ABRASION RESISTANCE OF FLY ASH BLENDED PERVIOUS CONCRETE

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ABSTRACT. High porosity with interconnected pores between aggregate particles is the basic features of Portland cement pervious concrete, which however cause a significant decrease in its strength and abrasion resistance. In this study Fly ash FA, silica fume SF and metakaolin MK were added to improve the abrasion resistance of pervious concrete. Laboratory test were conducted to evaluate the performance of binary and ternary blended pervious concrete. Test results have shown that adding FA and SF have desirably improved the abrasion resistance of pervious concrete. Adding mineral admixture saves the material and enhances the microstructure of cement paste that can effectively utilized in the pervious concrete application.

Keywords: Pervious concrete, mineral admixture, porosity, abrasion resistance, Permeability

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INTRODUCTION

Pervious concrete (PC) is composed of large aggregates which allow water to infiltrate into ground from surface. Considerable volume of rain water flow on impervious roadway, parkways and street roads is not absorbed by soil. Such waste of water disturbs the natural balance of ecosystem and results in frequent floods, thinning of ground water table and pollution of rivers. The obvious solution is to use pervious concrete on broad scale.

Generally PC consists of 270-415 kg/m3 of cement, 1190-1480 kg/m3 of aggregate and w/c ratio from 0.26-0.40. The 28 days compressive strength varies from 3.5-28 MPa, hydraulic conductivity in the range 0.2-5.4mm/s and pore size 2-8mm, depending on the type of aggregate and compaction technique used [1]. Fresh state of PC is a function of workability, unit weight and porosity and it is affected mainly by water to cement ratio, workability and properties of aggregates used. Aggregate in concrete is a big factor with type, size and water absorption playing crucial roles.
Raveling remains one of the prime challenges towards broader application of concrete technology [2]. Portland cement NFC have interconnected voids providing high porosity but at the same time decreasing strength and abrasion resistance.

Several studies have shown that small sized coarse aggregate, fine aggregates, polymer and other chemical admixture improve NFC properties [3,4]. Spalling and raveling are attributed as two biggest reason of abrasion are tested by cantabro test, loaded wheel abrasion test and surface abrasion tests ASTM C944 [64,116]. Addition of latex enhances the strength in abrasion.

The main function of NFC is the ability to pass water through interconnected network of pores. The hydraulic conductivity mainly depends upon porosity and the pore sizes [5]. Tests show that a minimum porosity of approximately 15% is required to achieve significant percolation. The permeability is inversely proportional to the strength properties [6,7]. Permeability is significantly influenced by the porosity [8]

EXPERIMENTAL METHODOLOGY

Material and specimen preparation

Two sizes of coarse aggregates 6.3mm and 4.75mm were and three mineral admixtures (namely FA, MK and SF) are considered in this study. FA, MK and SF were added in the mixture in binary and ternary combination by 30 percent cement replacement. The summary of mix proportion is given in table 1. For all the four pervious concrete mixtures standard cylinder100x200mm were cast for conducting all the physical and mechanical test. All the specimen were water cured for 28 days and left inside the laboratory undisturbed.

Table.1 Summary of pervious concrete mixtures

	PC	PF	PFS	PFM
Cement content	100%	70%PC+30%FA	70%PC+20%FA+10%SF	70%PC+20%FA+10%MK
Aggregates, Kg/m^3	1541	1541	1541	1541
Sand, % (By weight of total aggregate)	10	10	10	10
Water/c	0.34	0.34	0.34	0.34
C (m)/agg.	0.250	0.250	0.250	0.250
Super				

Physical Testing

Water absorption

Water absorption was measured after 28 days curing of standard cylinder by the relation given below**.**

$$\text{Water Absorption } \% = \left(\frac{W_1 - W_2}{W_1}\right) x\ 100$$

W_1 is initial weight of the specimen; W_2 is the weight after 24 hours water absorption.

Porosity

The porosity of all pervious concrete samples was determined by the method described in previous literature (9). The equations (1) were used to calculate open porosity of the concrete sample.

$$P_{open} = 1 - \left(\frac{W_2 - W_1}{\rho w V_1}\right) x\ 100\% \tag{1}$$

Where P_{open} is the open porosity (%), W_1 - Weight of the specimen under water, W2- Weight of the oven dried specimen, V_1- Volume of the specimen, ρ_w- Density of water.

Permeability

The standard test specimens were cylinders of (100mmϕ x 200mm) specifications. The outer surface of the specimen was sealed with help of polythene to stop flow of water along the sides of cylinder surface. The time water took to flow through the sample was noted down at falling head. The average of 3 readings was taken. The permeability coefficient was calculated using Darcy's law as given below:

$$k = \frac{A1L}{A2\ t} ln \frac{h1}{h2} \tag{2}$$

Where, k (mm/sec) - Coefficient of permeability, A_2 (mm^2) - Area of cross section of specimen, A_1 (mm^2) - Area of cross section of stand pipe, h_1- Initial water level, h_2 - Final water level, t - Time in sec for water to reach from h_1 to h_2.

