and also the geopolymer concrete should be durable. The durable concrete means the concrete should provide greater resistance towards the weathering

action, acid attacks and freeze and thaw cycles., deterioration and exposed to the harsh environment

In this project I have used different ratios of fly ash to GGBS which are 60:40,40:60 and 50:50 of 100 percent replacement of cement. In the current study on GPC are mainly focused on geopolymer technology to make fly ash and ground granulated blast furnace slag based geopolymer concrete and determination of its properties[5]

II. GEOPOLYMER CONCRETE

Geopolymer concrete is made up of source materials, fly ash, GGBS, and alkali liquids which are the combination of sodium silicate (NaSiO₃) and sodium hydroxide (NaOH) which form the binder due to the polymerization process. The binders created were termed as "geopolymers". Unlike ordinary Portland or pozzolanic cements, geopolymers do not form calcium-silicate-hydrates for matrix formation and strength, but the aluminosilicate gel formed by geopolymerization binds the aggregates and provides the strength to geopolymer concrete. Source materials and alkaline liquids are the two main constituents of geopolymers, the strengths of which depend on the nature of the materials and the types of liquids . Materials containing silicon and aluminium in amorphous form, which come from natural minerals or by-product materials, could be used as source materials for geopolymers. Kaolinite, clays, etc., are included in the natural minerals group whereas fly ash, silica fume, slag, rice-husk ash, red mud, etc., are by-product materials. For the manufacture of geopolymers,[4] the choice of source materials depends mainly on their availability and cost, the type of application and the specific demand of the users. Metallurgical slag was also used as a raw material to make geopolymer and it was found that the addition of slag enhanced the properties of the geopolymer. Among the available raw materials, fly ash has attracted more attention due to its ability in improving geopolymer physical properties and its availability in large quantities . However high compressive strength geopolymer composite was obtained at elevated temperatures curing which restricts its application to precast elements The manufacture of this new concrete follows the same production technology methods as in the case of OPC. [7]Nonetheless, whether it is geopolymer or Portland cement, concrete is a porous material, and concrete structures must be able to resist to physical, mechanical and chemical aggressions from their environment throughout their lifetime.

III. MATERIALS

A. FLY ASH

Fly ash is a by-product collected in the de-dusting of gases derived from the combustion of pulverized coal used in power plants. Fly ash is composed of fine particles, and its chemical composition is related to the different types and relative amounts of incombustible materials present in the coal. Fly ash particles are typically spherical, ranging in diameter from less than 1 μm to no more than 150 μm (Malhotra, Concrete Construction Engineering Handbook, 2008). Generally, its constitutive elements are: aluminum, silicon, calcium, magnesium, and iron. Thus, depending on the combustion process and the type of combustible, the ash can be silica, sand-lime or lime sulfur, in some cases with pozzolanic and hydraulic properties. Referring to the pozzolanic activity shown by fly ashes, the American Society for Testing and Materials (ASTM C125, 1975) defines a pozzolan as "a siliceous or siliceous and aluminous material which in itself possesses little or no cementitious value, but which will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties". Basically, the great interest for the use of fly ashes comes from their ability to react with calcium hydroxide to form calcium silicate hydrates which possess pozzolanic and hydraulic properties

TABLE 1: Physical properties of fly ash

Sl no	Physical properties	Fly ash
1	Specific gravity	2.26
2	fineness	6.8%

B. GROUND GRANULATED BLAST FURNACE SLAG

Ground granulated blast furnace slag (GGBS) is a byproduct given from the steel industry. Blast furnace slag is defined as "the non metallic product consisting essentially of calcium silicates and other bases that is to be developed in a molten condition simultaneously with iron and blast furnace to use as a cementitious material the GGBS must be ground as finer than the cement. the fineness of grind will determine how rapidly the slag will react in the concrete. In our project we are not using normal cement (OPC). are completely replacing cement with the fly ash and GGBS to make it completely a green concrete. The proportions of fly ash and GGBS can be seen in further chapters. The chemical composition of slag will vary depending upon source of raw materials and the blast furnace conditions. The major oxides exist within the slag in the form of a network of calcium, silicon, aluminium and magnesium ions in disordered combination with oxygen.

