STRENGTH AND PERMEABILITY CHARACTERISTICS OF COIR FIBRE REINFORCED PERVIOUS CONCRETE

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Abstract
Various sustainable and eco-friendly construction technologies are being implemented in pavements and pervious concrete pavement is one of them which captures surface infiltration in a network of voids and allows it to percolate into the underlying soil. Strength and permeability characteristics of pervious concrete of various mix ratios have been studied and based on the results influence of coir fibres on these have been investigated. Compressive strength is found to be decreased and permeability is found to be increased with increase in aggregate part and optimum mix ratio is arrived at 1:6. Coir fibres are added to the optimum mix by 0.1%, 0.5%, 1%, 1.5% and 2% of weight of cement. The optimum percentage of coir fibre is obtained as 1% of weight of cement with the increase in compressive strength by 64.9% and the decrease in permeability by 17.9% compared to the conventional pervious concrete. Hence pervious concrete of 1:6 cement:aggregate ratio with 1% of coir fibre is found to be performed well under static load condition with highly improved compressive strength without much sacrificing permeability.

I. INTRODUCTION

Interconnected voids in pervious concrete allow water to pass through pervious concrete layer, providing an effective solution for storm water management. Our cities are being covered with buildings and water-proof concrete roads and due to the lack of water permeability of the common concrete pavement; the rainwater is not filtered underground. Pervious concrete is a form of concrete with high water permeability which allow the passage of water to flow through easily through the existing inter connected large pore structure. Pervious concrete does not contain any sand and its air void content varies between 15 and 30%. A small amount of sand can be used for compressive strength improvement but air void content will be reduced and permeability lowered. But it is important to maintain the proper volume of paste/mortar in the mix design so that the aggregate is equally coated but the excess of paste/mortar does not fill the void space within coarse aggregate. Pervious concrete has been a building material of choice in landscaping for heavily used urban and garden paths, footpaths in country parks, rural trails, and other recreation areas and river side paths. Pervious concrete parking lots put rain water back in to the ground where it belongs.

So many experimental studies have been conducted in this area to make pervious concrete more strong and durable without compromising permeability. Hussam A. A. Rehman (2012) studied the mechanical characteristics of polypropylene and carbon fibre reinforced pervious aggregate concrete, containing different percentages of fibre. The test results indicated that the inclusion of fibre to the pervious concrete mixes did not affect the compressive strength significantly, while the splitting tensile strength and the modulus of rupture were improved significantly.

Nalini Thakre et al (2014) Studied on Strength and Permeability of Pervious Concrete by Using Nylon and Polypropylene Fibre. The permeability of nylon fiber mixed pervious concrete is increased as comparison to the plain pervious concrete. The permeability of polypropylene fibre mixed pervious concrete also showed the same results. The strength of pervious concrete is increased with fibre content of 0.2% beyond which the strength decreased.

Richa Bhardwaj (2015) studied the effect of Alccofine and polypropylene based Recron fibres on strength and compressibility of pervious concrete. Alccofine increased strength while fibres increase the impact strength. Results were compared with ordinary pervious concrete, which showed induction of compressibility in concrete. With optimum dosage and design, it is possible to not only increase the compressive and tensile strength, but also to enhance impact strength of pavements subjected to vehicular loading.

Hamdulay et al (2015) replaced cement in pervious concrete with industrial by-product such as fly ash and slag and assessed the change in properties of pervious concrete due to size of aggregates. The concrete is assessed for its compressive strength, split tensile strength, permeability and flexural strength. The results are interpreted based on graphs obtained. Flyash reduced the strength properties of the concrete and GGBS gave good results regarding the strength properties. Permeability was not much varied due to variation in paste density.

II. OBJECTIVES OF PRESENT STUDY

A. To arrive at optimum mix for strong and durable pervious concrete.

B. To study the effect of coir fibres on the performance of pervious concrete.

III. MATERIALS AND METHODOLOGY

Ordinary Portland cement of M53 grade having specific gravity of 2.95, standard consistency of 29% and initial setting time of 45minutes was used for casting the pervious concrete specimens. Coarse aggregates were natural gravels of 10mm-20mm size with specific gravity 2.8 and water absorption 1.7%. Drinkable clean water that is good for making ordinary concrete was used for mixing, casting and curing purpose. Coir fibres of length 1cm were used for reinforcing the pervious concrete.

