International Journal of Engineering Technology, Management and Applied Sciences

www.ijetmas.com May 2018, Volume 6, Issue 5, ISSN 2349-4476

Effect of Fly Ash on Properties of Pervious Concrete

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ABSTRACT

Environmental change, global warming and manage of industrial wastages is the matter of concern of the hour. In civil engineering, environmental concern is becoming more and more vital due to the population explosion, massive constructions and extensive use of industry materials like cement. Thus studies are going on across the globe to find the substitute of cement. As fly ash is a industrial waste product and its disposal is a head ache towards the industries and government but it has cementitious property, so its use in civil engineering industry can solve both the problems. Pervious concrete can be used in pavements as it allows water to seep into soil thus recharges ground water and reduces stormwater runoff creating an environmental friendly surface. In the present study experimental investigation is done on partial replacement of fly ash in pervious concrete upto 10%. Various tests like compressive strength, tensile strength and water permeability are done on the specimens and results are discussed.

Keywords

Fly ash, pervious concrete , partial replacement, compressive strength, tensile strength, water permeability

INTRODUCTION

Typical concrete pavement are impervious surfaces that shed storm water as runoff. Pervious concrete, the use of non-rigid pavers, and open-cell pavers help to reduce runoff from these surfaces by allowing storm water to be absorbed into the ground. The two basic components, which concrete is mainly composed of are binder (paste) and aggregates. The paste, which mainly consists of cement, water and supplementary cementitious materials, has main functions of binding up the aggregates, filling up the voids and thus making concrete strong and dense. The aggregates, both coarse and fine, provide volume to concrete. The voids in coarse aggregates are filled up by the fine aggregates and voids in the fine aggregates are filled up by cement, thus helping in making concrete a densely packed system. The strength of concrete increases with the decrease in voids.

As compared to other road making materials concrete pavements have higher modulus of elasticity and rigidity. Due to this property the pressure on the subgrade gets limited. The thickness of the concrete pavement is mainly determined by the magnitude of the wheel or axle loads and by the flexural strength of the concrete and there is no significant contribution provided by sub-bases.

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, porous concrete is instrumental in recharging groundwater, reducing stormwater runoff. It is a composite material consisting of coarse aggregate, Portland cement and water.

In this report, the effects of varying the components of pervious concrete on its compressive strength are investigated. The goal is to achieve a maximum compressive strength without inhibiting the permeability characteristics of the pervious concrete. This will be accomplished through extensive experiments on test cylinders and cubes. Experiments include tensile tests, permeability tests, and compression tests.

NEED FOR THE STUDY

The Ordinary Portland Cement (OPC) is one of the main ingredients used for the production of concrete, as there is no alternative in the civil construction industry. Unfortunately, production of cement involves emission of large amounts of carbon-dioxide gas in to the atmosphere, a major contributor for greenhouse effect and global warming. Hence it is inevitable either to search for another material or partly replace it by some other material. The search for any such material, which can be used as an alternative or as a supplementary for cement should lead to global sustainable development and lowest possible environmental impact. A number of studies are going on in India as well as abroad to study the impact of use of these pozzolanic materials as cement replacement.

EXPERIMENTAL WORK

The materials choosed for the experiment are ordinary portland cement(opc), fly ash, coarse aggregate, water.

The materials properties and the results obtained from the various test conducted on the materials used for partial cement replacement in pervious concrete. In order to achieve the objective of the present study, an experiment program was devised to investigate the effect of fly ash, as partial cement replacements, on the compressive, tensile strength and permeability of concrete.

Various tests were done to find out the physical and chemical properties of ordinary portland cement and the test results are illustrated in table 1.

Table 1 Properties of cement

Test	Result
Fineness test	7%
Consistency test	34%
Setting Time Test **1.Initial setting time** **2.Final setting time**	 35 minutes 11.5 hour
Soundness Test	1 mm
Specific Gravity	3.15

Fine aggregate content is limited in pervious concrete, and coarse aggregate is kept to a narrow gradation. A narrow grading is the important characteristic. Larger aggregates provide a rougher surface. Recent uses for pervious concrete have focused on parking lots, low-traffic pavements, and pedestrian walkways. For these applications, the smallest-sized aggregate feasible is used for aesthetic reasons. The aggregates which are retained over IS sieve 4.75mm aretermed as coarse aggregate. Both rounded aggregate (gravel) and angular aggregate (crushed stone) have been used to produce pervious concrete.The test results on coarse aggregates is given in table 2.

Table 2 Properties of aggregate

Test	Result
Impact value of aggregate	18.29%
Crushing Value of Aggregate	21.87%
Abrasion Value of Natural Aggregate	23.6%
Specific Gravity of Coarse Aggregate	2.86

The potable water is generally considered satisfactory for mixing and curing of concrete. Accordingly potable water was used for making concrete available in material testing laboratory.

