



STUDY OF STRENGTH DEVELOPMENT OF HIGH CALCIUM FLYASH BASED GEOPOLYMER CONCRETE USING M-SAND AS FINE AGGREGATE

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Abstract— Ordinary Portland Cement is a major construction material worldwide. Cement manufacturing industry is one of the carbon dioxide emitting sources besides deforestation and burning of fossil fuels. The global warming is caused by the emission of greenhouse gases, such as CO₂, to the atmosphere. The CO₂ contributes about 65% of global warming. The Cement industry contributes globally about 5-7% of greenhouse gas emission to the earth's atmosphere. In order to address environmental effects associated with Portland cement, there is a need to develop alternative binders to make concrete. The effort which we used is to produce more environment friendly concrete is the development of inorganic alumino-silicate polymer, called geopolymer which is synthesized from materials of geological origin or by-product materials such as fly ash that are rich in silicon and aluminum. In this project high-calcium (Class C) fly ash from Neyveli Thermal power plant has been used for the production of geopolymer concrete. The combination of sodium silicate and sodium hydroxide solution is used as alkaline solution for fly ash activation. The concentration of sodium hydroxide solution was maintained as 8M (Molarity) and also study the different properties of geopolymer concrete with replacement of manufactured sand. The curing condition of geopolymer concrete was varied as ambient curing. The compressive strength, Split Tensile Strength of the geopolymer concrete was tested at various ages such as 7, 14 and 28 days.

Keywords— green concrete, high calcium fly ash(class C), ambient curing, manufacturing sand, geopolymer,

I. INTRODUCTION

The ordinary cement concrete is widely used as the construction material in the world. Ordinary concrete usage likes construction of buildings, architectural buildings, roads, foundations etc., the green house gases are caused the global warming issue, the green house gases likes CO₂ are increased in the atmosphere by the human activities. And the cement industries are play the major role in emission on CO₂ in atmosphere. Such as like that the total amount of cement production is emit the same amount of CO₂ in atmosphere. Among the scarcity of cement and the manufacturing of Portland cement is the most energy intensive process. To overcome this, the byproduct fly ash has been acquaint in place of cement. The overall evaluated sharing of normal Portland concrete (OPC) generation to ozone harming substance discharges is assessed to be roughly 1.35 billion tons yearly or around 7% of the aggregate green house gas outflows to the earth's atmosphere. However, the cement industry is extremely energy intensive. By taking all the above information's we have choose a alternative solution of concrete making process ,we have use the fly ash is a alternative for cement and with alkaline liquid is binding material. In terms of CO₂ emission will be reduces to atmosphere. One of the effort to produces the eco friendly concrete is to minimize the utilization of ordinary cement concrete by replacing the geopolymer concrete. The geopolymer concrete technology was first stick in to the world by the French professor Davidovits in 1978. In another way to say the

geopolymer concrete is ‘inorganic polymers’. The inorganic polymers are chemically reacted between the fly ash and alkaline activating solutions of sodium hydroxide and sodium silicate. By applying these geopolymer technology has reduce the industrial by product wastes. And fly ash is using main source material to produce concrete is called as fly ash based geopolymer concrete. And these study will be focus on properties of geopolymer concrete such as like compressive strength, split tensile strength of concrete.

1.1 Objective

- To produce the concrete mix without using of cement.
- To compare the strength variation of ordinary cement concrete with geopolymer concrete.
- To analyze the cost different for each others productions.
- To examine the experimental investigation of fly ash based ‘Geopolymer Technology’ in India.
- To check the boding of high calcium fly ash based geopolymer concrete.

II. LITERATURE REVIEW

Ammar motorwala et al (2013) in this study considering the increasing demand of construction materials and development of alternative materials for construction due to growth of environmental concentration , this paper deals with the feasibility of alkaline activated geopolymer concrete for upcoming constructions materials. This study mainly concentrated about structural behavior of fly ash based geopolymer concrete, and know about the basic mixture proportioning of geopolymer concrete.

