Experimental Study on Behavior of Geopolymer Tiles with Fly ash and GGBS

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Abstract — Around the world, concrete is most frequently used for all construction purpose due its ease of the operation, good mechanical strength and economical. However, the excessive usage of the concrete results in more consumption of the cement during the manufacturing huge amounts of carbon dioxide is released. The, geopolymer concrete has a lower carbon footprint than conventional concrete. The alumina and silicate-holding materials will react with each other with the alkaline activators which will result in the formation of the geopolymer concrete which can be used as the replacement for the OPC. In this experiment geopolymer tiles are manufactured using different normality 6N, 8N, 10N of Sodium Hydroxide. For the 8N NaOH in the mix has given the maximum strength and used for further studies .The study is also conducted with varying ratio of fly ash and GGBS and 25% FA - 75%GGBS ratio has given the maximum strength in the test results.

Keywords: Fly Ash, GGBS, Alkaline Activator, Geopolymer

I. Introduction

Geopolymer concrete is a concrete in which the alumina and silicate source materials will react with the alkaline activators which will result in the formation of the geopolymer concrete which can be used as the replacement for the ordinary Portland cement. In the year 1978 Davidovits was the first one to introduce the term geopolymer. He used to describe the group of the mineral binders that have the same composition that of the zeolites except they have an amorphous structure. Geopolymer concrete uses the things which contain alumina and silicate holding materials like iron ore waste like fly ash, GGBS etc[1,2,3]. withe use of these and alkaline activators like sodium hydroxide and sodium silicate can form suitable replacement for the ordinary Portland cement and it also reduces the carbon footprint in the environment.

Geopolymerisation is a new technology adopted these days to reduce the use of Portland cement in concrete, which is an environment-friendly approach to use industrial byproducts. This concept of geopolymer was first developed by Joseph Davidovits in the 1970s. Geopolymer compound consists of aluminosilicate source material mixed with alkaline solutions at ambient or elevated temperatures from 30°C to 100°C [4]The source materials mainly considered are flyash, GGBS, rice husk ash, etc., with high silicon (Si) and aluminium (Al) content. Factors such as the type of application, cost and availability have to be considered while selecting source material [3,5]

II. Materials & Methodology

1) Fly ash: Fly ash is a fine powdered byproduct of burning pulverized coal in electric generation power plants. The properties of fly ash include the following; specific gravity 2.94.
2) GGBS -Ground-granulated blast-furnace slag is obtained by quenching molten iron slag. It is a by-product of iron and steel-making from a blast furnace in water or steam, to produce a granular product that is then dried and ground into a fine powder. The properties of GGBS includes specific gravity 1.92.
3) Alkaline Activators the combination of sodium hydroxide and sodium silicate solutions are used for the activation of fly ash based geopolymer concrete. It is observed that the compressive strength of geopolymer concrete increases with increase in concentration of sodium hydroxide solution and or sodium silicate solution with increased viscosity of fresh mix.
4) Fine Aggregate: River sand was used as fine aggregate which conforms to IS: 383-1970 and grading zone II. The sand was made to pass through 4.75mm sieve to remove any particles greater than 4.75mm.
5) Coarse Aggregate: Coarse aggregate used in the investigation is angular aggregates with rough surfaces of nominal size of 20mm and conforming to IS: 383-1970. Normally, coarse aggregates occupy 70%-80% of the total volume of concrete but self-compacting concrete have only 50% of the total volume of concrete.

Fig. 1: Materials

A. *Mix design:*

THERE FOR 1 m3
Quantity of FLY ASH =202.5 kg/m3
Quantity of GGBS =202.5 kg/m3
Quantity of Na_2SiO_3 = 70.88 kg/m3
Quantity of NaOH =70.88 kg/m3
Sand content = 683.13 kg/m3
Coarse aggregate content=1268.66 kg/m3
Water Content =108.35 kg

B. *Mixing*

In the process of mixing of the materials the batching of the materials is done. Each amount of the material by mix design for the trial is weighed down. The alkaline activators will be prepared according to the required molarity before 24 hours. Firstly GGBS, fly ash, coarse and fine aggregates are laid down and then water and alkaline activators are mixed thoroughly as shown in fig 3

Figure 3: Dry and Wet Mixing

C. Casting

After the mixing of the material, the mould which is greased is kept to next to mixing and the it's laid down into mould by three layers. Each layering receiving 25 blows from tramping rod for compaction of concrete as shown in fig 4 &5

Fig. 4: Casting

D. Curing

Curing for the concrete is done by keeping the specimen of in water for 3, 7,28 days respectively. Curing can be done by via water, keeping in the oven or natural sunlight curing.

