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Flextural Strength Behaviour of Pervious Concrete Using Fiber and Mineral Admixtures

BHUVANESH K V[1], SREEVIDYA V[1], HEMA S[1] AND M VADIVEL[2]

[1]*Department of Civil Engineering, Sri Krishna College of Technology, India*

[2]*Department of Civil Engineering, Nehru Institute of Technology, INDIA*

Email: *bhuvaneshkv96@gmail.com*

Abstract: Pervious concrete has been used for over 30 years. Because of its high porosity, the most common usages have been in the area of storm water management, but have been limited to use in pavements with low volume traffic because of its low compressive strength compared to conventional concrete. Fly ash and glass fibers have been shown in numerous post studies to increase the strength and durability of conventional concrete. In this study, six batches of pervious concrete with different amounts of aggregate, cement, fly ash and glass fibers were prepared to find the mix that generated high compressive strength and study the effect of fly ash on the compressive strength and permeability of pervious concrete. Materials used in this study were selected based on literature reviews and recommendations from local sources. Unconfined compressive strength tests were carried out on pervious concrete specimens with fly ash contents of 0%, 5%, 10%, 15%, 20%, 25%, 30% by weight of the total cementitious materials. Falling head permeability tests were carried out on specimens having 5% and 30% fly ash. The results indicated the pervious concrete containing 5% fly ash can achieve compressive strength greater than 3,000 psi at void content of 10%, and a compressive strength 2,300 psi with a permeability of 0.13 cm/s at a void content of 15%. The pervious concrete with 30% fly ash had a compressive strength of 2,000 psi and the permeability of 0.21 cm/s at a void content of 15.8%. Also various size of coarse aggregate is used such as 10mm, 20mm, 40mm. A set of slab is designed for testing bending moment, flextural strength, deformation and ductility factor of pervious concrete.

Keywords: *Pervious concrete Concrete, Material Properties, Hardened Concrete Properties*

1. Introduction

According to National Ready Mixed Concrete Association (NRMCA) pervious concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water from precipitation and other sources to pass through it, thereby reducing the runoff from a site and recharging ground water levels. It is also known as “no-fines concrete” and is composed of Portland cement, coarse aggregate, water, admixtures, and little or no sand. In the past 30 years, pervious concrete has been increasingly used in the various states, and is among the Best Management Practices (BMPs) recommended by the Environmental Protection Agency (EPA). By capturing storm water and allowing it to seep into the ground, pervious concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting storm water regulations. Other benefits of using pervious concrete are reduction of downstream flows, erosion and sediment reduction of large volumes of surface pollution flowing into rivers; decrease of urban heat island effect; eliminating traffic noise; and enhancing safety of driving during raining. The use of pervious concrete in building site design can also aid in the process of qualifying the building for Leadership in Energy and Environmental Design (LEED) Green Building Rating System credits. Due to the advantages of pervious concrete, the utilization and construction properties of pervious concrete have been studied by many researchers. The characteristic of high permeability of pervious concrete contributes to its advantage in storm water management. However, the mechanical properties such as compressive strength are reduced due to this character, limiting the application of pervious concrete to the roads that have light volume traffic. The advantage of pervious concrete can be enhanced by substituting some of the cement with other materials, such as fly ash, glass fibers. Fly ash is one of the by-products of coal combustion in power generation plants. Large amount of fly ash are discarded each year, increasing costs for disposal. On the other hand, fly ash has been shown to improve the overall performance of concrete, when substituted for a portion of the cement. Hence, when fly ash is used in pervious concrete, the occupation of landfill space can be reduced and CO_2 emissions generated during cement production can be decreased, improving the sustainability of pervious concrete.

2. Material Properties

The properties of materials used in the concrete are discussed below:

Cement

Ordinary Portland cement of 53 grades available in local market was used. The specific gravity of cement that was taken was 3.14

Coarse Aggregate

Locally available coarse aggregate having the maximum size of 10, 20, 40 mm is used. The specific gravity of coarse aggregate that was taken was 2.67

Fly ash

Fly ash is used as a replacement for cement. The specific gravity of fly ash that was taken was 2.32.

Fiber

Fibers used in the for of glass fiber which has the density of 2.46

Water

Water is an important ingredient of concrete as it actually participates in the chemical reaction with cement. Potable water available in the laboratory was used.

3. Experimental Investigation

In this investigation the hardened properties of Pervious concrete for various replacement percentages of Fly ash, glass fibers and using various proportions of coarse aggregate.

Mix proportions

Based on the EFNARC guidelines the mix proportions of pervious concrete were prepared for M30 grade.

Hardened properties of pervious concrete

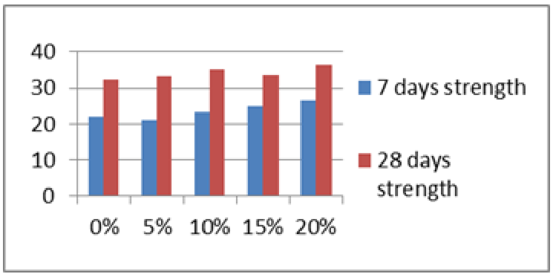
In order to find the mechanical properties Compressive strength tests were conducted at 28 days of cube (150 X 150 X 150 mm) specimens.

For each combination, two specimens were tested. In order to find the split tensile strength of concrete 28 days of cylinder (150 X 300 mm) specimen is cast. For each combination, two specimens were tested.