Abrasion Resistance

The abrasion resistances of pervious concrete samples were determined by los angles abrasion machine in accordance with ASTM C1747.The percentage of mass loss was determined by using formula-

$$\text{Mass loss\%} = \left(\frac{W_1 - W_2}{W_1}\right) x\ 100 \tag{3}$$

W_1 is initial weight of the specimen; W_2 is the weight after revolution

RESULT AND DISCUSSION

Influence on physical properties

Figure 3 shows the results for water absorption of pervious concrete samples at 28 days of curing. The samples were oven dried after the 28 curing and then soaked for 24 hours before taking the measurements. The WA rates were seen with ternary blend of about 5.85 % and lowest for control mix. The aggregate plays significant role in the porosity and density of pervious concrete mixtures. The aggregate gradation and cement to aggregate ratio contribute more in porosity than water to cement ration and paste volume [10]. The porosity of all the mixture is in the range 18.5±1 % which are in accordance with recommendation of ACI-522R. In this experimental work binary combination of aggregates (6.3-4.75mm) are taken. The density of ternary blends are slightly higher than binary and control mix may be due to the close packing between mineral admixtures helped achieve higher density in the mixtures.

The Density and porosity have shown reverse trend with respect to the mixture, representing its excellent inverse relation with density (shown in figure 4). Regression coefficient of 0.93 shows its good correlation with density.

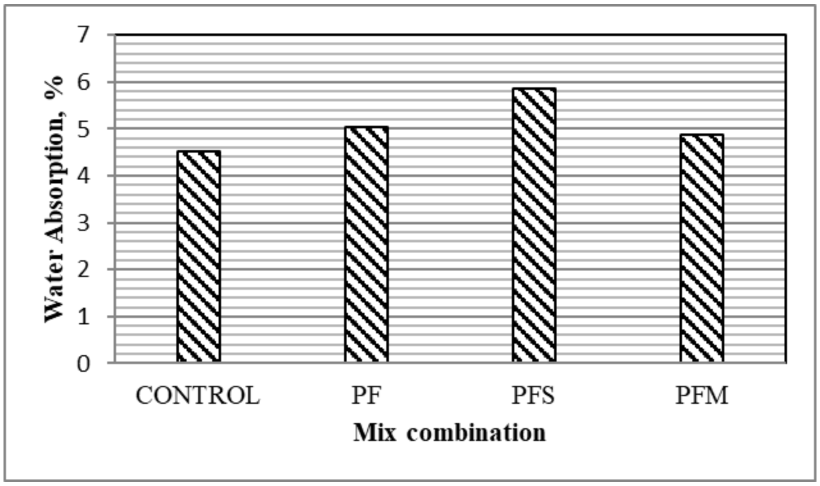

Figure 3 Water absorption of all Pervious concrete mixtures at 28 days

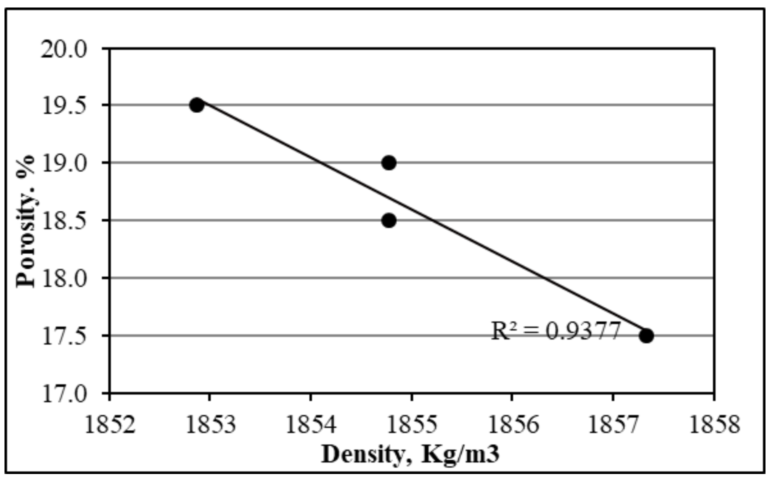

Figure 4 Relationship between Porosity and Density of all pervious concrete mixes

Influence on Permeability

Testing concrete for permeability has not been standardized. The values of the coefficient of permeability quoted in different publications may not be comparable. In such tests the steady flow of water through concrete is measured and Darcy's equation is used to calculate the coefficient of permeability (K). Figure 5 shows the results of permeability of all pervious concrete mixtures. The values of K are in the range (10-11.6) mm/s which is in accordance with ACI-522R.The higher coefficient was obtained for the mix PF and lower for PFM (mix containing FA and MK). The lower permeability of ternary blend may be due to the dense paste. The K is also observed to be increasing with the porosity of the mix (Figure 6). The network of pores in the concrete helps the water to flow through them which increases the porosity and permeability.