TABLE 2 Physical properties of GGBS

Sl No	Physical properties	GGBS
1	Specific gravity	2.13
2	Fineness	4.3%

C. ACTIVATOR SOLUTION

The alkali solution is used for alkalination of GGBS thus leading to polymerization which results in geopolymer binder. Sodium hydroxide and sodium silicate is used as mediums to form alkali solutions. Different concentrations of

NaOH solution were prepared in the Lab. Sodium silicate of 40% concentration and required grade was added to sodium hydroxide solution and the alkali solution was prepared. Sodium silicate are colourless glassy or crystalline or white powders in form. Na_2SiO_3 are stable alkaline solutions. This solution was prepared 1 day prior to be used and consumed within 36 hours. The solution was prepared and it should be kept covered at room temperature for gel formation

IV. METHODOLOGY

The fly ash and GGBS based geopolymer concrete specimens (GPC) were prepared with an alkaline solution ratio (sodium silicate to sodium hydroxide) of 2 by mass, since the strength was maximum, when the ratio of sodium hydroxide and sodium silicate was 2.. The grades of concrete chosen were based on IS 456-2000. The molarity of sodium hydroxide was varied as 8M, 10M and 12M. the ratio of GGBS and Fly ash is taken as 50:50. The cube specimen of size 150mmx150mmx150mm were casted. after casting the specimens they are kept in sun for 1 day. Then specimens were kept in the solution consists of 1% of 0.05N MgSO_4 and 0.25% of 1N H_2SO_4 solution for 14 days, 28 days and 56 days. after these time period the cubes were tested according to visibility, mass change and strength test. Then this has been compared with the OPC concrete

V. MIX PROPORTIONS

D. DESIGN MIX

Mix design for M30 cement concrete as per IS 10262:2009 was prepared as control mix with ratio of 1:1.5:2.5 and 0.4 w/c ratio. The control specimens were water cured for 28 days.

E. GEOPOLYMER MIX

In geopolymer mix there is a several mixes according to the proportion of GGBS to fly ash has a binding material and varying concentrations of NaOH in the alkali activator solution.

The mixes are shown in the below table.3

TABLE 3 Quantities of materials required for geopolymer concrete with varying in concentration of alkaline solution:

8 Molarity			10 Molarity			12 Molarity		
Mix	Fly ash	GG BS	Mix	Fly ash	GG BS	Mix	Fly ash	GGBS
M8.1	40%	60%	M10.1	40%	60%	M12.1	40%	60%
	240	360		240	360		240	360
M8.2	50%	50%	M10.2	50%	50%	M12.2	50%	50%
	300	300		300	300		300	300
M8.3	60%	40%	M10.3	60%	40%	M12.3	60%	40%
	360	240		360	240		360	240

VI. RESULTS & DISCUSSION

A. COMPRESSION STRENGTH OF GPC

For the compression test we have casted 8M, 10M and 12M geopolymer concrete cubes of size 150mmx150mmx150mm. after casting cubes it has been kept in a sunlight for 3 days at ambient temperature curing. After this the cubes were tested for compression test. From the literature it is known that the

Geopolymer concrete will obtain 99.99% strength within 3 days hence in this project have tested the cubes after 3 days for its strength

TABLE 4 Compression strength values of 12M NaOH Cubes

GGBS and fly ash	load(KN)	strength
8M		
M8.1	713	31.7
M8.2	756	33.6
M8.3	868	38.6
10M		
M10.1	873	38.8
M10.2	913	45.6
M10.3	1093	48.6
12M		
M12.1	1016	45.17
M12.2	1098	48.8
M12.3	1248	55.47

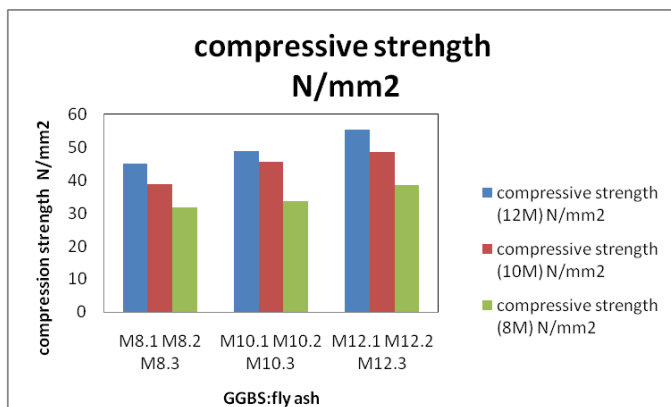


Fig. 1. Comparison graph for compressive strength for 8M, 10M and 12M concentration of NaOH in Geopolymer concrete