Fly ash is the waste byproduct of burning coal in electrical power plants; it used to be landfilled, but now a significant amount is used in cement. This material can be used to replace 5-65% of the Portland cement.Fly ash used in the study was sourced from HindalcoPlant, Hirakud.

MIXINGG AND DESIGNING

While pervious concrete contains the same basic ingredients as the more common conventional concrete (ie. aggregate, Portland cement, water, and a variety of admixtures), the proportioning of ingredients is quite different. One major difference is the requirement of increased void space within the pervious concrete. With low water to cement ratio, the need for void space within the mix design, and little to no fine aggregates, the conventional design of concrete needs to be adjusted accordingly. Ranges of materials commonly associated with pervious concrete are listed below. These ranges are based on previous researches.

Table-3 Mixing details

Material	Proportion range	Selected Proportion
Fly ash	5-20%	5-10%
Coarse aggregate Single size(10to 8mm)	1190 to 1480 kg/m3	1190 kg/m3
w/c ratio	0.27 to0.34 (without admixture)	0.34
Aggregate : cement ratio	4 to 4.5 : 1	4..2 : 1
Fine : coarse aggregate ratio	0 to 1.1	0

To study compressive strength, the cubes of 150mm ×150mm ×150 mm are casted for various mixes. Five compositions are considered for casting the specimens. And the compositions are as follows:

1. Cement + Coarse aggregates + water (No substitution) : NOR1,NOR2,NOR3
2. Cement + Coarse aggregates + water + fly Ash (5% substitution) : FA5-1,FA5-2,FA5-3
3. Cement + Coarse aggregates + water + fly ash (10% substitution) : FA10-1,FA10-2,FA10-3

Six cubes are casted for each composition. The quantities of cement, coarse aggregate, fly ash and water for each batch replacement are weighed separately. The cement and fly ash are mixed dry to a uniform colour separately. The coarse aggregates are mixed to get uniform distribution throughout the batch. Then water is added to the mix. Firstly, 50 to 70% of water is added to the mix and then mixed thoroughly for 2 to 3 minutes. The Cubes are filled with fresh concrete using vibrating table. Three cubes are casted for each parameter. The compressive strength test is carried out for 7 days 14 days and 28 days.

Figure1: casting of specimens for compressive strength test

The determination of the splitting tensile strength of cylindrical concrete samples such as moulded cylinder is outlined in this procedure. The splitting tensile strength of the three 150mm diameter, 300mm long cylinders was determined. Tensile splitting strength of test specimens are tested after 28 days of curing. Five compositions are considered for casting the specimens. And the compositions are as follows:

1. Cement + Coarse aggregates + water (No substitution) : NOS1,NOS2,NOS3
2. Cement + Coarse aggregates + water + fly Ash (5% substitution) : FAS5-1,FAS5-2,FAS5-3
3. Cement + Coarse aggregates + water + fly ash (10% substitution) : FAS10-1,FAS10-2,FAS10-3

Figure2: set up for compressive strength test

www.ijetmas.com May 2018, Volume 6, Issue 5, ISSN 2349-4476

The tensile splitting strength of the three 150mm diameter, 300mm long cylinders was determined. Tensile splitting strength of test specimens are tested after 28 days of curing.

A diametric compressive load will be applied along the length of the sample at a continuous rate until failure occurs. This loading induces tensile stresses on the plane containing the applied load, causing tensile failure of the sample. The splitting tensile strength will be determined by dividing the maximum applied load by the appropriate geometrical factors.

Figure 3 Tensile strength test

The total porosity was measured using the water displacement method based on the Archimedes' principle of buoyancy, which states that the buoyancy force is equal to the weight of fluid displaced. The total porosity includes both closed and open pores and can be measured using the buoyancy float apparatus. The dry mass, submerged mass, and total volume, must be known to calculate the porosity value

RESULT AND ANALYSIS

The effect on compressive strength, tensile strength and permeability of pervious concrete, due to partial replacement of cement with fly ash and ground granulated blast furnace slag in the concrete mix is discussed. Tests are performed at 7 days, 14 days and 28 days of curing of concrete. No super-plasticizer is used in all the mixes.