Rangan (2014) conducted studies on heat cured low calcium fly ash based geopolymer concrete. The influence of salient factors such as water to geopolymer solids ratio, mixing time, curing time and curing temperature on the properties of geopolymer concrete in the fresh and hardened states were identified. The short term and long term properties of geopolymer concrete, creep and drying shrinkage, sulfate and sulfuric acid resistance of geopolymer concrete were discussed. The economic benefits of the geopolymer concrete were also briefly discussed. This paper concluded that heat cured low - calcium fly ash based geopolymer concrete possess excellent resistance to sulfate attack, good acid resistance, undergoes low creep and drying shrinkage.

Vijay et al., (2010) described the effect of curing types such as ambient curing and hot curing on the compressive strength of fly ash based geopolymer concrete. For hot curing, the temperature was maintained as 60°C for 24 hrs in hot air oven. The compressive strength of hot cured concrete was higher than the ambient cured concrete. In ambient curing, the compressive strength increases about five times with age of concrete from 7 days to 28 days. The compressive strength of hot cured fly ash based geopolymer concrete has not increased substantially after 7 days. The density of geopolymer concrete was around 2400 Kg/m³, which is equivalent to that of conventional concrete.

Hardjito et al., (2005) presented the effect of mixture composition on the compressive strength of fly ash based geopolymer concrete. Water to sodium oxide molar ratio and water to geopolymer solids ratio had influence on the compressive strength of geopolymer concrete. When these ratio increases, compressive strength of geopolymer decreases. As the water to sodium oxide molar ratio increased, the mixture contained more water and became more workable. The total mass of water is the sum of mass of water in sodium silicate solution, mass of water in sodium hydroxide solution and extra water if any added in concrete. The mass of geopolymer solids is the sum of the mass of fly ash, mass of sodium hydroxide flakes and mass of sodium silicate solids. Sodium oxide to silicon oxide molar ratio within the range of 0.095 to 0.120 had no significant effect on the compressive strength.

III. MATERIALS USED

This chapter generally deals with the what methodology will be used and these research project mainly focus on the strength property of high calcium fly ash based geopolymer concrete. And also study the main source material to produce the geopolymer concrete along high calcium fly ash and other raw materials.

3.1. Fly Ash

high calcium class C flyash (ASTM) obtained from lignite based thermal power station (Neyveli Lignite Corporation, Neyveli, Tamil Nadu, India) is used as the source material for the GPC respectively. The entire quantity of flyash required for the thesis work is collected at one time and preserve for the entire stretch of its use for making GPC. The chemical composition of cement and flyash used are determined as per the Indian standards.

3.2. Alkali-activators

The commonly used alkaline activator was combination of the sodium hydroxide pellets and sodium silicate solution (the solution which consist of 26.23% of solids (pellets) and 73.77% of water by mass). These materials are purchased from local market. The concentration of sodium hydroxide solution was maintained as 8M (Molarity).and taking ratio of sodium silicate ($\text{Na}_2\text{O SiO}_2$) to Na OH as 2.5.

3.3. Fine and Coarse aggregates

Locally available clean river sand was used as fine aggregate in the study conforming to Zone II as per IS 383-1970. The locally available crushed granite coarse of size 12.5mm was used for making concrete mix.

3.4. Preparation of activating solution

The sodium hydroxide solution is prepared 24 hours prior to use, because after dissolving flakes of Na OH in water, the temperature of solution can go up to 80°C , hence it is necessary to cool it at room temperature before use. The solids dissolved in water making a solution with the required concentration is allowed to cool to reduce the generated heat for 4 to 6 hours. Then it is mixed with sodium silicate solution. The sodium hydroxide solution thus prepared is mixed together with sodium silicate solution one day before adding the liquid to the solid dry constituents. To get desired alkaline solution.

