Comparative Studies on Floor Tiles using Geopolymer Concrete and Cement Concrete

Balakumaran. M[1], Cyril Xavier. T[1], Ponmathan Kumar. P[1], Praveen Kumar. J[1]
Mr. Ganesh Kumar. M[2]
UG Students[1], Nadar Saraswathi College of Engineering and Technology, Theni, Tamilnadu, India.
Senior Lecturer[2], Nadar Saraswathi College of Engineering and Technology, Theni, Tamilnadu, India.

***Abstract*—This experimental study compares the market available cement concrete floor tiles and geopolymer floor tiles. Geopolymer results from the reaction of a source material that is rich in silica and alumina (Fly ash) with alkaline liquid. Geopolymer concrete tiles manufactured with the ratio of (Fly ash, Fine aggregate and coarse aggregate) 1:1:2 and the ratio of alkaline solution to fly ash are taken as 0.2, 0.3 & 0.4. By adding 2% of super plasticizer, the water to fly ash ratio comes about 0.15. The geopolymer is designed for 14molarity. After casting the floor tiles, it placed in hot air oven at 80°C for 24 hours curing. After 7 days of casting, Wet Transverse test, Water absorption test and Wear test were carried out for both geopolymer tiles and cement concrete tiles specimens as per IS 1237:2012. The performance of Geopolymer concrete floor tile with 0.4 alkaline solution is similar to Ordinary cement concrete floor tile.**

Keywords*—Ordinary Portland Cement concrete, Geopolymer concrete, Fly ash, Sodium Hydroxide, Sodium Silicate.

I. INTRODUCTION

The demand for Ordinary Portland Cement would increase further in the future. The production of cement is annually increasing about 3% (McCaffrey-2002). The manufacturing of OPC requires the burning of large quantities of fossil fuel and decomposition of lime stone, which results in significant emissions of CO_2 to atmosphere. Manufacturing of one ton of cement liberates about one ton of CO_2 to atmosphere (Roy-1999). Since Portland cement is responsible for upward of 85 percent of the energy and 90 percent of the carbon dioxide attributed to a typical ready-mixed concrete (Marceau et al. 2007), the potential energy and carbon dioxide savings through the use of geopolymers can be considerable. Among greenhouse gases, CO_2 contributes about 65% of global warming, which become a major concern. Although the use of Portland cement is unavoidable in the foreseeable future, many efforts are being made to reduce the use of Portland cement in concrete. On the other hand, the abundant availability of fly ash worldwide creates opportunity to utilize this by-product of burning coal, as a substitute for OPC to manufacture concrete. Geopolymer concrete offers waste utilization and reductions of CO_2 emissions.

II. PAST RESEARCH ON GEOPOLYMER

Davidovits (1999) proposed that binders could be produced by a polymeric reaction of alkaline liquids with the silicon and the aluminum in fly ash. The term binder means geopolymers. The ultimate structure of the geopolymer depends largely on the ratio of Si to Al (Si : Al). Water is not involved in the chemical reaction of Geopolymer concrete and instead water is expelled during curing and subsequent drying. This is in contrast to the hydration reactions that occur when Portland cement is mixed with water, which produce the primary hydration products calcium silicate hydrate and calcium hydroxide.

III. REVIEW OF LITERATURE

(Vijaya Rangan B) Fly ash-based geopolymer concrete has excellent compressive strength. The elastic properties of hardened concrete and the behavior and strength of reinforced structural members are similar to those of Portland cement concrete. . The fly ash-based geopolymer concrete also shows excellent resistance to fire, sulfate attack, undergoes low creep, and suffers very little drying shrinkage.

(Aaron Darius - 2012) GPC have superior resistance to chemical attack making them suitable for aggressive soils. GPC have high compressive strength. GPC paver blocks outperform OPC paver blocks under freezing and thawing conditions. This makes them suitable for arctic environments where OPC based products deteriorate rapidly.

(František Škvára) The geopolymer concrete is resistant to the corrosive environments.

(Abdul Aleem 2012) The production of versatile, cost-effective geopolymer concrete can be mixed and hardened essentially like Portland cement. Due to the high early strength Geopolymer Concrete shall be effectively used in the precast industries, so that huge production is possible in short duration and the breakage during transportation shall also be minimized. High early strength was obtained in the Geopolymer concrete mix. The increase in percentage of fine aggregates and coarse aggregates increased the compressive strength up to the optimum level.

(Arumairaj 2012) The Geopolymer concrete showed high performance with respect to the strength. The Geopolymer concrete was a good workable mix. High early strength was obtained in the Geopolymer concrete mix. The increase in percentage of fine aggregates and coarse aggregates increased the compressive strength up to the optimum level.

(Anuar K.A - 2011) The concentration (in term of morality) of NaOH influenced the strength characteristic of geopolymer concrete. The higher concentration of sodium hydroxide (NaOH) solution, higher compressive strength of geopolymer concrete will produced because the higher concentration of NaOH will make the good bonding between aggregate and paste of the concrete.