For the geopolymer concrete to be cured heat curing is preferred more than water. The specimen can be kept in oven at 60 temperature for 24 hours or kept outside in the sun for 7 days to attain its strength.

Fig. 5: Demolded Tile Kept for Curing

III. TEST RESULTS AND DISCUSSION

A. Compressive Strength Test

Here the compressive strength will test is done for 2 different shape samples from each normality that is 6M,8M and 10M for 50% flyash and 50% GGBS. The sample 1 is of damaru shape and sample 2 is of square shape.Test is conducted after 7 days of ambient curing given in fig 6

Fig. 6: Testing and Failure Pattern of Sample

NaOH concentration	sample	FLYASH GGBS combinations	Weight in kg	Load (KN)	Compressive strength N/mm2
6N	1	50:50	4.25	349	7.9
	2		4.38	560	12.69
8N	1	50:50	4.89	645	14.62
	2		4.34	495	11.22
10N	1	50:50	5.28	495	12.22
	2		5.85	654	14.82
Normal concrete block			4.22	834	18.91

Table 1: Compressive Strength of Specimen

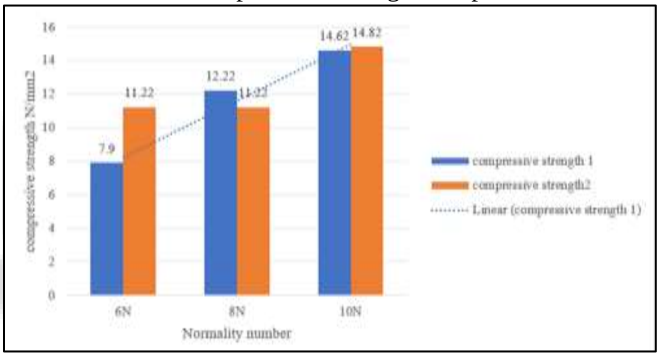

Fig. 7: Compressive Strength of Geopolymer tiles

The test results for compressive strength were obtained for different concentration of NaOH such as 6N, 8N and 10N are with fly ash and GGBS combinations is given in fig 7.The test results of compressive strength of 8N NaOH and 10 N NaOH for different mix combinations of flyash and GGBS.

