Geopolymer Concrete with Replacement of Cement

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***Abstract*- Concrete is the most abundant manmade material in the world. One of the main ingredients in a normal concrete mixture is Portland cement. However, the production of cement is responsible for approximately 5% of the world's carbon dioxide emissions. In order to create a more sustainable world, engineers and scientists must develop and put into use a green building material. Geo-polymer concrete is also much more durable that ordinary concrete due to its resistance to corrosion. It is also much stronger than ordinary concrete. Geo-polymer is made by the mixture of fly ash, sodium hydroxide, sodium Silicate and water. In this paper, we will present different properties like compressive strength, durability etc. of geo-polymer concrete with comparison to Portland cement.**

Keywords - Geo-Polymer Concrete, Fly Ash, Ggbs, Portland Cement

I. INTRODUCTION

Concrete is one of the most widely used construction material. Portland cement production is a major contributor to carbon-dioxide emissions. The global warming is caused by the emission of greenhouse gases, such as carbon-di-oxide, to the atmosphere by human activities. Among the greenhouse gases, carbon-dioxide contributes about 65% of global warming. Many efforts are being made in order to reduce the use of Portland cement in concrete. These efforts include the utilization of supplementary cementing materials such as fly ash, silica fume, granulated blast furnace slag, rice-husk ash and metakaolin, and finding alternative binders to Portland cement. In terms of reducing the global warming, the geo-polymer technology could reduce the carbon-di-oxide emission to the atmosphere caused by Cement about 80%. In this project, the effort was made to study the strength parameters of geo-polymer concrete. Objective of research is to assess comparison by strength of concrete by cement. In this study the different strength properties of geo-polymer concrete with percentage replacement of GGBS and also evaluate the optimum mix proportion of Geo-polymer concrete with fly ash replaced in various percentages by Ground Granulated Blast Furnance Slag (GGBS) [1]. In the last compare the cost variation of geo-polymer concrete with normal concrete.

A. Origin of Term 'Geo-polymer'

The term ''Geo-polymer'' was first introduced to the world by Davidovits of France resulting in a new field of research and technology [2]. Geo-polymer also known as 'inorganic polymer' has emerged as a 'green' binder with wide potentials for manufacturing sustainable materials for environmental, refractory and construction applications. Geo-polymer concrete (gpc) has ingredients required for creation of geo-polymer binders such as Geo-polymer source materials such as fly ash, ggbs, Metakaolin, rice husk ash, etc.

B. Properties Of Geo-Polymer Concrete

Geopolymer are inorganic binders, which are identified by the basic properties such as Compressive strength depends on curing time and curing temperature. As the curing time and temperature increases, the compressive strength increases. Then, Resistance to corrosion, since no limestone is used as a material, Geopolymer cement has excellent properties within both acid and salt environments. It is especially suitable for tough environmental conditions. Geopolymer specimens are possessing better durability and thermal stability characteristics [3].

II. METHODOLOGY

In this study various materials and method of conducting the test was discussed in detail and detailed methodology of the work was presented in Fig. 1. In this study materials are used such as Fly ash, Ground granulated blast furnace slag (GGBS), Chemicals (Sodium hydroxide, Sodium silicate) and aggregates (Fine aggregates and Coarse aggregates). Fly ash is one of the most abundant materials on the Earth. It is also a crucial ingredient in the creation of geopolymer concrete due to its role in the geopolymerization process. A pozzolan is a material that exhibits cementitious properties when combined with calcium hydroxide. Fly ash is the main by product created from the combustion of coal in coal-fired power plants. There are two "classes" of fly ash, Class F and Class C. Each class of fly ash has its own unique properties. Ground granulated blast furnace slag comprises mainly of calcium oxide, silicon di-oxide, aluminium oxide, magnesium oxide. It has the same main chemical constituents as ordinary portland cement but in different proportions. And the addition of G.G.B.S in Geo-Polymer Concrete increases the strength of the concrete and also curing of Geo-Polymer concrete at room temperature is possible. A combination of alkaline silicate solution and alkaline hydroxide solution was chosen as the alkaline liquid. Sodium-based solutions were chosen because they were cheaper than Potassium-based solutions. The sodium hydroxide solids were of a laboratory grade in pellets form with 99% purity, obtained from local suppliers. The sodium hydroxide (NaOH) solution was prepared by dissolving the pellets (a small, rounded, compressed mass of a substance of sodium hydroxide)in water. The mass of sodium hydroxide solids in a solution varied depending on the concentration of the solution expressed in terms of molar, M. For instance, sodium hydroxide solution with a concentration of 8M consisted of 8x40 = 320 grams of sodium hydroxide solids (in pellet form) per liter of the solution, where 40 is the molecular weight of sodium hydroxide. Sodium silicate solution (water glass) obtained from local suppliers was used. The chemical composition of the sodium silicate solution was Na_2O=8%, SiO_2=28%, and water 64% by mass. The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid.

The methodology explains about the step by step procedure that is going to be done in the project. The methodology is explained in the following figure.