(Raijiwala D.B - 2011) Further good structural properties can be achieved with increase in polymerization temperature along with prolonged curing period in oven.

(D Hardjito - 2005) The extended mixing time resulted in better polymerisation process, and hence enhanced properties of hardened concrete.

IV) MATERIALS, MIXURE COMPOSITIONS

In this experimental work fly ash obtained from a Tuticorin power plant was used as the source material. Sodium silicate solution and sodium hydroxide liquids were mixed (Alkaline ratio 0.4) together and the activator solution was prepared at least one day prior to its use. To improve the workability of fresh concrete, a commercially available naphthalene based super-plasticiser was used. A combination of locally available aggregates, i.e. granite-type coarse aggregates (6mm) and fine sand (M-sand) were mixed together.

Table (1) Mixture composition

Alkaline ratio of GPC	Fly ash	M- sand	Coarse Aggregate	Alkaline solution	Sodium Hydroxide	Sodium Silicate	Super plasticizer
	Kg/m^3						
0.2	656	656	1312	131	39	92	13
0.3	656	656	1312	197	59	138	13
0.4	656	656	1312	262	79	184	13

The detail of the Mixture of geopolymer concrete is given in Table 1. The aggregates and the fly ash were mixed dry in a pan mixer for about 3 minutes. At the end of this dry mixing, the activator solution, the super plasticizer, and the extra water were mixed together for another 3 to 5 minutes. The fresh concrete is prepared.

Figure (1) Fresh Geopolymer concrete

V) FRESH CONCRETE TESTS

Fresh concrete undergo the tests of slump test and compaction test then the results obtained.

A) SLUMP TEST

The slump values of fresh concrete are in table (2) and it plotted in Graph (1)

Table (2) Slump test value

Type of concrete	OPC concrete	GPC with alkaline ratio		
		0.2	0.3	0.4
W/C ratio or W/F ratio	0.45	0.15	0.15	0.15
Slump value (mm)	75	72	74	76

Graph (1) Slump value comparison

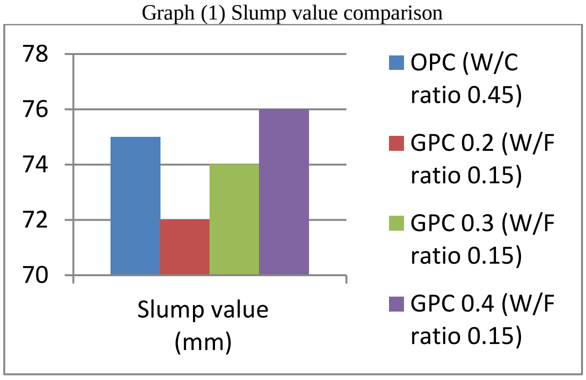


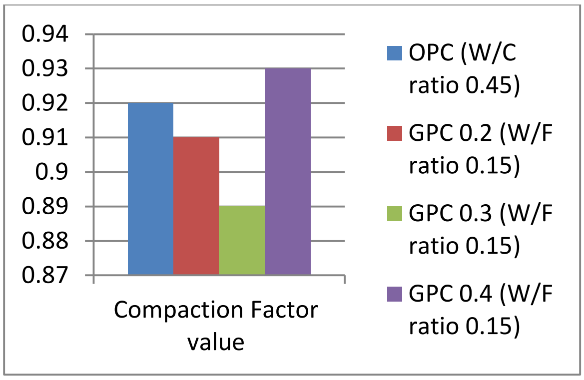
Figure (2) Slump test

B) COMPACTION FACTOR TEST

The compaction factor value is indicated in table (3) and it plotted in Figure (2)

Table (3) Compaction factor test

Type of concrete	OPC concrete	GPC with alkaline ratio		
		0.2	0.3	0.4
W/C ratio or W/F ratio	0.45	0.15	0.15	0.15
Compaction factor value	0.92	0.91	0.89	0.93



Graph (2) Compaction Factor value comparison

Figure (3) Compaction factor test

VI) CASTING, CURING

The fresh concrete had a stiff consistency and was glossy in appearance. The fresh concrete mixture was then cast in moulds in two layers. Each layer vibrated for 10 seconds on a vibrating table. Immediately after casting, the samples were covered by a film to avoid the loss of water due to evaporation during curing at an elevated temperature. The specimens were cured in hot air oven at 80°C temperature for 24hours or it placed in ambient temperature for 3days. Polymerization process accelerates when the specimen placed in hot air oven, and it slowly done when specimen placed in ambient temperature.