3.1. Mix design

The process of mix design is illustrated by the concrete mix design for the trial mix with chemical ratio 0.45 and molarity 8M

1. Assume density of the concrete = 2400 Kg/m^3
2. Take mass of combined aggregate = 77% (75% to 80%)
= 1848 Kg/m^3
3. Coarse aggregate = $1848 \times 0.7 = 1293.6 \text{ Kg/m}^3$
4. Fine aggregate = $1848 - 1293.6 = 554.4 \text{ Kg/m}^3$
5. Mass of fly ash and alkaline liquid = 552 Kg/m^3
6. Taking alkaline liquid to fly ash ratio = 0.45
- 7 Molarity of Na OH = 8M
8. Mass of fly ash = $554 / (1+0.45) = 380.6 \text{ Kg/ m}^3$
9. Mass of alkaline liquid = $552 - 380.6 = 171.4 \text{ Kg/m}^3$
Consider ratio of sodium silicate to sodium hydroxide =2.5
10. Mass of Na OH = $171.4 / (1 + 2.5) = 48.97 \text{ Kg/ m}^3$
11. Mass of $\text{Na}_2 \text{ SiO}_3 = 171.4 - 48.97 = 122.43 \text{ Kg/ m}^3$
12. Water in $\text{Na}_2 \text{ SiO}_3$ is 55.9% therefore $122.43 \times 0.559 = 68.43 \text{ Kg/ m}^3$

13. Solid sodium silicate $(122.43 - 6.43) = 54 \text{ Kg/m}^3$
14. Solids in Na OH $(48.97 \times 0.2623) = 12.84 \text{ Kg/ m}^3$
15. Water in Na OH is $(48.97 - 12.4) = 36.13 \text{ Kg/ m}^3$
16. Total mass of water $(68.43 + 36.13) = 104.96 \text{ Kg/ m}^3$
17. Mass of geopolymer concrete solids $= 446.84 \text{ Kg/ m}^3$
18. Ratio of water to geopolymer solids $= 0.234$

IV. EXPERIMENTAL LABORATORY WORK

The laboratory experimental work was ascertain the mechanical properties of the geopolymer concrete like compressive strength, split tensile strength of concrete according to the above mix design (M_{20}) concrete mix.

4.1 Compressive strength results

The compressive strength was calculated by the average of the 3 cube specimens sizes are taken in $150 \text{ mm} \times 150 \text{ mm} \times 150 \text{ mm}$. the age of curing will be varied from 7,14 and 28 days. Results are shown in below table 1 and 2 for cube compressive strength and fig 1 shows the details of both compressive strength results .

Table 1 compressive strength results for geopolymer concrete using river sand

Curing days	Curing specimen no	Strength N/mm^2	Average N/mm^2
7	1	13.36	13.95
	2	14.52	
	3	13.96	
28	1	25.88	25.33
	2	24.79	
	3	25.32	

Table 2 compressive strength for geopolymer concrete using M- sand

Curing days	Curing specimen no	Strength N/mm^2	Average N/mm^2
7	1	15.43	16.14
	2	16.33	
	3	16.67	
28	1	27.59	27.78
	2	28.01	
	3	27.74	

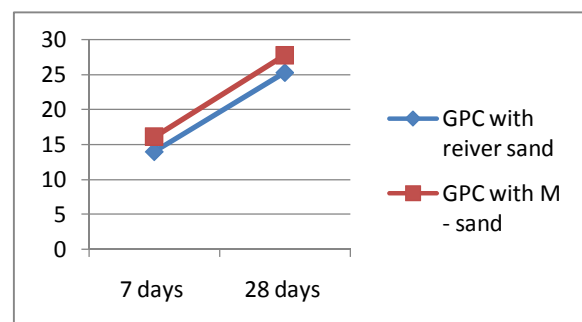


Fig.1 compressive strength for cubes

IV. DISCUSSION

The main objective of the study was develop the strength of geopolymers concrete with the use of industrial waste like fly ash and manufacturing sand. The compressive strength of cubes are compared with the geopolymers concrete to geopolymers concrete with m-sand. The fully replacement of manufacturing sand geopolymers concrete is more efficient and eco-friendly when compare to others. the replacement of m-sand for geopolymers concrete has to improve the compressive strength and the same time reduce the hydration. Achieving ultra high strength. in further investigation. The utilization of flyash in concrete solves the problems of its disposal task keeping the environment free from pollution and scarcity of cement.

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