Development of Reinforced Geopolymer Pervious Concrete

Development of Reinforced Geopolymer Previous Blocks.

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Abstract : This study aims to prepare a geopolymer pervious concrete with reinforcement using the welded wire mesh with three different molarities as 10.5M, 13.5M and 16.5M and to compare the developed concrete with the geopolymer pervious concrete without reinforcement on its properties like compressive strength and permeability. Generally pervious concrete has high permeability and less compressive strength so the main aim of this study was to develop the reinforced geopolymer pervious concrete with comparatively high compressive strength then the geopolymer previous concrete without reinforcement.

***IndexTerms* - Geopolymer, Pervious Concrete, Reinforcement.**

1. INTRODUCTION

Pervious concrete pavement is a unique and effective means to address important environmental issues and support green, sustainable growth. By capturing stormwater and allowing it to seep into the ground, pervious concrete is the best instrumental in recharging groundwater and reducing stormwater runoff. Pervious concrete has been developed in the USA in order to meet US Environmental Protection Agency (EPA) stormwater regulation requirements. The American Society for Testing and Materials (ASTM) Concrete Committee (C09) has focused on this concrete and formed a subcommittee to deal exclusively with pervious concrete production, properties and usage.

Geopolymer pervious concrete is a modern approach made up of waste materials like fly ash, blast furnace slag and other waste products with alkali activators like sodium hydroxide and sodium silicate as the binders. It is much more economical than the conventional concrete due to the use of waste material as well as it doesn't need water for curing. Many researchers agree on the fact that geopolymer technology reduces the emission of carbon dioxide by 90% compared to ordinary portland cement; therefore geopolymer concrete can be seen as the most adequate response to the ecological problem posed by OPC. In addition, in contrast with OPC, the production of geopolymer concrete necessitates less consumption of natural resources, such as coal ash, to produce the binder.

2. EXPERIMENTAL DETAILS

2.1 Materials

Class F Fly ash obtained from Satpura Thermal Power Station, Sarni, Madhya Pradesh , Sodium hydroxide and Sodium silicate were used as alkali activators, course aggregate of size 12.5 mm to 20 mm and welded wire mesh of 11 gauge of 105 gm in the shape of cage for each specimen was used as reinforcement.

2.2 Mix proportion, mixing, casting and curing

In this project 18 specimens were prepared. The 3 trial mixes were prepared without reinforcement as A1, A2 and A3 where as other 3 trial mixes were prepared with reinforcement as R1, R2 and R3. The fly ash to coarse aggregate ratio of 1:4 by weight, a constant sodium hydroxide to sodium silicate ratio of 1:1 and the alkaline liquid to fly ash ratio of 0.35 and density of 2000 kg/m^3 were the mix proportions of geopolymer pervious concrete. In order to study the effects of sodium hydroxide concentration, 3 concentrations of sodium hydroxide viz., 10.5, 13.5 and 16.5 Molar (M) were used. The proportions are shown in Table 1.

Fly ash, coarse aggregate and alkaline solution was mixed together and were casted in the cube of 150mm×150mm×150mm. The moulds were de moulded after 24hrs and were kept in the oven for curing. The intermediate curing of 6hrs for 3 days were done and then the cubes were kept at the normal room temperature for 7 days and then the cubes were tested for compressive strength and permeability.

2.3 Testing Details

2.3.1 Water Permeability

The infiltration rate or water permeability test of the geopolymer pervious concrete was done as per ASTM C170 which is the standard infiltration test for pervious concrete and was calculated by the equation 1. The water permeability of the specimens are shown in Table 2.

$$I=KM/(D^2 \times t) \qquad (1)$$

Where,
I = infiltration rate, mm/hr (in./hr)
M = mass of infiltrated water, kg (lb)
D = inside diameter of infiltration ring, mm (in.)
t = time required to measured amount of water to infiltrate the concrete (sec)
K = infiltration constant 4,583,666,000 in SI units or 126,870 in (inch-pound) units.

2.3.2 Compressive Strength

The compressive strength test of the specimens were done at the age of 7 days on the compressive strength testing machine. The compressive strength of the specimens are shown in Table 3.

Table 1: Mix Design of Geopolymer Pervious Concrete.

Mix (Without reinforcement)	Fly ash (Unit)	Coarse aggregate (Unit)	Molarity (M)	Mix (With reinforcement)	Fly ash (Unit)	Coarse aggregate (Unit)	Molarity (M)
A1	1	4	10.5	R1	1	4	10.5
A2	1	4	13.5	R2	1	4	13.5
A3	1	4	16.5	R3	1	4	16.5

3. RESULTS AND DISCUSSION

3.1 Water Permeability

The water permeability of the specimen are shown in Table 2.

Table 2 : Water Permeability of Geopolymer Pervious Concrete.

Mix (Without reinforcement)	Permeability (cm/s)	Mix (With reinforcement)	Permeability (cm/s)
A1	1.7	R1	1.7
A2	1.4	R2	1.4
A3	1.2	R3	1.2

It can be seen in Table 2 that the water permeability of specimen without reinforcement is same as that of specimen with reinforcement i.e. the permeability of mix A1 is same as the permeability of mix R1, permeability of mix A2 is same as the permeability of mix R2 and the permeability of mix A3 is same as the permeability of mix R3. This shows that there is no effect of reinforcement on the water permeability of geoplymer pervious concrete.

