Experimental Study on Fly Ash Based Geopolymer Concrete Paver Block

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Abstract—**Presently, the world is experiencing a drastic climatic change which occurs due to the increase in the amount of greenhouse gasses. CO_2 is one among the gasses that contribute to the greenhouse effect. Production and usage of cement contributes to 40% of the total CO_2 emitted into the atmosphere. Environmental responsibility has initiated in sustainability and eco friendly methods of infrastructure development. In future, there is going to be a time when there will be scarcity for cement and water. So, we have adopted geo- polymer concreting method to produce paver block which doesn't require cement and water. Also we are doing a comparative study between conventional paver block and geo polymer paver block, under the discipline of strength, cost and eco-friendliness.**

Keywords—geopolymer; green house gases; sustanability; eco-friendliness.

I. Introduction

Davidovits (1988; 1994) proposed that an alkaline liquid could be used toreact with the silicon (Si) and the aluminum (Al) in a source material of geological origin or in by-product materials such as fly ash and rice husk ash to produce binders. Because the chemical reaction that takes place in this case is a polymerization process, he coined the term 'Geopolymer' to represent these binders. Geopolymers are members of the family of inorganic polymers. The chemical composition of the geopolymer material is similar to natural zeolitic materials, but the microstructure is amorphous. The polymerization process involves a substantially fast chemical reaction under alkaline condition on Si-Al minerals that result in a three-dimensional polymeric chain and ring structure consisting of Si-O-Al-O bonds (Davidovits, 1994).

This water, expelled from the geopolymer matrix during the curing and further drying periods, leaves behind discontinuous nana-pores in the matrix, which provide benefits to the performance of geopolymers. The water in a geopolymer mixture, therefore, plays no role in the chemical reaction that takes place; it merely provides the workability to the mixture during handling. This is in contrast to the chemical reaction of water in a Portland cement concrete mixture during the hydration process.

There are two main constituents of geopolymers, namely the source materialsand the alkaline liquids. The source materials for geopolymers based on alumina-silicate should be rich in silicon (Si) and aluminum (Al). These could be natural minerals such as kaolinite, clays, etc. Alternatively, by-product materials such as fly ash, silica fume, slag, rice-husk ash, red mud, etc could be used as source materials. The choice of the source materials for making geopolymers depends on factors such as availability, cost, type of application, and specific demand of the end users. The alkaline liquids are from soluble alkali metals that are usually Sodium or Potassium based. The most common alkaline liquid used in geopolymerisation is a combination of sodium hydroxide (NaOH) or potassium hydroxide (KOH) and sodium silicate or potassium silicate.

II. MATERIALS

a. Fly Ash

Fly ash is the most abundantly used mineral admixture as replacement for cement in mortar. It is also the main ingredient for geopolymer mortar due to its active participation in the geopolymerization process. Pozzolanic material exhibits cementitious properties when combined with calcium hydroxide. Fly ash is used as the pozzolana in many concrete applications. Fly ash is used as cement replacement.

b. Fine Aggregate

Locally obtained trichy river sand is used as the fine aggregate in the mortar mixes. The sieve analysis result indicates that the sand confirms to zone-II as per IS: 383- 1970.

c. Sodium Hydroxide

Generally, NaOH is available in market in 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 based on the molarity required. 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.

d. Sodium Silicate

It is also known as water-glass which is available in the market in gel form. The ratio of SiO_2 and Na_2O in sodium silicate gel highly affects the strength of geopolymer mortar. Mainly it is seen that a ratio ranging from 1 to 1.5 gives a satisfactory result.

III. MIX PROPORTION AND EXPERIMENTAL INVESTIGATION

a. Geopolymer Mix Design

Sodium hydroxide concentration	=14 M
Na_2SiO_3 to NaOH ratio	=1:2.50
Mix ratio	=1:0.6:1
Alkaline activator to Fly ash ratio	=0.62
Curing type	=oven curing
Curing period (oven)	=24 hrs@72°c -75°c

Fig.1 Moulding of Paver block

b. Preparation of alkaline activator solution

A combination of sodium hydroxide solution and sodium silicate solution was used as alkaline activators for geo polymerization. To prepare sodium hydroxide solution of 14 molarity (14M), 400 g of sodium hydroxide flakes were dissolved in distilled water and made up to one liter. The ratio of sodium hydroxide to sodium silicate is 1:2.5. As the reaction will evolve hot fumes, it will take one day to the solution to cool down. So, the solution should be mixed with one day prior to casting.

c. Preparation on geopolymer concrete

The raw materials are taken in calculated amounts. Then first the fly ash is mixed with the fine aggregate (quarry dust). Then the mix is mixed with coarse aggregate (6mm chips). Then finally alkaline activator solution is mixed with addition to super plasticizer for workability and the geo polymer concrete is prepared and is ready for casting.

Then Geopolymer concrete is poured into the mould. The mould is zigzag in shape, for the calculation purpose we have considered it as cuboid. For each rubber moulds of size 240 mm × 120 mm × 80 mm are used. The time period taken for demoulding is 4 days then the specimens are kept in heat curing chamber for oven curing.

Fig.2 Compaction using Table Vibrator

d. Compression test

Then specimen is placed in the compression testing machine in the recommended manner. Now the specimen is subjected to compression load after which they will crack. The readings are noted.

Fig.3 finished Paver block

Fig.4 Compaction testing machine

IV. TEST RESULT

A. Result and discussion

Sample	**Compressive strength**	
	Conventional Paver Block	*Geo-Polymer Paver Block*
GPPB-1	34.78 N/mm^2	42.71 N/mm^2
GPPB-2	35.26 N/mm^2	41.67 N/mm^2
Average	35.02 N/mm^2	42.19 N/mm^2

Cost analysis	
Conventional Paver block	*Geo-polymer Paver block*
Rs. 19.50	Rs. 31

The basic properties of materials were tested and the results are tabulated .The specimens are cured using heat curing chamber .The compressive strength of conventional paver block is compared with our geopolymer paver block. Conventional paverblock has a compressive strength of 35.02 N/mm^2 while our geopolymer aver block has a compressive strength of 42.19N/mm^2.

As CO_2 is the major contributor for the green house effect we have eliminated CO_2 by eliminating cement from our concrete.

In future there may be a crisis for water , that is when geopolymer concrete will get into good effect.

B. Conclusion

The following conclusions are made from the experimental study

1) This paper presents brief details of geopolymer concrete using sustainable materials.
2) This geopolymer paver blocks completely eliminates the CO_2 emissions.
3) The cost of geopolymer paver block is higher than conventional paver block but it gives more strength when compared conventional paver block and it doesn't harm to nature.

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