Non Destructive Testing on Geopolymer Concrete using Concrete Demolition Waste

A.Prabhakaran [1], G.Rajagopal [1], S. Ashok Manikandan [2]

[1]UG Student, Department of Civil Engineering, P.S.R.Engineering College, Sivakasi.
[2]Assistant Professor, Department of Civil Engineering, P.S.R.Engineering College, Sivakasi.

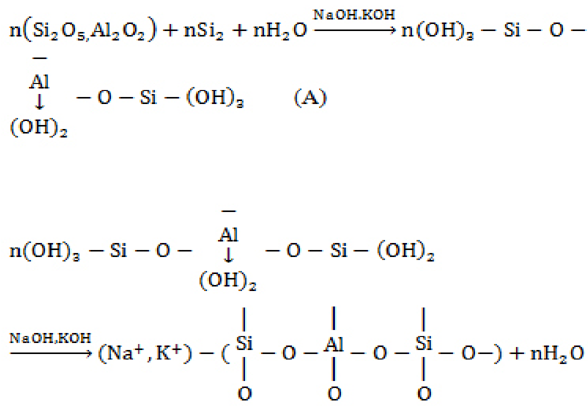
Abstract **-** *The need to reduce the global anthropogenic carbon dioxide has encouraged researchers to search for sustainable building materials. Cement, the second most consumed product in the world, contributes nearly 7% of the global carbon dioxide emission. Geopolymer concrete (GPC) is manufactured using industrial waste like fly ash, GGBS is considered as a more eco-friendly alternative to Ordinary Portland Cement (OPC) based concrete. The feasibility of production of geopolymer concrete using coarser bottom ash is evaluated in this study. The simple geopolymer concrete, based on 100% CDW, reached an Optimum strength.*

Keywords* — *Fly Ash, Geopolymer Concrete, Sodium Hydroxide (NaOH), Sodium Silicate(Na2sio3).

I. INTRODUCTION

Geopolymer is a type of amorphous alumino-silicate product that exhibits the ideal Properties of rock-forming elements, i.e., hardness, chemical stability and longevity. The properties of geopolymer include high early strength, low shrinkage, freeze-thaw resistance, sulphate resistance and corrosion resistance. These high-alkali binders do not generate any alkali-aggregate reaction. The geopolymer binder is a low-CO_2 cementious material. It does not rely on the calcination of limestone that generates CO_2. This technology can save up to 80% of CO_2 emissions caused by the cement and aggregate industries. It is reported that the worldwide cement industry contributes around 1.65 billion tons of the greenhouse gas emissions annually, Due to the production of Portland cement, it is estimated that by the year 2020, the CO_2 emissions will rise by about 50% from the current levels.

Therefore,to preserve the global environment from the impact of cement production, it isnow believed that new binders are indispensable to replace Portland cement. In this regard, the geopolymer concrete is one of the revolutionary developments related to novel materials resulting in low-cost and environmentally friendly material as an alternative to the Portland cement. Geopolymer Concrete is an innovative binder material and is produced by totally replacing the Portland cement. It is demonstrated that the geopolymeric cement generates 5–6 times less CO_2 than Portland cement. Therefore, the use of geopolymer technology not only significantly reduces the CO_2 emissions by the cement industries.



The sodium hydroxide with 97-98% purity, in flake or pellet form, is commercially available. The solids must be dissolved in water to make a solution with the required concentration. The concentration of sodium hydroxide solution can vary in the range between 8 Molar and 16 Molar. The mass of NaOH solids in a solution varies depending on the concentration of the solution. For instance, NaOH solution with a concentration of 8 Molar consists of 8x40 = 320 grams of NaOH solids per liter of the solution, where 40 is the molecular weight of NaOH.

The mass of NaOH solids was measured as 262 grams per kg of NaOH solution with a concentration of 8 Molar. Similarly, the mass of NaOH solids per kg of the solution for other concentrations was measured as 10 Molar: 314 grams, 12 Molar: 361 grams, 14 Molar: 404 grams, and 16 Molar: 444 grams (Hardjito and Rangan, 2005). Note that the mass of NaOH solids is only a fraction of the mass of the NaOH solution, and water is the major component. In order to improve the workability, a high range water reducer super plasticizer and extra water may be added to the mixture.

II. OBJECTIVE

To investigation on geopolymer concrete by Replacing coarse aggregate by concrete demolition waste and find Flexural strength and Tensile strength of the geopolymer concrete.

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III. LITERATURE REVIEW

Several authors have reported the use of Fly ash in Geopolymer Concrete for various civil engineering applications.

