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Study on Strength Characteristics of Geopolymer Concrete using M-Sand

S.Selvamuthukumar[1], S. Kumaravel[2]
[1,2]Assistant Professor, Department of Civil and Structural Engineering, Annamalai University, Tamil Nadu, India.
smk_au@yahoo.com[2]

Abstract

A major environmental issue in the world is pollution in cement production. Geopolymer concrete also in construction industry is an alternate cement material as well as an eco-friendly material. Using fly ash, ground granulated blast furnace slag as base materials and sodium hydroxide and sodium silicate combination as alkaline activators, the geopolymer concrete is prepared. The sand is an important part of concrete; it is mainly procured from natural sources. Environmental and economy aspects are better obtained, if locally available sources can be used. Manufactured sand substitutes the fine aggregate in the concrete in several percentages as the sand is well graded and gives greater concrete power. In the present analysis, the strength of concrete with manufactured sand is studied in proportions of different percentage as a replacement for natural sand.

Keywords: Fly ash, GGBS, Geopolymer concrete, Alkaline solution.

1. Introduction

An important material in concrete is ordinary Portland cement (OPC). Due to the emission of carbon dioxide, the cement industry is responsible for ecological pollution [1]. The by-product materials like fly ash, GGBS, metakaoline, rice husk ash, silica fume etc., generated from various industries have rapidly increased and not being effectively utilized. It is usually being buried as landfills, which in turn has affected many aquifers and fresh water sources leading to many disposal problems [2], the alkaline solution and fly ash are mixed with silicon (Si) and aluminum (Al) to create the binder. Geopolymer is the chemical process in which binder production takes place [3]. Geopolymer technology is showing considerable promise as an alternative binder to cement for application in the concrete industry.

In general, the increase in the content of CaO in the slag occurs as the basicity of the slag is raised and the compressive strength is improving [4]. The main components of blast furnace slag are CaO (30–50%), SiO2 (28–38%), Al2O3 (8–24%), and MgO (1–18%). The use of GGBS significantly lowers the risk of alkali-silica reaction damage [5]. In concrete, low-calcium-based fly ash and GGBS are used at level 50:50 [6]. Manufactured sand is the dust of the quarry or the crushed granite stone that is sieved and made of natural sand to suit particle size in order to be used as a fine aggregate. It is named M-Sand too [7]. The long-term efficiency of mortars subject to chemical solutions is enhanced by the substitution of natural river sand with crushed limestone sand [8]. In comparing to concrete with natural river sand, concrete with supplied sand shows greater compressive strength. Concrete bond strength with M-sand is greater and hence rebar production length can be shortened, contributing to building economy.

2. Preparation of Concrete

2.1 Fly Ash and Ggbs Aggregates

Low-calcium (Class - F) fly ash obtained from the Mettur Thermal Power Station is used in these studies. Low-calcium fly ash has been successfully used to manufacture geopolymer concrete when the silicon and aluminum oxides constituted about 80% by mass with the Si-to-Al ratio of about 2.5. The part of replacement in fly ash for the geopolymer concrete increases the engineering properties of the material. Ground granulated blast furnace slag (GGBS) is a byproduct from the blast furnaces used to make iron.

2.2 AggregatesAlkaline Liquid

Manufactured sand (M-Sand) for concrete construction is a replacement for river sand. By grinding, manufactured sand is produced from hard granite stone. The crushed sand, washed and graded as a building material, is cubical in shape with grounded edges. The size of M-Sand is less than 4.75mm. Sand was stored inside the laboratory throughout the experimental investigation. In the manufacture of geopolymer concrete, coarse aggregates used by the concrete industry is12-20 mm size. In the case of geopolymer concrete, the aggregate grading curves currently used in practical reality are applicable. The properties of aggregate used are listed below:

Sp. gravity of fine aggregate (sand) = 2.66

(M-sand) = 2.69

coarse aggregate = 2.71

Fineness modulus of fine aggregate = 2.48

coarse aggregate = 2.12

2.3 Alkaline Liquid Results And Disscussion

Alkaline solution is usually prepared by combining the sodium hydroxide solution and sodium silicate at room temperature. When the two solutions are mixed together polymerization reaction takes place, liquid release is prepared as binding. Sodium hydroxide pellets are collected and dissolved in water at 12 molar concentration levels. The solids must be dissolved in water to make a solution with the required concentration. The concentration of sodium hydroxide solution can vary in different molar. Depending on 12 mole, the mass of NaOH solids in a solution varies, consisting of 12 x 40 = 480 gm of NaOH solids per liters of water, where 40 is NaOH's molecular weight, whereas the mass of water is the major component in both alkaline solutions.

2.4 Mixing, Casting and Curing

The geopolymer concrete with M-sand Constituents is in Figure 1, manufactured by adopting the conventional techniques are used. The fly ash 90%, GGBS (10%) are used, and the fine aggregate River sand are replace M-sand in different percentages of 10, 25, 50, 75 and 100 are used, which are dry mixed together in man mix. The saturated surface dry (SSD) coarse aggregate nominal size is added and mixed with grade of concrete M 25, ratio 1: 1.55: 2.74: 0.50 are calculated in IS code method and uniformly distributed throughout the batch. The chemical solution is added and the entire batch mix, constituents of GPC in one cubic meter are given Table 1.

