A Comparative Study on Strength Improvement of Concrete by Using Fly Ash Based Geopolymer

Anu Anand P.[1], Dhannya Dev[2], Faris T.K.[3],Havvabi I.P.[4],Naseef P.M.[5],Rabinshad P.[6]Harishma Raveendran[7]

[1-6] 4th year B-Tech student, Civil Engineering, CCET Valanchery, Kerala, India
[7] Assistant professor, Dept. of Civil Engineering, CCET Valanchery, Kerala, India

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Abstract - *The demand of concrete is increasing day by day for satisfying the need of development of infrastructure facilities. It is well established fact that the production of OPC not only consumes significant amount of natural resources and energy but also releases substantial quantity of carbon dioxide to the atmosphere. Therefore, it is essential to find alternatives to make the concrete environment friendly. Geopolymer is an inorganic alumino-silicate compound, synthesized from fly ash. The fly ash, one of the source materials for geopolymer binders, is available abundantly in India, but to date its utilization is limited. Hence it is essential to make the efforts to utilize this by-product in concrete manufacturing in order to make the concrete more environmental friendly. This paper describes the experimental work conducted by casting 20 geopolymer concrete mixes to evaluate the effect of various parameters affecting it's the compressive strength in order to enhance its overall performance.*

1.INTRODUCTION

Geopolymer is a heterogeneous material comprising of sodium silicate (Na_2Sio_3) and sodium hydroxide (NaOH) which is adhesive in nature and has good bonding properties. The Cordi-Geopolymere private research laboratory in Saint-Quentin in 1972 discovered a fresh inorganic material called as 'geopolymer'. Geopolymer can be formed at low temperature and small amount of time. After shorter setting and hardening time, geopolymer with tightly packed poly-crystalline structure is formed showing better mechanical properties.Geopolymer is extremely environmentally attractive for various reasons. Its performance as construction materials can be compared with Portland cement in lots of ways but the geopolymer needs no heart in its manufacturing process. This implies a substantial benefit with regards to reducing global carbon dioxide emission. Furthermore, the utilization of industrial by-products meets the increasing trend towards waste re-utilization.

The production of geopolymer concrete is carried out using the conventional concrete technology methods. The fly ash based geopolymer concrete consists 75% to 80% by mass of aggregate, which is bound by a geopolymer paste formed by the reaction of the silicon and aluminium within the fly ash and the alkaline liquid made up of sodium hydroxide and sodium silicate solution with addition of superplasticiser. In this paper, various factors which influencing the strength of concrete are studied and results are discussed by various graphs corresponding to the strength of the test cubes

1.1 Objectives

- The main objective of the project is to study the feasibility of using geopolymer as an alternative stabilizing material instead of cement.
- To prepare geopolymer by mixing sodium silicate solution and sodium hydroxide solution.
- To study the effect of fly ash geopolymer on compressive strength of concrete at different mix ratio of fly ash.
- To study the effect of fly ash geopolymer on tensile strength of concrete at different mix ratio of fly ash.

1.2 Scope of the Work

- To improve the properties of concrete by adding fly ash geopolymer
- Availability of efficient disposal of waste material
- To reduce the emission of CO_2 during cement production
- Economical compared to conventional brick masonry

2. PREVIOUS RESEARCH

Zhen Liu et al. (2016) study the feasibility of FA based geopolymer on loess stabilization. Loess is an eolian, nonstratified deposit that is primarily composed of silt-sized mineral particles and clay particles transported by wind. The metastable structure of natural loess has resulted in construction delays and catastrophic failures. It is found that KOH renders a higher unconfined compressive strength than NaOH geopolymers. With an increasing FA/loess ratio, the compressive strength and Young's modulus increase.

Chao-Lung Hwang et al. (2015) investigated the effect of alkali activator and rice husk ash content on strength development of fly ash and residual rice husk ash based geopolymers. Compressive strength of all the geopolymer samples increased with curing age.

Xiaolu Guo et al. (2013) investigate the feasibility of using geopolymers based on class C fly ash to self-solidify heavy metal wastes. All leaching concentrations of heavy metals from geopolymers are far lower than the maximum concentration limits.

Wang et al. (2005) proved experimentally that the compressive strength, along with the apparent density and the content of the amorphous phase of metakaolinite-based geopolymer, increase with the increase of NaOH concentration within the range 4–12 mol/L. This is caused by the enhanced dissolution of the metakaolinite particulates and therefore the accelerated condensation of the monomer in the clear presence of higher NaOH concentration.

Prakash R. Vora . (2012) The demand of concrete is increasing day by day for satisfying the need of development of infrastructure facilities. It is well established fact that the production of OPC not only consumes significant amount of natural resources and energy but also releases substantial quantity of carbon dioxide to the atmosphere. Therefore, it is essential to find alternatives to make the concrete environment friendly. Geopolymer is an inorganic alumino-silicate compound, synthesized from fly ash.

3. MATERIALS AND METHODOLOGY

3.1 Material

3.1.1 Fly Ash

Fly ash (FA) is obtained from one of the coal combustion products. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned. Fly ash used in this study was obtained from Angamali.

Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO_2) ,aluminium oxide (Al_2O_3) and calcim oxide (CaO), the main mineral compounds in coal-bearing rock strata.

Table: 1 Properties of Class F Fly Ash

SL NO	Chemical Component	Values
1	Silica (SiO_2)	55
2	Alumina (Al_2O_2)	26
3	Ferric oxide (Fe_2O_2)	7
4	Calcium oxide (CaO)	9
5	Magnesium oxide (MgO)	2
6	Sulfate oxide (SO_2)	1
7	Loss of Ignition (LOI)	6

Fig.1 Class F Fly Ash

3.1.2 Sodium Hydroxide (NaOH)

NaOH is also commonly used as an alkaline activator in geopolymer production. Generally NaOH is available in 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 NaOH was formed by dissolving it in water with different molarity. 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.

Fig.2 Sodium Hydroxide Pellets

3.1.3 Sodium Silicate

Sodium silicate is also known as waterglass which is available in the market in gel form. The ratio of SiO2 and Na2O in sodium silicate gel highly affects the strength of geopolymer concrete. Mainly it is seen that a ratio ranging from 2 to 2.5 gives a satisfactory result.

Fig.3 Sodium Silicate

3.2 Methodology

FA geopolymer is made by mixing Flyash and geopolymer liquor in required proportions. The geopolymer is obtained by the addition of sodium hydroxide pellets (NaOH) and sodium silicate (SiO_2) along with water and stirred well until the solution in made. This solution in mixed up with the amount by flyash, fine aggregate and coarse aggregate taken according to the selected mix ratio. And the strength characters are evaluated. Laboratory teste conducted are Fineness Test, Consistency, Specific Gravity, Sieve Analysis and Compression Test.

4. RESULTS AND DISCUSSION

The compression strength of the FA geopolymer concrete in M20 ratio was found out to be 29.44 N/mm^2, which in higher than ordinary M20 cement concrete and , hence the project is successful.

5.CONCLUSIONS

In this study, the feasibility of using flyash based geopolymer as an effective replacement for cement in the construction field is proposed. And the collective results of the study shows an satisfying construction, which entire that the flyash based geopolymer can be used instead of cement mortar, and the properties of the geopolymer with similar to that of the cement mortar.

The main aim proposed by the project was to find a suitable substituent for the cement in construction field, in order to find a solution for the environment, economical and strength issues of the cement.

The study results addreses these issues effectivily.

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