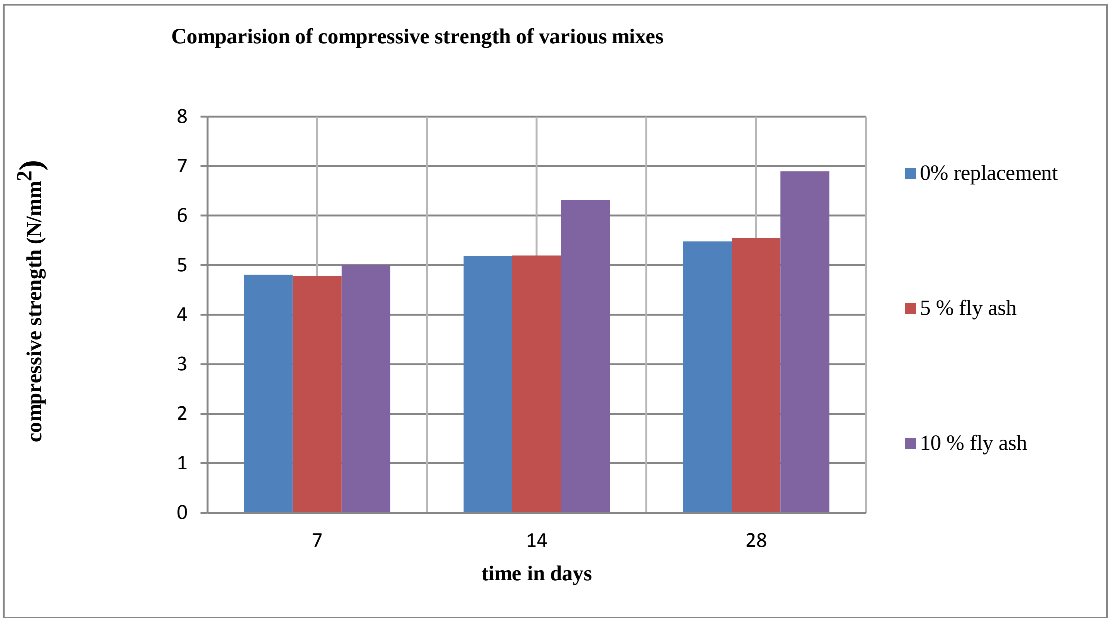

Figure 4: plot of compressive strength test result

Table 4 : Test result of tensile strength test

pervious concrete composition	Tensile strength(28 days)
no repacement	1.21
5% repacement with fly ash	1.23
10% replacement with fly ash	1.287

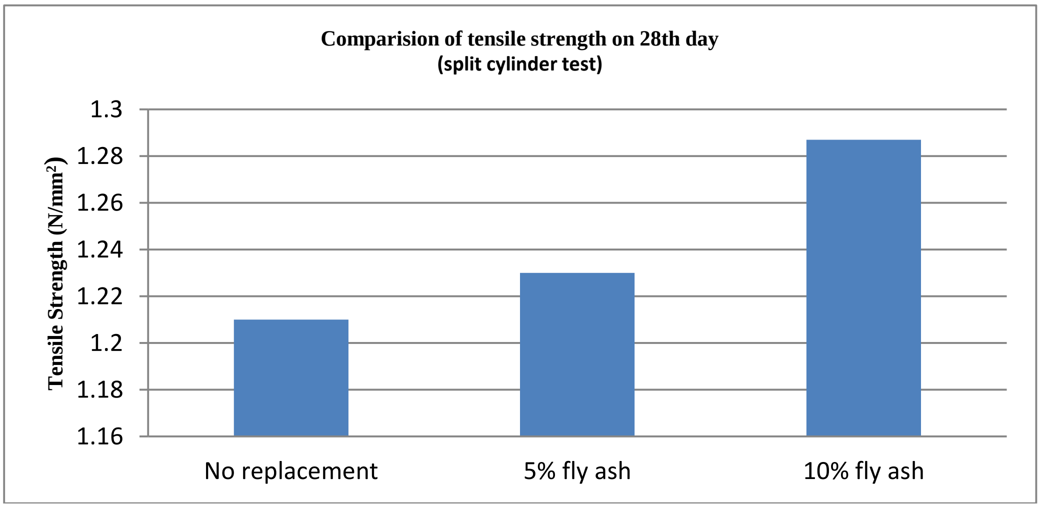

Figure 5: Tensile strength test Result

In water permeability test coefficient of water permeability is calculate by percolation of water through inter connected voids at required time with known quantity of water. Water permeability test of pervious concrete was conducted according to IS: 3085 – 1965.