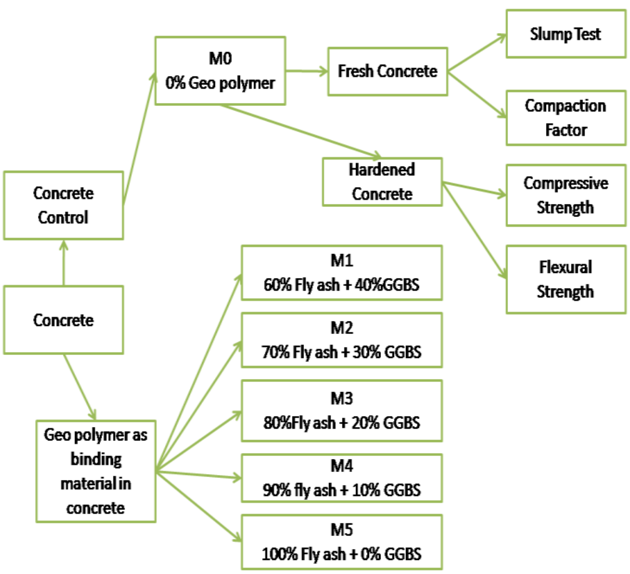

Fig.1. Methodology of Geo-Polymer Concrete

Most of the reported works on geo-polymer material to date were related to the properties of geo-polymer paste or mortar, measured by using small size specimens. In addition, the complete details of the mixture compositions of the geo-polymer paste were not reported. Palomo et al (1999) studied the geo-polymerization of low-calcium ASTM Class F fly ash (molar Si/Al=1.81) using four different solutions with the solution-to-fly ash ratio by mass of 0.25 to 0.40. The molar SiO_2/K_2O or SiO_2/Na_2O of the solutions was in the range of 0.63 to 1.23. The mixture of sodium silicate solution and sodium hydroxide solution forms the alkaline liquid.A combination of alkaline silicate solution and alkaline hydroxide solution was chosen as the alkaline liquid. Sodium based solutions were chosen because they were cheaper than potassium-based solutions. The Alkali activator solution has to be prepared 24 hours advance before use. The Sodium hydroxide is available in small flakes and Sodium Silicate in crystal forms depending on the required solution of different morality has to be prepared.

Some of the trials carried out indicated that the workability and strength characteristics of such mixes were not satisfactory. Such a thing is possible because GPC involves more constituents in its binder (GGBS, flyash, Sodium silicate, Sodium hydroxide and water), whose interactions and final structure and chemical composition are strongly dependent on the source of the material and their production process. Therefore the formulation of the GPC mixture was done by trial and error basis. Numerous trial mixes were cast and tested for compressive strength at the end of 28 days. The primary objective or performing the trial and error procedure was to obtain a good cohesive mix with satisfactory workability.

III. RESULTS & DISCUSSIONS

The Compressive strength, Split tensile strength and Flexural strength tests are performed to assess the comparative changes in concrete. The test specimens for compressive strength test were made of cubes having a size of 150mm x 150mm x 150mm cast iron steel moulds were used. For each mix proportion three numbers of cubes were cast and tested at the age of 7 days and 28 days. The test specimens for split tensile strength test were made of cylinders having a size of 100mm diameter and 300mm high cast iron moulds were used. For each mix proportion three numbers of cylinders were cast and tested at 28 days. The test specimens for Flexural strength test were made of prism having a size of 500mm x 100mm x 100mm cast iron steel moulds were used. For each mix proportion three numbers of prisms were cast and tested at the age of 28 days.

A. Compressive Strength Test

The variation of compressive strength at the age of 7th and 28th days with optimum percentage of GGBS and flyash were given below in Table 1. From the test results, it was observed that the maximum compressive strength was obtained for mix M2 with 30% GGBS and 70% flyash.

TABLE 1. COMPRESSIVE STRENGTH

Mix id	Fly ash %	GGBS %	Compressive strength N/mm2	
			7^{th} day	28^{th} day
M1	100	-	12.88	16.30
M2	90	10	18.67	21.11
M3	80	20	26.85	34.32
M4	70	30	37.33	42.48
M5	60	40	42.77	45.55

B. Flexural Strength

The results of flexural strength of concrete at the age of 28 days are presented in Table. The variations in flexural strength at the age of 28 days with different percentage of GGBS and Flyash were plotted .From the test results, it was observed that when the percentage of GGBS increases, the flexural strength of concrete also increases. On the contrary, the strength decreases when the percentage of flyash increases.

TABLE 2. FLEXURAL STRENGTH

Mix id	Binder %		Flexural strength n/mm2
	Fly ash	ggbs	28th day
M1	100	-	2.40
M2	90	10	3.58
M3	80	20	4.16
M4	70	30	4.68
M5	60	40	5.97

C. WORKABILITY

The tests related to workability of fresh concrete are slump test and compaction factor. The measured slump values of fly ash based geopolymer with constant water/cement ratio 0.55 are 38, 39, 42, 49, 53, 61 mm for different mixes such as M1(100% flyash+0% ggbs), M2(90% flyash+10% ggbs), M3(80% flyash+20% ggbs), M4(70% flyash+30% ggbs), and M5(60% flyash+40% ggbs) respectively.

IV. CONCLUSION

Based on the experimental investigation the following conclusions are listed below: The optimum replacement level of fly ash by GGBS in GPC will be carried out. Water absorption property is lesser than the nominal concrete**.** It was observed that the slump value increases with increase in percentage of fly ash based geopolymer for the replacement of cement with the same w/c ratio.

REFRENCES

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