VII) TILE SPECIMEN TESTS

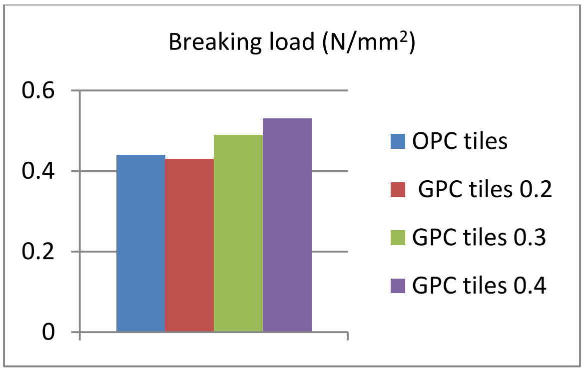
The specimens were then removed from the moulds. The specimens were tested wet transverse test, wear test and water absorption test and results obtained.

A) WET TRANSVERSE STRENGTH TEST

The compaction factor value is indicated in table (5) and it plotted in Figure (2)

Table (4) Wet transverse test

Tile specimen	Breaking Load (N/mm^2)
OPC concrete	0.44
GPC with alkaline ratio 0.2	0.43
GPC with alkaline ratio 0.3	0.49
GPC with alkaline ratio 0.4	0.53



Graph (3) Wet transverse strength test values between OPC and GPC

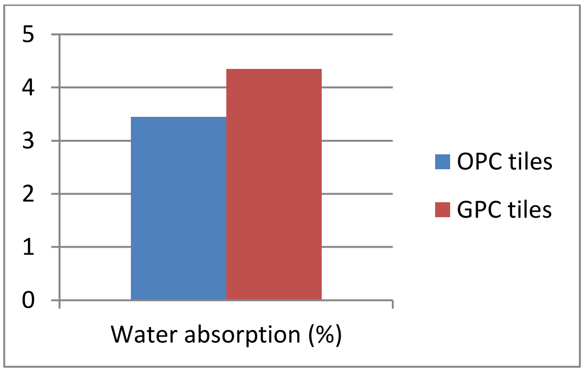
Figure (4) Wet transverse test

B) WATER ABSORPTION TEST

The Water absorption test values are indicated in table (4) and it plotted in Figure (3)

Table (5) Water absorption test

Tile specimen	Water absorption (%)
OPC Concrete tiles	3.41
GPC tiles	4.35



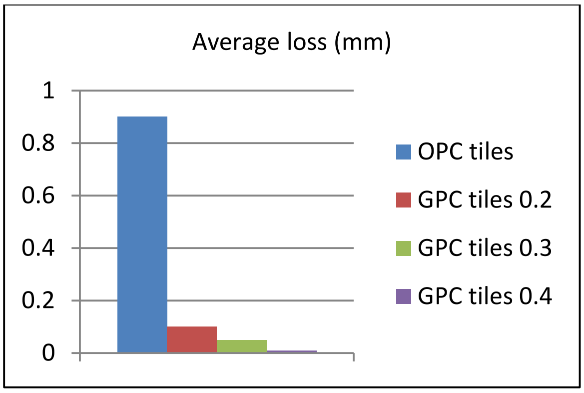
Graph (4) Comparison of Water absorption values between OPC and GPC

C) RESISTANCE TO WEAR TEST

The compaction factor value is indicated in table (6) and it plotted in Figure (5)

Table (6) Wear test

Average loss (mm)	OPC concrete	GPC with alkaline ratio		
		0.2	0.3	0.4
	0.9	0.1	0.05	0.01



Graph (5) Resistance to wear test values between OPC and GPC

Figure (5) Resistance to wear test

VIII) RESULT AND DISCUSSION

Slump test values and Compaction factor test values shows the behavior of fresh Geopolymer concrete with alkaline ratio 0.2 is less than OPC, GPC with alkaline ratio 0.3 is equal to OPC and GPC with alkaline ratio 0.4 is greater than OPC fresh concrete. GPC tile with an alkaline ratio 0.4 absorbs water little more than OPC tile, but both values are less than 6%. Wet transverse test results also shows the behavior of GPC tile with alkaline ratio 0.2 is less than OPC tile, GPC tile with alkaline ratio 0.3 is equal to OPC tile and GPC tile with alkaline ratio 0.4 is greater than OPC tile. In Wear test, OPC tiles losses 0.9mm while wear, but GPC 0.2 losses 0.1mm, GPC 0.3 losses only 0.05mm and GPC 0.4 didn't wear due to the alkaline ratio 0.4.

IX) CONCLUSION

Geopolymer concrete tile with alkaline ratio 0.4 is behaves like OPC concrete tile. Geopolymer concrete requires less water content (0.15%) for the preparation of concrete and it doesn't need water curing. Geopolymer concrete offers environmental protection. Fly ash is used as the source material, instead of the Portland cement, to make concrete. Geopolymer concrete is suitable for tiles. Simple guidelines for the design of mixture proportions are included. The properties and the strength of hardened geopolymer concrete is similar to Portland cement concrete. M-sand replaced for river sand, so the scarcity of river sand can be avoided. Moreover Geopolymer floor tile is Eco friendly because it emits CO_2 up to 78 Kg/ton of geopolymer production in the other hand OPC emits 900 Kg/ton of cement production.

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