Figure 1 shows the comparison of compressive strength of 8M, 10M and 12M concentration of NaOH geopolymer cubes in which the 12M concentration geopolymer cubes shows the high strength from this we can conclude that as the concentration of the NaOH in concrete increases the strength of the concrete also increases gradually. Hence for further studies using 50:50 ratio that is GGBS to fly ash ratio with varying concentrations of NaOH GPC cubes

B. DURABILITY OF GEOPOLYMER CONCRETE.

Durability of the concrete is defined as the ability of which it produces resistance towards the weathering action, chemical attack, abrasion and freezing and thawing cycles. To check the durability of the cycles To check the durability of the geopolymer concrete in this paper have conducted chemical attack test i.e., sulfate attack test.

The specimens of size 150mmx150mmx150mm were kept in the solution consists of 1% of 0.05N MgSO₄ and 0.25% of 1N H₂SO₄ solution for 14 days, 28 days and 56 days. After these time period the cubes were tested according to visibility, mass change and strength test. Then this has been compared with the OPC concrete. From sulphate attack test can find out

which concrete produces the high resistance to the acid hence the durability of the concrete cannot be measured within the short time hence the concrete cubes has to be placed in the acid solution to minimum of 56 days and the durability of the concrete can be measured by visibility, change in colour and also the strength of the concrete. Here both geopolymer concrete as well as the OPC has been compared and conclude which geopolymer concrete gives the high resistance towards the acids.

TABLE 5 Results of the durability test of Geopolymer concrete

Concrete	Molarity	Days	Compression Strength(N/mm ²)
GPC	8	14	35.68
		28	34.25
		56	33.55
	10	14	45.55
		28	44.177
		56	43.15
	12	14	46.66
		28	43.91
		56	43.33
OPC	—	14	42.17
		28	38.93
		56	35.86

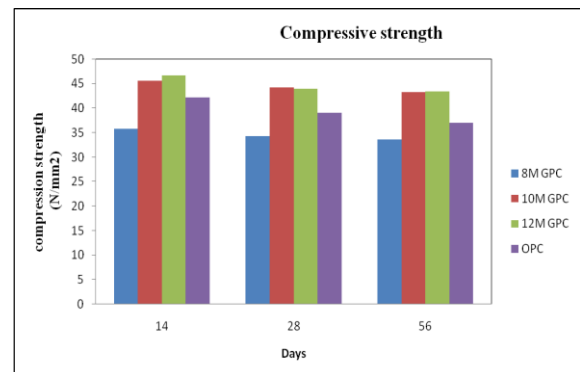


Fig 1 Comparison of the compressive strength of different concentrations of NaOH present in GPC cubes with conventional concrete.

As per the figure 2 can conclude that the geopolymer concrete which has been placed in the acid solution shows a gradual decrease of its strength but if compare to the normal OPC Concrete the resistance to acid attack is high in geopolymer concrete. Hence can conclude that geopolymer concrete shows greater durability than the normal concrete. The comparison graph shows the slight reduction in the strength of GPC concrete, 8M GPC concrete has reduced to 2.13% and 10M GPC concrete has reduced to 2.4% and 12M GPC has reduced to 3.33% and the OPC has reduced to 6.31%. The reduction of strength is of 8M GPC is less compared to other two GPC mixes hence the 8M geopolymer concrete shows high durability

VII. CONCLUSION

- F With increasing in the molarity of NaOH concentration the strength of GPC is also increasing .
- The test results show the compressive strength of GPC with ambient curing temperature results in higher compressive strength.
- From test results it is observed that the compressive strength of GPC increases with the percentage of GGBS
- The test on compression strength show that 50:50 i.e., GGBS :fly ash has considered as optimum mix with better compression strength.
- The durability test values indicates that geopolymer concrete. ,shows better durability compared to normal concrete

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