Table 1. Constituents of Geopolymer Concrete

Fly ash (kg/m^3)	GGBS (kg/m^3)	NaOH (kg/m^3)		Sodium silicate (kg/m^3)	Fine aggregate (kg/m^3)	Coarse aggregate (kg/m^3)
		Solid	Water			
410.0	41.0	27.01	29.26	145.82	645.16	1093.12
1		**0.50**			**1.55**	**2.74**

Figure 1. Constituents of Geopolymer Concrete

Table 2. GPC average compressive strength

Specimens	River Sand (%)	M-Sand (%)	Average compressive strength (N/mm^2)	
			7 days	28 days
S1	90	10	23.46	31.39
S2	75	25	24.15	32.86
S3	50	50	**26.23**	**34.12**
S4	25	75	25.35	33.05
S5	0	100	23.85	32.10

Slump cone was used to measure the fresh GPC. The prepared concrete is kept in moulds of specimen cube size 100x100x100mm they are stored at room temperature for one day in the rest time after casting the specimens. The word 'Rest Cycle' is coined to denote the time taken at an elevated temperature from the end of the casting of the test sample to the start of curing. The compressive strength machine of 1000 kN capacity is used to apply the axial force of compression. Geopolymer concrete cubes of average compressive strength at 7 and 28 days respectively are given in Table 2.

3. Results and Discussion

Geopolymer concrete of grade M 25 mix was kept as 1:1.55:2.74. The sodium hydroxide and sodium silicate solution were used as alkaline activators. The ratio between activator solutions to fly ash was 0.50. The ratio of sodium silicate to sodium hydroxide solution by mass was kept as 2.5. The molarity of sodium hydroxide is kept as 12M.

Geopolymer concrete of mix ratio 1:1.15:2.30 fly ash and GGBS with alkaline solution and the compressive strength of concrete is obtained.

The result of slump was found as 115 mm was obtained. GPC fresh concrete is Good workability.

The density of geopolymer concrete is found as 2330 kg/m3. The 7 and 28 days average compressive strength of geopolymer concrete cubes given in Figure 2.

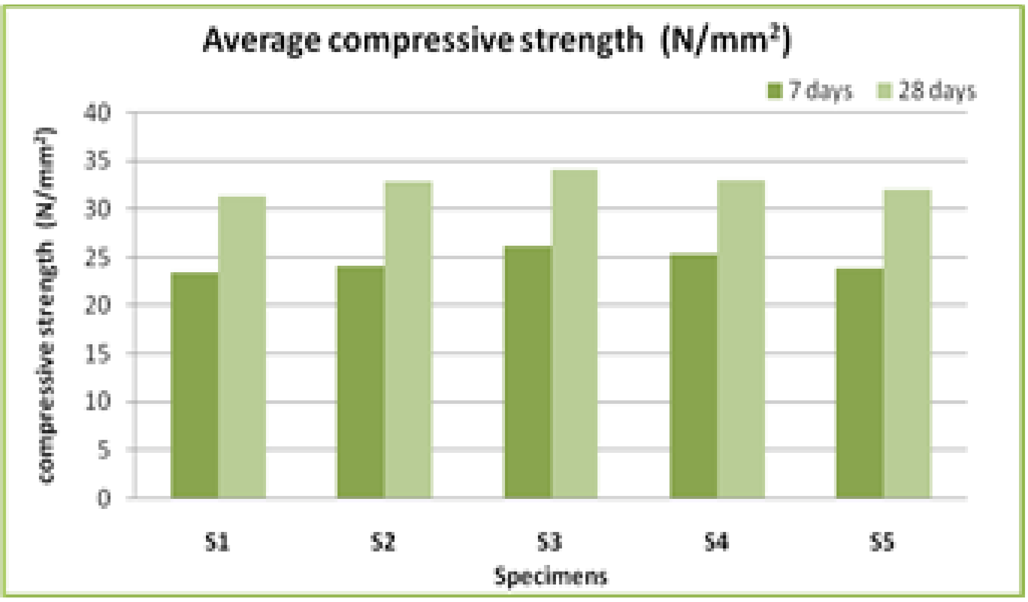

Figure 2. Average compressive strength of geopolymer concrete

In contrast to river sand in the 50:50 range, the strength variation with respect to river sand and manufactured sand for the different geopolymer mixes in 7 and 28 days shows increased values for m-sand is a better strength of 34.12 N / mm2 (S3) respectively.

Conclusion

Geopolymer concrete is more eco friendly and has the ability for many uses, such as precast units, to replace ordinary Portland cement concrete. As the particle shape is angular, manufactured sand yields mixes with low working capacity and can be compensated by adding admixtures to the mix. From the findings, it is obviously evident that percentage replacement of natural sand by processed sand has given useful strength relative to all other replacements. The average density of geopolymer concrete based on fly ash is similar to OPC concrete. From the results obtained, it is clear that the geopolymer concrete is encouraging. By properly choosing, the affecting parameters such as making a concrete for different days it can beincreased. In terms of strength and durability, manufactured sand is the best alternative to natural sand.

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