Table 5 : Test result of permeability test

PC COMPOSITION	PERMEABILITY(cm/sec)
NO REPLACEMENT	0.211011
5% FLY ASH	0.18337
10% FLY ASH	0.16809

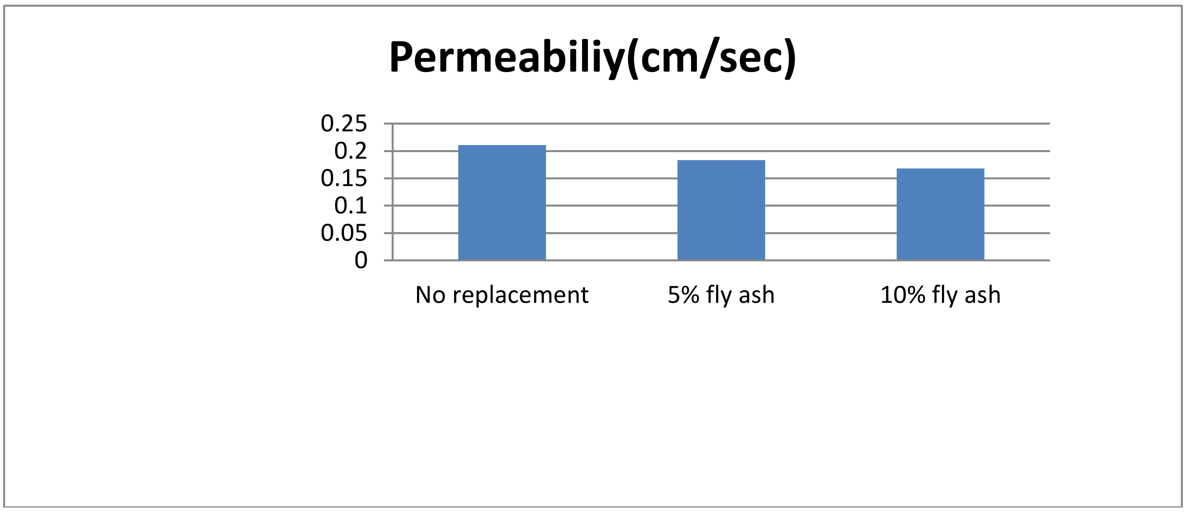

Figure 6 Plot of permeability for various compositions of PC

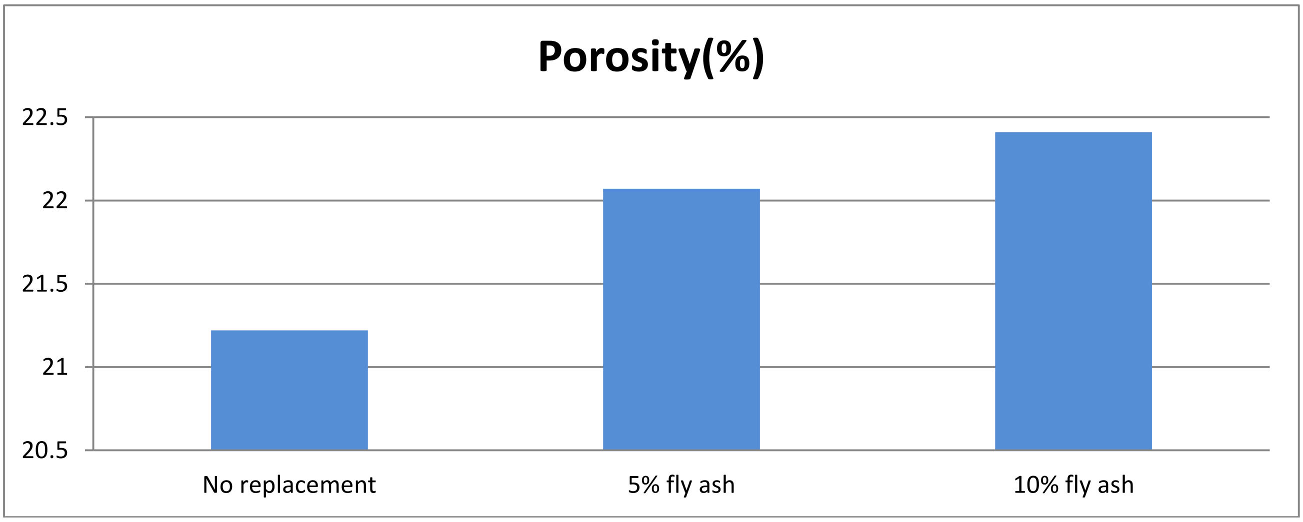

Figure 7 Plot of porosity for various compositions of PC

CONCLUSION

Based on tests and results, In cement replacement with Fly ash with 10 % shows highest compressive strength and high water permeability. Based on the results, relationships between porosity & compressive strength, porosity and permeability and tensile strength are established for pervious concrete within the porosity ranges from 5 to 10 percentages. The increase in the % of Fly ash both compressive and tensile strength increases. And water absorption increases with the increase of fly ash %.Finally, as replacement of cement increases workability of concrete decreases gradually. Thus partial replacement of fly ash is beneficial from both economical and environmental point of view.

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