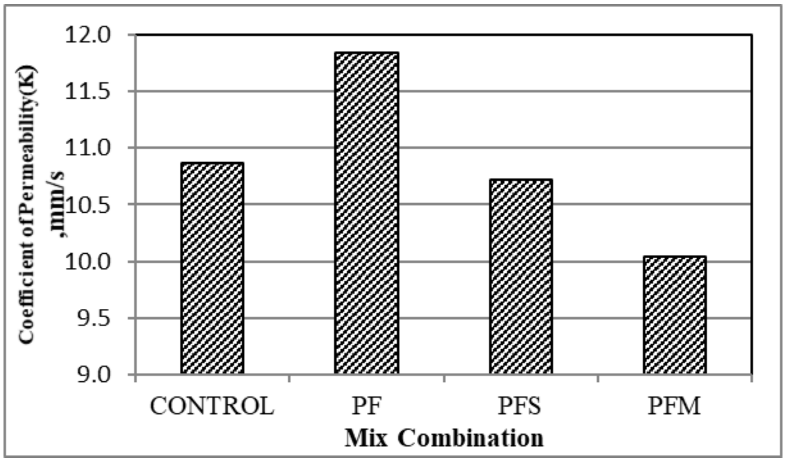

Figure 5 Coefficient of Permeability (K) of all pervious concrete mix combination

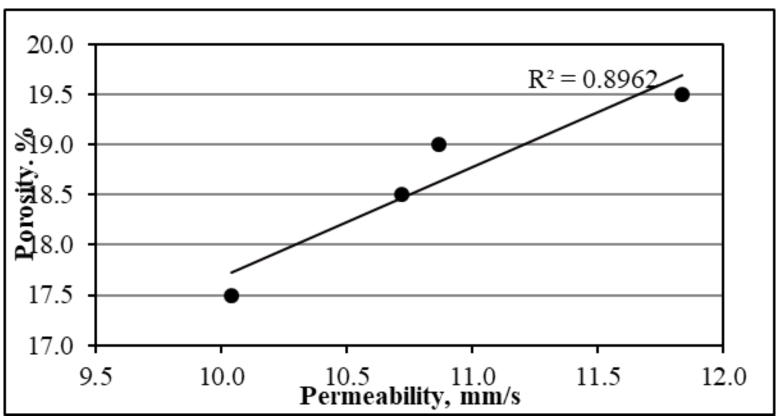

Figure 6 Relationship between Porosity and Permeability of all pervious concrete mixes

Influence on Abrasion resistance

Under many circumstances, concrete surfaces are subjected to wear. This may be due to attrition by sliding, scraping or percussion. The main difficulty in abrasion testing is to make sure that the result of a test represents the comparative resistance of concrete to a given type of wear. Figure 7 shows the results of the abrasion resistance of all pervious concrete mixes. For determining abrasion resistance by impact the LA machine was used. With the increasing number of revolution the specimen becomes more and more spherical. The edges of the specimen were damaged during initial 150 cycles. Percentage mass loss decreased with increased number of revolution. Ternary blend in comparison to binary and control mix have shown improved abrasion. The probable reason could be the improved cement matrix of ternary blend. The ternary blends are useful in pervious concrete.

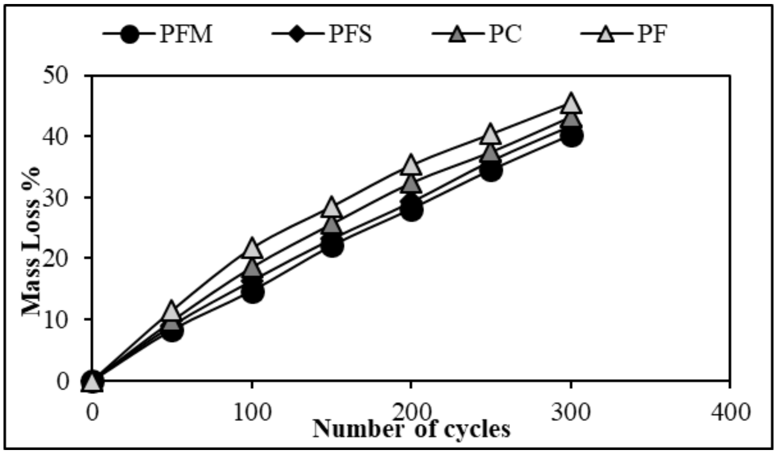

Figure 7 Relationship between Percentage mass loss and Number of cycle at LA abrasion testing at 28 days of curing

CONCLUSION

Based on the obtained data in this study the use of mineral admixture to make binary and ternary blend replacing 30% by weight of cement in the pervious mixture positively influences the abrasion resistance. The pozzolana modifies the microstructure of the concrete in terms of its physical and chemical characteristics. There seems to be an interaction between mixture variable that affects physical and permeability properties of pervious concrete. The ternary blends improved the physical characteristics of concrete relatively to the control sample. The results obtained for porosity density and permeability are in the acceptable range and can be utilized in the pervious concrete application. Adding mineral admixture saves the material and also improves the microstructure of cement paste.

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