It can also be seen that the permeability of mix A2 is less than the permeability of mix A1 and the permeability of mix A3 is further lesser than the permeability of mix A1 and mix A2. Since the permeability of the mixes are in decreasing order it can be said that the water permeability of geoplymer pervious concrete decreases with increase in molarity of sodium hydroxide.

The relation between water permeability of mixes A1, R1, A2, R2 and A3, R3 and molarity are shown in figure 1.

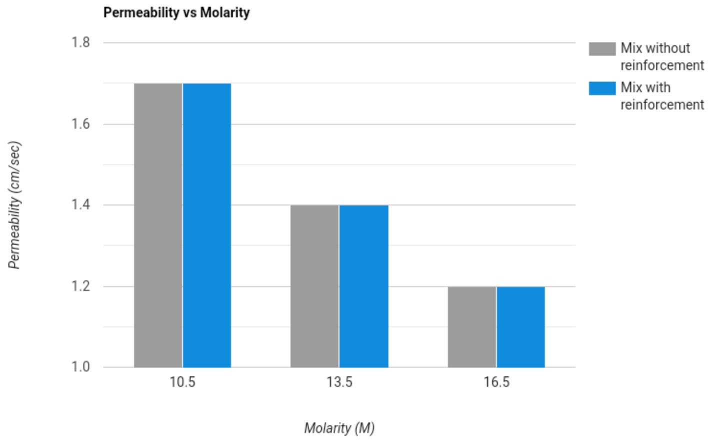

Figure 1.

3.2 Compressive Strength

The compressive strength of the specimen are shown in Table 3.

Table 3 : Compressive Strength of Geopolymer Pervious Concrete.

Mix (Without reinforcement)	Compressive strength (MPa)	Mix (With reinforcement)	Compressive strength (MPa)
A1	3	R1	3.5
A2	6.3	R2	7
A3	8.5	R3	9

It can be seen in table 3 that the compressive strength of the mixes without reinforcement (A1, A2 and A3) are in increasing order i.e. 3MPa, 6.3MPa and 8.5MPa respectively. Also the compressive strength of mixes with reinforcement (R1, R2 and R3) are also in increasing order i.e. 3.5Mpa, 7MPa and 9MPa respectively. This means that the compressive strength of the geopolymer pervious concrete increases with increase in the molarity of sodium hydroxide.

Whereas it can be seen that the compressive strength of mixes with reinforcement (R1, R2 and R3) are more than the compressive strength of mixes without reinforcement (A1, A2 and A3). The means the compressive strength of the geopolymer pervious concrete increases with the introduction of reinforcement in the concrete.

The relation between compressive strength of mixes A1, R1, A2, R2 and A3, R3 and molarity are shown in figure 2.

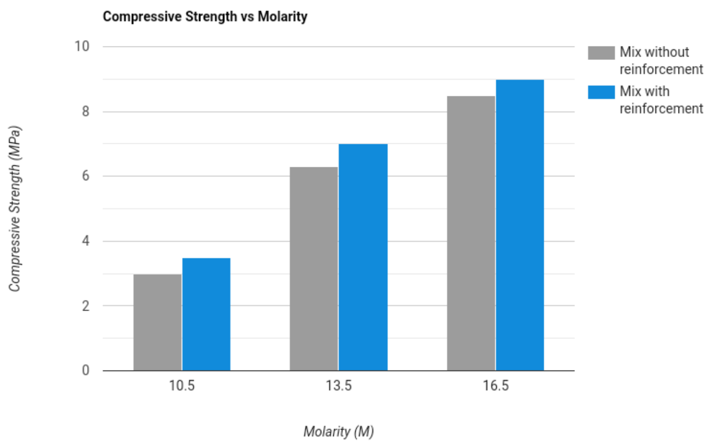

Figure 2.

4. ACKNOWLEDGMENT

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5. CONCLUSION

In order to manage the stormwater runoff, to improve groundwater recharge and to expand the use of fly ash as a geopolymer binder, geopolymer pervious concrete were prepared from alkali-activated fly ash binder, coarse aggregate and wire mesh. The compressive strength of the geopolymer pervious concrete between 3 Mpa and 9 Mpa were obtained. The water permeability of geopolymer pervious concrete between 1.2 cm/sec and 1.7 cm/sec were obtained. It has therefore been demonstrated that reinforced geopolymer pervious concrete could be used as previous paver blocks also with acceptable strength for various applications.

6.REFRENCES

[1] Tennis, Paul, D.; Leming, Michael, L.; and Akers, David, J., Pervious Concrete Pavements, EB302.02, Portland Cement Association, Skokie, Illinois, and National Ready Mixed Concrete Association, Silver Spring, Maryland, USA, 2004, 36 pages.
[2] John T. Kevern , Design of Pervious Concrete Mixtures (2009): 1-29.
[3] Tawatchai, Pervious high-calcium fly ash geopolymer concrete , 30 (2012): 366–371.
[4] Mohammed Sonebia, Pervious Concrete: Mix Design, Properties and Applications, (2016) 1: 109 – 115.
[5] Yang J,Jiang G. Experimental study on properties of pervious concrete pavement materials. Cem Concr Res 2003;33(3):381–6.