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Geopolymer Concrete with M-sand and Ceramic aggregate

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ABSTRACT

Geopolymer a binding material in construction industry is an alternate cement material as well as an eco friendly material. We can reduce the ill effects on environment, by increasing the usage of industrial waste products in the construction industry. The current limitation in geopolymer concrete has been applied in precast members. Geopolymer concrete is a industrial waste product based material that is used in the present study, to produce the geopolymer concrete with a partial aggregate replacement, where fly ash and GGBS is used as a base material, NaOH and Na_2SiO_3 as an alkaline solution. Since there is a demand for fine aggregate (River sand), as an alternate manufacture sand (M-sand) is used. The coarse aggregate is an alternate material for ceramic waste in different percentage of 5, 10, 15, 20, and 25. The fresh concrete is obtained with workability, density and compressive strength of 7 and 28 days.

Keywords: Fly ash, GGBS, M-Sand, Alkaline solution, Ceramic aggregate.

1. INTRODUCTION

A major environmental issue in the world is pollution in cement production. An important material in concrete is ordinary cement. 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. The aluminates and silicates react together to form an alumino silicate gel which is initially formed as an aluminium rich gel, since the aluminum is more reactive and dissolves faster than silicon. At a later stage as more silicon dissolves, the gel structures gets reorganized to form zeolite gel which is more stable than the previous gel since Si – O bonds are more stronger than Al - O bonds [2]. The alkaline solution and fly ash are mixed with silicon (Si) and aluminium (Al) to create the binder [3]. Geopolymer technology is showing considerable promise as an alternate binder to cement for application within the concrete industry. Using fly ash, GGBS as base materials and NaOH and Na2SiO3 combination as alkaline solution (AS) and mixer of fine aggregate and course aggregate this geopolymer concrete is prepared.

In concrete, low-calcium based fly ash and GGBS are used at level 50:50, the strength is increase more. River sand has been used as fine aggregate in concrete for several decades [4-6]. However, excavation of river sand has been limited due to the depletion of river sand in many countries including india. Manufactured sand (M-sand) is popular as machine-made sand, artificial sand and crushed stone sand. M-sand has been used for products and engineering application of premixed concrete with partially and completely replacing the river sand in concrete [7-9]. Use of hazardous waste in concrete-making will lead to green environment and sustainable concrete technology then such concrete also can be called as 'Green' concrete. Concrete made with ceramic electrical insulator waste as coarse aggregate. Indian ceramic production is 100 Million ton per year. In the ceramic industry, about 15% to 30% waste material is generated from the entire production [10-12]. This waste isn't recycled in any form at the present. However, the ceramic waste is durable, hard and highly immune to biological, chemical, and physical degradation forces. The alternate materials for course aggregate in the ceramic waste in different percentage are studied as follows.

2. PREPARATION OF CONCRETE

2.1 Materials

Low-calcium fly ash 90 percent was used and ground granulated furnace slag is a byproduct material from the blast furnaces, which is used to make iron, where 10 percent is replaced with fly ash. Manufactured sand (M-Sand) for geopolymer concrete is a replacement for river sand. By grinding, manufactured sand is produced from hard granite stone. The crushed sand is washed and graded as a building material in cubic shape with rounded edges. The size of M-sand is less than 4.75mm in Zone – II. The components of GPC are coarse aggregates of IS code provision of nominal size 12 mm to 20 mm of impact value 24.63. The Damaged electric insulator ceramic are crushed in the nominal size, were partially replaced with of coarse aggregate by the percentages of 5, 10, 15, 20 and 25. The testing of materials are listed below in the Table 1.

Table 1 Materials Test

S.No	Tests performed	Values
1	Specific gravity of M-sand	2.69
2	Specific gravity of Ceramic waste	2.71
3	Fineness modulus of M-sand	2.48
4	Fineness modulus of Ceramic waste	7.37
5	Impact value of Ceramic waste	23.70

2.2 Alkaline Solution (AS)

The binder is prepared in sodium hydroxide (NaOH) and sodium silicate (Na_2SiO_3) materials of ratio 2.5, when the two materials are mixed together polymerization reaction takes place it liberates great deal of warmth, so it is recommended to go away it for about 24 hours for the alkaline liquid to get ready as a binding agent. 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 mass of sodium hydroxide solids during a solution varies, consisting of 480 gm of NaOH solids per litre of water, where 40 is NaOH relative molecular mass, whereas the mass of water is that the major component in both alkaline solutions (AS). Alkaline solution is usually prepared by combining the sodium hydroxide solution and sodium silicate at room temperature.