The following tables show the Compressive strength of pervious concrete with fly ash and fiber:

Table 1: *Compressive Strength of Pervious Concrete with Fly Ash and Fibers*

S. No	Percentage replacement of fly ash	Percentage replacement of fibers	7 days (N/mm^2)	28 days (N/mm^2)
1	0	0	22.01	32.24
2	5	1	21.21	33.22
3	10	1	23.35	35.28
4	15	1	24.85	33.26
5	20	1	26.64	36.56
6	25	1	27.14	35.12
7	30	1	26.18	37.22



The above graph shows the variation in the Harden properties of Pervious concrete with fly ash and fiber.

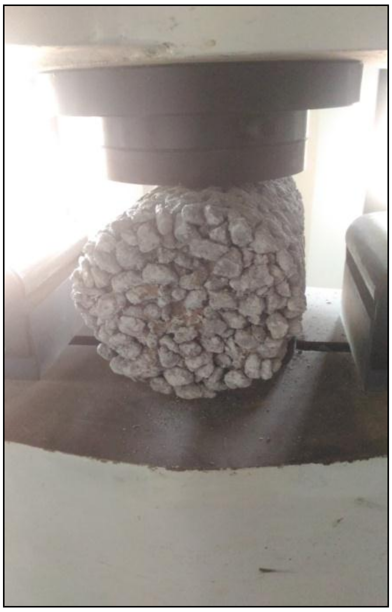
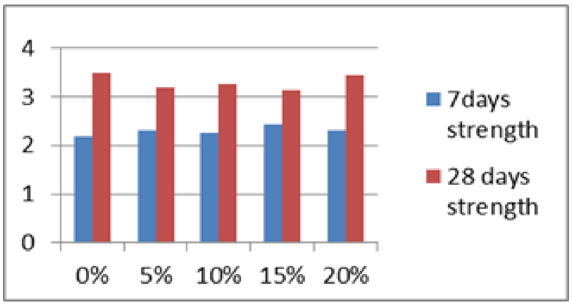


Table 2: *Split Tensile Strength of Pervious Concrete with Fly Ash and Fiber*

S. No	Percentage replacement of fly ash	Percentage replacement of fibers	7 days (N/mm^2)	28 days (N/mm^2)
1	0	0	2.18	3.50
2	5	1	2.32	3.20
3	10	1	2.25	3.26
4	15	1	2.44	3.15
5	20	1	2.31	3.45

6	25	1	2.63	3.66
7	30	1	2.83	3.88



The above graph shows the variation in the split tensile strength of pervious concrete with Fly ash and fiber.

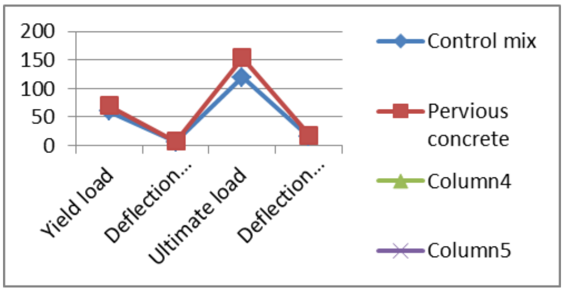
Flexural Behaviour of Slab

A set of slab is casted for M30 ratio ad cured for 28 days. Later the slab is tested for

- Load Deformation
- Compressive Strength
- Ductility Factor

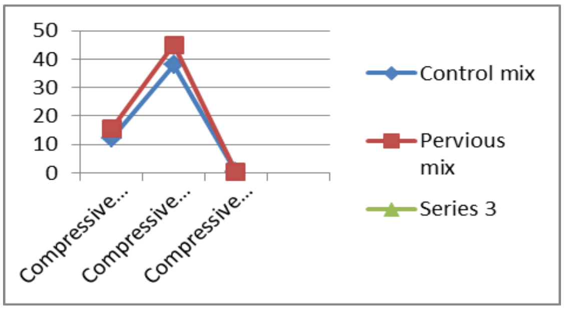
Table 3: *Load Deformation Behaviour of Slab Specimens*

Specimen Details	Yield load (KN)	Deflection at Yield load (mm)	Ultimate load (KN)	Deflection at ultimate load (mm)
Control mix	60	6.97	120	15.71
Pervious concrete	70	7.73	154	18.56



Above graph shows the load deformation behaviour of slab

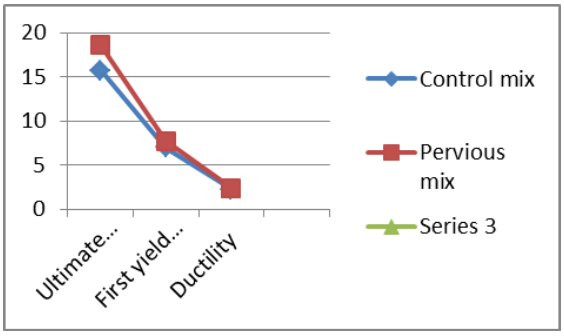
Table 4: *Compressive Strength Index*



Above graph shows the strength factor between normal mix and pervious mix

Table 5: *Ductility Factor*

Specimen Details	Ultimate Displacement (mm) Du	First Yield Displacement (mm) Dy	Ductility $\mu_D = Du/Dy$
Control mix	15.71	6.97	2.25
Pervious mix	18.56	7.73	2.40



Above graph shows the Ductility factor between normal mix and pervious mix

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