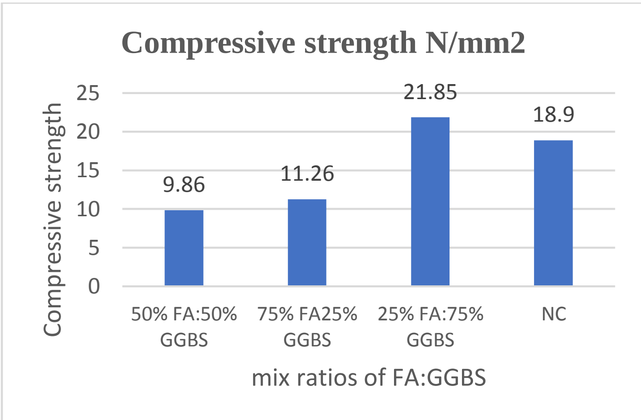

Fig. 8: Compressive Strength of 8 N NaOH Geopolymer tiles

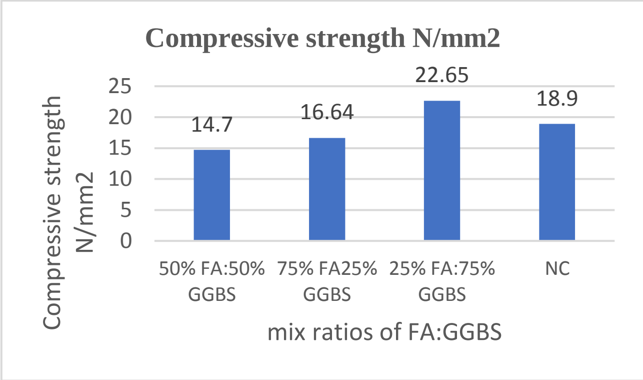

Fig. 9: Compressive Strength of 10N NaOH Geopolymer tiles

B. Flexural Strength

The test results for Flexural strength were obtained from the test results of 8N NaOH and 25FA -75GGBS mix combination of geopolymer tiles were given in the figure 10 which comparable with the normal concrete values .

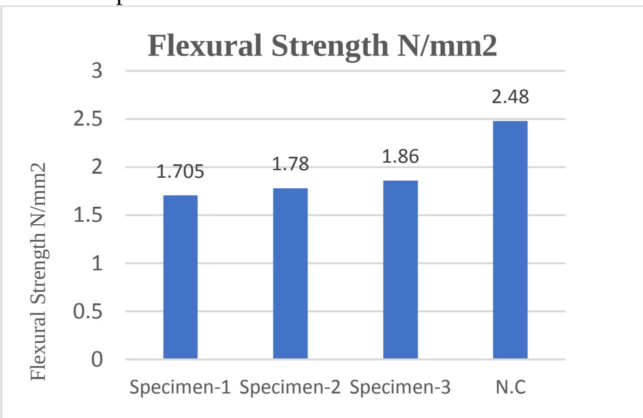

Fig. 10: Flexural Strength of 10N NaOH Geopolymer tiles

C. SEM Analysis

Scanning electron microscopy (SEM) is an analytical technique used for analyzing at high magnifications and producing high-resolution images. In SEM analysis, a focused beam of electrons is directed to sample specimen by scanning coils to produce secondary electrons and backscattered electrons. The white particles represented the anhydrous flyash or slag grains. The greyish matrix represented the N-A-S-H or C-A-S-H gel, which was more compact and less porous. The dense microcracking in the image was due to intense drying and shrinkage in these materials. The SEM image of the mix is given 25FA -75GGBS with 8N NaOH is given in fig 11

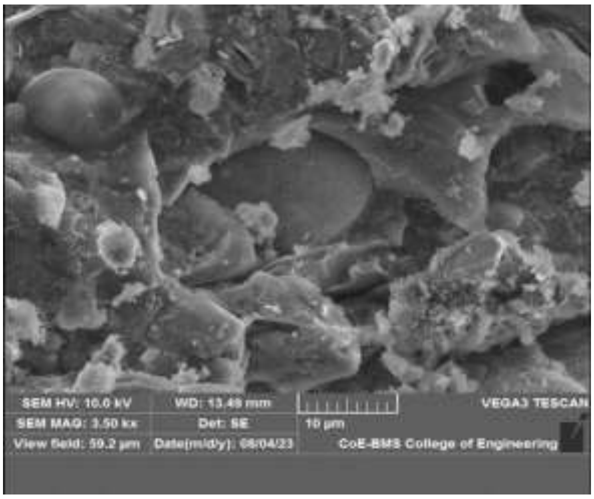

Fig. 11: Sem Of Geopolymer Concrete (8N NaOH (25FA -75GGBS)).

IV. CONCLUSIONS

- Use of geopolymer concrete for pavement tiles manufacturing instead of conventional concrete will result less CO_2 emission. GGBS which is a byproduct of Steel and iron industry can be effectively used for the manufacturing of geopolymer concrete tiles
- The 8N and 10N NaOH has given the good strength results and as the normality increases the strength also increased chosen 8N as the optimum concentration. The 8N normality of NaOH gives the maximum strength with the fly ash and GGBS as source materials.
- The maximum strength is given by 8N NaOH for 25%-fly ash and 75% GGBS mix ratio.The water absorption percentage of geopolymer tiles obtained less than 2%.
- The flexural strength test is conducted and results shows the strength comparable to normal concrete.
- The strength of geopolymer tiles is greater than that of concrete tiles.

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