2.3 Cube casting

Cube casting is done by adopting the conventional techniques, the fly ash 90% and GGBS 10% with alkaline solution of ratio 0.40 are used. The fine aggregate M-sand is use and the coarse aggregate is partially replaced by 5%, 10%, 15%, 20% and 25%. The saturated surface dry coarse aggregate of nominal size is added, which are dry mixed together in man mix. The grade of concrete M 30 as ratio 1: 1.35: 2.84: 0.40 are calculated. The constituents of GPC in one cubic meter are given Table 2.

Table 2 Constituents of Geopolymer Concrete

Fly ash (kg/m^3)	GGBS (kg/m^3)	NaOH (kg/m^3)		Sodium silicate (kg/m^3)	Fine aggregate M-Sand (kg/m^3)	Coarse aggregate (kg/m^3)
		Solid	Water			
369	41	25.3	28.6	132	553.5	1164.4
1		**0.40**			**1.35**	**2.84**

Figure 1 Constituents of Geopolymer Concrete

The fresh geopolymer concrete is usually cohesive in nature. The workability of fresh concrete for slump values are measured 145, 160, 165, 170, **182** and 178mm. The prepared concrete is kept in moulds of specimen cube size 100x100x100mm and casting for 3 layers of 25 stocks filled and 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 3.

Table 3 GPC average compressive strength

Specimens	Stone Aggregate (%)	Ceramic Aggregate (%)	Average compressive strength (N/mm^2)	
			7 days	28 days
GPCM	100	0	27.80	36.84
GPCM 1	95	5	29.13	37.10
GPCM 2	90	10	28.92	37.86
GPCM 3	85	15	30.63	38.32
GPCM 4	80	20	31.12	39.63
GPCM 5	75	25	29.84	37.45

3. RESULTS AND DISSCUSSION

The ratio of sodium silicate to sodium hydroxide solution by mass was kept as 2.5. The molarity of NaOH is kept as 12M concentration. The ratio of alkaline solution to fly ash was 0.40, fly ash and GGBS is aluminates and silicates react together to form an alumino silicate gel a good binder. GPC of grade M 30 mix was kept as mix ratio of 1:1.35:2.84. The results of fresh concrete are measured in slump was found as 182 mm was obtained, GPC fresh concrete is sweet workability. The density of geopolymer concrete is found as 2330 kg/m3. The 7 and 28 days average compressive strength of geopolymer concrete cubes are given in Figure 2. The coarse aggregate 80% HBG metal and 20% of ceramic aggregate of maximum strength increases the values of 31.12 and 39.63 N/mm^2 respectively.

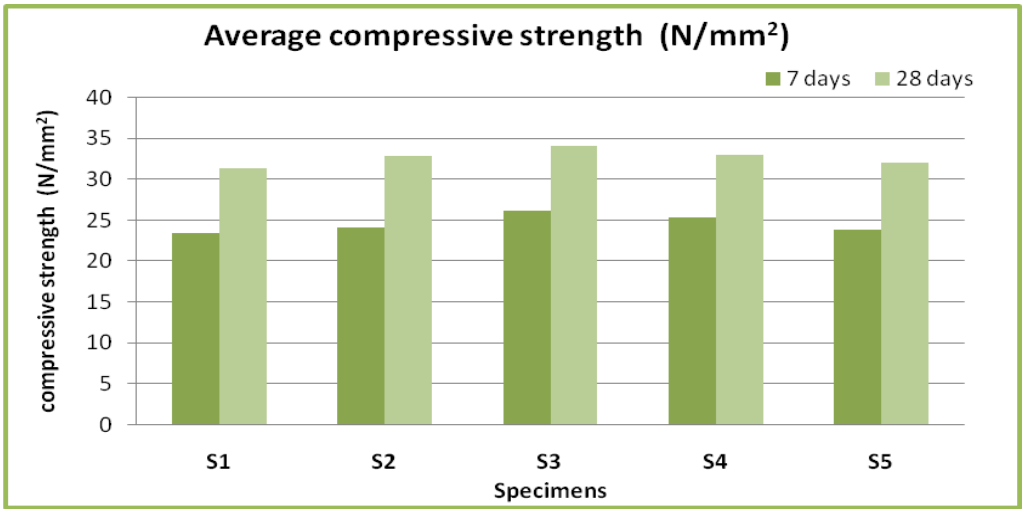

Figure 2 Average compressive strength of GPC

4. CONCLUSION

Geopolymer concrete is more eco friendly and has the ability for many uses, such as precast units, pavements, bridge decks, etc. It is also an alkaline activator and a good binding material, the fresh geopolymer concrete is easy to handle for first few minutes without any sign of setting but after few minutes it sets rapidly. The compressive strength test results thus it is observed is the 20% replacement of ceramic aggregate mix that has high strength than the other mixes in the 28th day test. Its increase strength and extended durability of concrete. Thus the use of waste material is reducing the pollution free environment.

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