A. Allahverdi & E. Najafi Kani(2012) Proposed that geopolymerization can transform a wide range of waste alumino silicate materials into building materials with excellent chemical and physical properties such as fire and acid resistance. In this research work, geopolymerization of construction waste materials with different alkali-activators based on combinations of Na_2SiO_3 and NaOH has been investigated.The results obtained reveal that construction wastes can be activated using a proportioned mixture of Na_2SiO_3 and NaOH resulting in the formation of a geopolymer cement system exhibiting suitable workability and acceptable setting time and compressive strength.

Shankar H. Sanni & Khadiranaikar, R. B (2012) suggested that the grades choosen for the investigation were M-30, M-40, M-50 and M-60, the mixes were designed for molarity of 8M and 12M. The alkaline solution used for present study is the combination of sodium silicate and sodium hydroxide solution with the ratio of 2.50 and 3.50.The test specimens were 150x150x150 mm cubes, 100x200 mm cylinders heat-cured at 60°C in an oven.The test results indicate that the heat-cured fly ash-based geopolymer concrete has an excellent resistance to acid and sulphate attack when compared to conventional concrete.Thus we can say that the production of geopolymers have a relative higher strength, excellent volume stability and better durability.

Jaydeep S & Chakravarthy B.J (Oct 2013) discussed that due to growing environmental concerns of the cement industry alternative cement technologies have become an area of increasing interest. One such thing is "GEOPOLYMER CONCRETE". It utilizes an alternate material including fly ash as binding material in place of cement. This fly ash reacts with alkaline solution NaOH and sodium silicate (Na_2sio_3) to form a gel which binds fine and coarse aggregates. Concrete cubes of size 150*150*150 mm were prepared. When compared with conventional concrete or any other concrete method it is more advantageous, economical and eco friendly.

Ganesh Kumar S, et al., (Dec-2015) suggested that the demand of concrete is increasing day by day and cement is used for satisfying the need of development of infrastructure facilities, 1 tone cement production generates 1 tone CO_2, which adversely affect the environment. Geopolymer concrete uses fly ash and alkaline solution as their Binding Materials. Geopolymer requires oven curing in the varying range of 60°C to 100°C for a period of 24 to 96 hours.Replacement of Fly ash by GGBS increases the Strength gradually without Oven curing provision.

Alexander Vásquez, et al., proposed that the present study, the synthesis of geopolymers based on alkaline activation. The highest compressive strength was obtained in systems activated with sodium silicate, which enabled geopolymer synthesis at room temperature. The results obtained in the present study demonstrate the feasibility of using concrete demolition wastes as precursors to obtain geopolymer cements.

Prof.More Pratap Kishanrao (May 2013) proposed that reducing the greenhouse gas emissions is the need of the hour. Five to eight percent of the world"s manmade greenhouse gas emissions are from the Cement industry itself. It is an established fact that the green house gas emissions are reduced by 80% in Geopolymer concrete vis-a-vis the conventional Portland cement manufacturing, as it does not involve carbonate burns etc. Thus Geopolymer based Concrete is highly environment friendly and the same time it can be made a high-performance concrete. In the present study, fly ash, blast furnace slag and catalytic liquids have been used to prepare Geopolymer concrete mixes. This study is continued to investigate the behaviour of such Geopolymer concrete under high temperatures ranging from 100^0C to 500^0C.

IV.METHODOLOGY

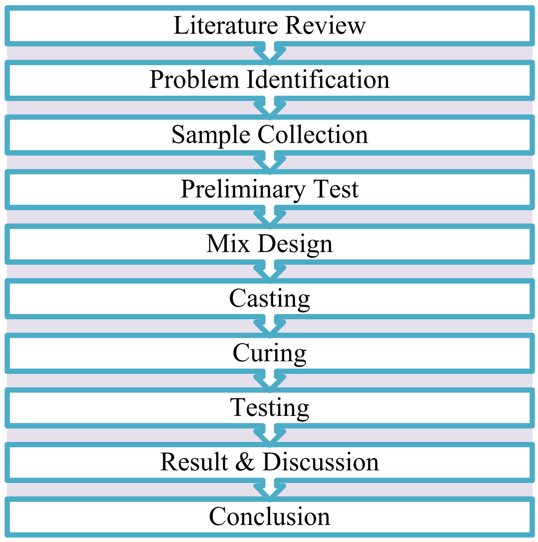

Fig. 1 Flow chart for Methodology

V. STUDY OF MATERIALS

5.1 Fly Ash

The power requirements of the country have increased a lot due to industrial growth.Fly ash is an inorganic, non-combustible by-product of coal - burning power plants. As coal is burnt at high temperatures, carbon is burnt off and most of the mineral impurities are carried away by the flue gas in the form of ash.

5.2 Fine Aggregate

Good quality locally available river sand passing through 2.36 rnm sieve was used for all experimental investigations and the product considered.

