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. Preliminary Test on Materials

A. *Testing of flyash*

1. *Fineness Test of flyash*

Correctly 100grms of flyash was weighed and taken in a standard IS sieve no.9 (90 microns).The lumps were broken down and the material was sieved continuously for 15 minutes using sieve shaker. The residue left on the sieve was weighed. This weight does not exceed 5% for flyash. Percentage of residue left on sieve = (weight retained/weight taken) x 100

Result: Percentage of residue left on sieve = 0.28%

2. Specific Gravity Of Fly Ash

It is found with the help of Le Chatelier's apparatus.Weight of empty flask (w1).The bottle with some amount of fly ash and weighed it (w2).Fill in the flask with fly ash and kerosene filled up to the brim of the flask and weighed it (w3).The flask with kerosene filled up to the brim of the flask and weighed it (w4)Specific gravity of kerosene = 0.79

Specific Gravity = ((w2 – w1) / (w2-w1) – (w3-w4)) ×0.79

Specific Gravity of Flyash (G) = 1.93

B. Testing of Fine Aggregate

1. Sieve analysis of quarry dust

The sample was brought to air – dried condition before weighing and sieving was achieved after drying at room temperature. The air – dry sample was weighed

Fineness modulus =3.13

Zone conformation = Zone-II

2. Specific Gravity Test of quarry dust

It is found with the help of Le Chatelier's apparatus.Weight of empty flask (w1).The bottle with some amount of fly ash and weighed it (w2).Fill in the flask with fly ash and kerosene filled up to the brim of the flask and weighed it (w3).The flask with kerosene filled up to the brim of the flask and weighed it (w4)Specific gravity of kerosene = 0.79

Specific Gravity = ((w2 – w1) / (w2-w1) – (w3-w4)) ×0.79

Specific Gravity of Fine Aggregate (G) = 2.72

C. Testing of Coarse Aggregate

1. Specific Gravity Test of Coarse Aggregate

The container was dried thoroughly and weighed as W_1 gram. 800 gram of fine aggregate was taken in the container and weighed as W_2 gram. The container was filled with water up to the top. Then it was shacked well and stirred thoroughly with the glass rod to remove the entrapped air. After the air has been removed the container r was completely filled with water up to the mark. The outside of container r was dried with a clean cloth and it was weighed as W_3 grams. The container was cleaned thoroughly. The container was completely filled with water up to the top. Then outside of the container was dried with a clean cloth and it was weighed as W_4 grams.

Result: Specific Gravity of Coarse Aggregate (G) = 2.66

III. MIX DESIGN

Design stipulations

a)	Characteristic compressive strength required	=	35MPa
b)	Maximum size of aggregate (angular)	=	6mm
c)	Specific gravity of fly ash	=	1.93
d)	Specific gravity of coarse aggregate	=	2.66
e)	Specific gravity of fine aggregate	=	2.72
f)	Sand conforming	=	zone II
g)	Specific gravity of NaOH	=	1.47
h)	Specific gravity of Na_2Sio_3	=	1.6

Solution

Step 1: Selection of fly ash to the compressive ratio

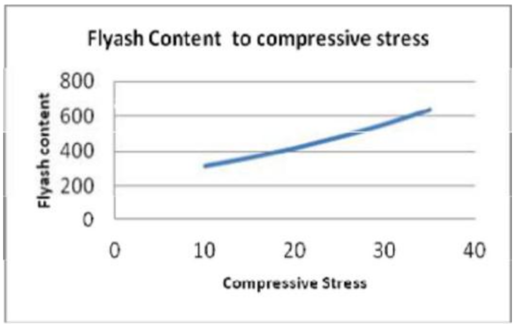

Figure 6.1: Shows fly ash content to the compressive strength

The amount of fly ash required for M35 grade =620 Kg/m^3 is Derived from the above figure 6.1.

Step 2: Selection of alkaline liquid ratio

Generalized relation between free alkaline liquid to fly ash ratio and compressive strength of concrete from the figure 6.2

The ratio between Sodium hydroxide to sodium silicate is 1:2.5 from the table 6.1

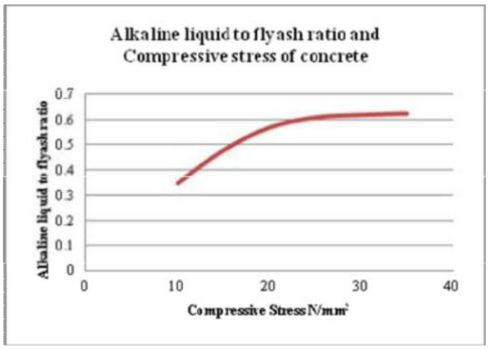

Figure 6.2: The amount of alkaline liquid required accordance to compressive stress

The amount of Alkaline liquid =0.62 x fly ash content

= 0.62 x 620

= 384.40Kg/m^3

Amount of Sodium silicate Solution = 274.57 Kg/m^3

Amount of Sodium Hydroxide Solution = 109.83 Kg/m^3

Morality to be used in the concrete is 14 molar in which 400 grams of NaOH solids dissolved in 600 grams of water. Solids = 43.93 Kg/m^3 Water = 65.90 Kg/m^3

Table 6.1: Sodium hydroxide to sodium silicate ratio accordance to compressive strength

Compressive strength	Sodium hydroxide	Sodium silicate
10	1	3
15	1	2.5
20	1	2.5
25	1	2.5
30	1	2.5
35	1	2.5
40	1	2.5
45	1	2.5

Step 3: Selection of water content

The maximum water content to add extra is 0.06 Water to fly ash ratio

The minimum water content to be added extra is 0.02 water to fly ash ratio

According to workability extra water can be added this is due to fly ash is arrived from various plant which have different properties in absorption of water in order to match extra water is added.

Amount of water add extra 0.03 to water fly ash ratio = 0.03x620 = 18.6 kg/m^3

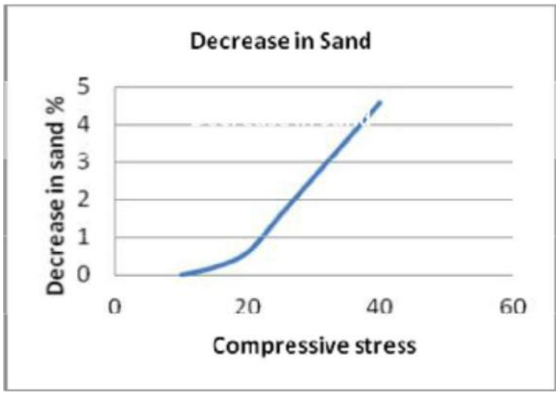

Figure 6.3: Adjustment of values in sand content percentage

Table 6.2: Approximate sand contents per cubic meter of concrete for grades up to M35grade

Nominal size of coarse aggregate	Sand as percentage of total aggregate by absolute volume
10mm	40
20mm	35

Change in condition	Sand content in %
For sand conforming to Zone II	0%
For decrease in sand content	–2.5%
Total	–2.5%

From above graph decrease in sand content= 3.5%

Total aggregate by absolute volume = (42 – 3.5)
= 38.5%

Estimation of Air Content

Table 6.3: Approximate air content

Nominal maximum size of aggregate in mm	Entrapped air as percentage of volume of concrete
10	3%
20	2%

Determination of aggregate content

From table, for the specified maximum size of aggregate of 10 mm, the amount of entrapped air in the wet concrete is 3 %. Taking this into account and applying the following equations:

$$V = \left[\frac{SO}{S_{SO}} + \frac{S}{S_S} + \frac{F}{S_F} + \frac{1}{P}\frac{F_a}{SF_a}\right] \times \frac{1}{1000}$$

$$V = \left[\frac{SO}{S_{SO}} + \frac{S}{S_S} + \frac{F}{S_F} + \frac{1}{1-P}\frac{C_a}{SC_a}\right] \times \frac{1}{1000}$$

Where,

V = Absolute volume of fresh concrete, which is equal to gross volume minus the volume of entrapped air.

S = Sodium Silicate Solution (kg) per m^3 of concrete.

SO = Sodium Hydroxide Solution (kg) per m^3 of concrete

F = Weight of Fly ash (kg) per of m^3 of concrete

S_F = Specific gravity of Fly ash

P = Ratio of fine aggregate to total aggregate by absolute volume

F_a, C_a = Total masses of fine aggregate and coarse aggregate (kg) per m^3 of concrete respectively

SF_a, SC_a = Specific gravity of saturated surface dry fine aggregate and coarse aggregate respectively.

Fine aggregate content:

$$V = \left[\frac{109.83}{1.47} + \frac{274.57}{1.60} + \frac{620}{1.93} + \frac{1}{0.385} \times \frac{F_a}{2.72}\right] \times \frac{1}{1000}$$

F_a= 372 Kg/m^3

Coarse aggregate content:

$$V = \left[\frac{109.83}{1.47} + \frac{274.57}{1.60} + \frac{620}{1.93} + \frac{1}{1-0.385} \times \frac{C_a}{2.66}\right] \times \frac{1}{1000}$$

C_a=620 Kg/m^3

Table 6.4: Mix proportion

Sodium silicate	Sodium hydroxide solution	Extra water	Fly ash	Fine aggregate	Coarse aggregate
274.57 kg/m^3	109.83 kg/m^3	18.6 kg/m^3	620 kg/m^3	372 kg/m^3	620 kg/m^3
0.62		0.03	1	0.6	1

IV. IMPACT TEST ON CONCRETE

The specimen is placed in the impact testing apparatus and the clamps are tightened. Now we should give blows until initial crack appears on the specimen and the number of blows is noted. This process is continued until the specimen has its final cracking.

Sample	Number of blows			
	Conventional Paver Block		Geo-polymer Paver Block	
	Initial Crack	Final crack	Initial Crack	Final crack
GPPB-3	28	37	68	79
GPPB-4	30	39	62	75
Average	29	38	64	77

A. Result and discussion

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 an impact strength of 29(initial cracking) 38 blows(final cracking) while our geopolymer paver block has an impact strength of 64 blows(initial cracking) 77 blows final cracking.

As c02 is the major contributor for the green house effect we have eliminated co2 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.

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