5.3 Coarse Aggregate

The coarse aggregate particles passing through 20mm and retained on 12.5 mm I.S Sieve used as the natural aggregate which met the grading requirement of IS 383-1970.

5.5 Alkaline Liquid

Generally alkaline liquids are prepared by mixing of the sodium hydroxide solution and sodium silicate at room temperature.For instance, NaOH solution with a concentration of 8M consisted of 8x40 = 320 grams of NaOH solids (in flake or pellet form) per litre of the solution.

5.6 Super plasticizer

In order to improve the workability of fresh concrete, high-range water-reducing naphthalene based super plasticizer was added to the mixture. The dosage of super plasticizer also has an effect on the compressive strength of the concrete The specific super plasticizer used in the mixture made for the project is **Conplast SP430**.

VI. CASTING & TESTING

This chapter which explains experimental process of mixing, casting, curing and testing of geopolymer concrete.

6.1 Sodium Hydroxide Mixing

As the NaOH was hand mixed with water. It was mixed a minimum of 24 hours prior to its intended time of usage in a mix. This waiting time period allowed the solids to fully dissolve throughout the solution as well as to enable inspection and detection of badly mixed solution prior to use.

6.2 Casting on Geopolymer concrete

The geopolymer concrete used in this study is composed of low calcium fly ash and alkaline solution composed NaOH and sodium silicate combination. NaOH is mixed with deionized water at a concentration of 12 molarity and in the ratio of Alkaline Activator and Fly ash is 0.4.

Fig .2 Casting of geopolymer concrete

6.3 Curing on Geopolymer concrete

The geopolymer concrete was cured under heated 80^{o}C for 24 hours, used in heat chamber.

Fig.3 Curing of geopolymer concrete

6.4 Testing on geopolymer concrete

The mould could be easily separated from cast elements after its initial setting. The contact surface of the mould were greased before casting the specimens to ease the demoulding process. The geopolymer concrete was cured under heated 80^{o}C for 24 hours.

6.4.1 Compressive strength

The specimen is then placed in the machine in such a manner that the load shall be applied. The maximum load at failure was taken and compressive strength is calculated using the equation.

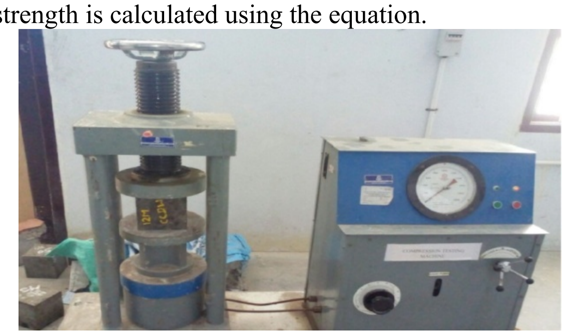

Fig .4 Compression test on geopolymer concrete

6.4.2 Rebound Hammer Test

The Schmidt hammer method is today routinely used to test the strength and the quality of rock and hardened concrete. There are several in-situ methods are available to access the condition of existing building structure. This is one of the most primitive and simplest tests to evaluate strength of concrete although results using this test vary significantly based on surface, carbonation.

Fig.5 Rebound Hammer Test on geopolymer concrete

VII. RESULT AND DISCUSSION

7.1 Compressive strength

Table No.1 Compressive strength Test Result

		Load (kN)	Strength (N/mm^2)	Avg. Value (N/mm^2)
Conventi-onal concrete	Sample 1	730	32.4	33
	Sample 2	750	33.3	
	Sample 3	750	33.3	
CDW Concrete	Sample 1	620	27.5	28.36
	Sample 2	650	28.9	
	Sample 3	640	28.4	

7.2 Rebound Hammer Test

Table No.2 Non Destructive Test Result

For Convension Concrete

SPECIMEN	R.H.N	MEAN VALUE	COMPRESSIVE STRENGTH(MPa)
Face 1	37	36.67	35
	38		
	35		
Face 2	36	38.33	37
	38		
	41		
Face 3	28	31.35	26
	34		
	32		
	Average		32.67

For CDW Concrete

SPECIMEN	R.H.N	MEAN VALUE	COMPRESSIVE STRENGTH(MPa)
Face 1	27	32.33	27
	36		
	34		
Face 2	33	32.4	28
	28		
	36		
Face 3	31	34.6	31
	31		
	38		
	Average		28.67

VIII. CONCLUSION

Geopolymer Concrete by replacing Concrete Demolision Waste had shown a significant potential as a good engineering material for the future research, as the Geopolymer Concrete is not only environmental friendly but also it possesses excellent mechanical properties, both in short term and long term. The economic benefits and contributions of Geopolymer concrete to sustainable development are evident. Geopolymer concrete had very less curing time. Higher concentration of activated alkali solution results into achieve the optimum strengths.

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