In the first stage of study, cement to aggregate ratio is varied as 1:4, 1:6, 1:8 and 1:10 with water:cement ratio of 0.4. For each ratio, three cubes of size 150x150x150mm, three beams of size 500x100x100 mm and three cylinders of 150 mm diameter and 300mm height were casted for testing compressive strength, flexural test and split tensile test respectively. Permeability studies were conducted on pervious concrete cylindrical specimens using falling head method. The specimens were made in moulds in three layers. The specimens were remoulded after 24 hours and cured for 28 days. After finalizing the optimum mix ratio which give maximum strength and better permeability all the test were repeated by adding coir fibres 0.1%, 0.5%, 1%, 1.5% and 2% of weight of cement. Fig 1 shows the preparation of coir fibre reinforced pervious concrete (CFRPC).

Permeability test involves flow of water through a sample connected to a standpipe which provides the water head and also allows measuring the volume of water passing through the sample. Before starting the flow measurements, the sample is saturated. Water is allowed to flow through the sample until the flow reaches the equilibrium and then after time required for the water to drop from the upper level to lower level is recorded.

The permeability of the sample is calculated by the following equation:

$$K = [2.3\, a\, L / A\, \Delta t].\log (h_1/h_2)$$

where

L = Height of the concrete sample.

A = The sample cross section.

A = Cross sectional area of reservoir.

Δt = The recorded time for the water to flow through the sample.

h_1 & h_2 = The upper & lower water level in the reservoir measured.

Fig 1 Preparation of CFRPC

Fig 2 shows the permeability apparatus prepared by using PVC pipe.

Fig 2 Permeability Apparatus

IV. RESULTS AND DISCUSSIONS

A. Effect of Mix Ratio on Performance of Pervious concrete

After 28 days of curing, specimens with each mix ratio is tested for various properties. The obtained test results are shown in Table 1.

Table 1 Test Results of Specimens with Various Ratios

Mix ratio	Compressive strength (N/mm^2)	Split tensile strength (N/mm^2)	Flexural strength (N/mm^2)	Permeability (cm/s)
1:4	15.00	1.95	2.72	1.00
1:6	11.55	1.13	1.35	1.17
1:8	8.00	0.85	0.54	1.50
1:10	5.00	0.57	0.11	2.44

The variation of compressive strength and permeability of specimens with different mix ratio is shown in Fig 3. The compressive strength is found to be decreased and permeability is found to be increased with increase in the aggregate content due to increase in the void ratio. Optimum mix ratio is selected as 1:6 from the meeting points of two curves.

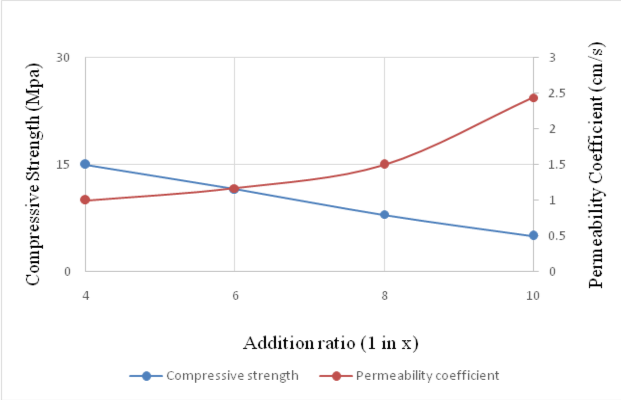

Fig 3 Variation of Compressive Strength and Permeability with mix ratio

B. Effect of Coir Fibres on Performance of Pervious concrete with Optimum Mix

After 28 days of curing the fibre added pervious concrete specimens are tested. The results obtained are listed below Table 2.

Table 2 Test Result of CFRPC

% of coir fibre	Compressive strength (N/mm²)	Split tensile strength (N/mm²)	Flexural strength (N/mm²)	Permeability coefficient (cm/s)
0	10.22	1.13	1.275	1.08
0.1	12.00	1.18	1.53	1.06
0.5	13.71	1.56	1.71	1.02
1	16.86	1.83	2.41	0.96
1.5	14.62	1.49	1.89	0.92
2	12.88	1.27	1.62	0.91

The variation of compressive strength, split tensile strength, flexural strength and permeability coefficient with different percentage of coir fibre are shown in fig 4, 5, 6 and 7 respectively.

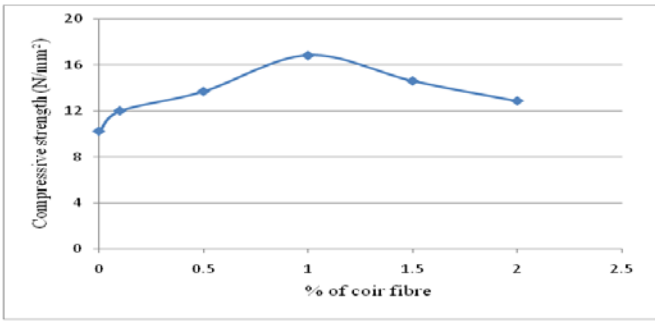

Fig 4 Compressive Strength of CFRPC

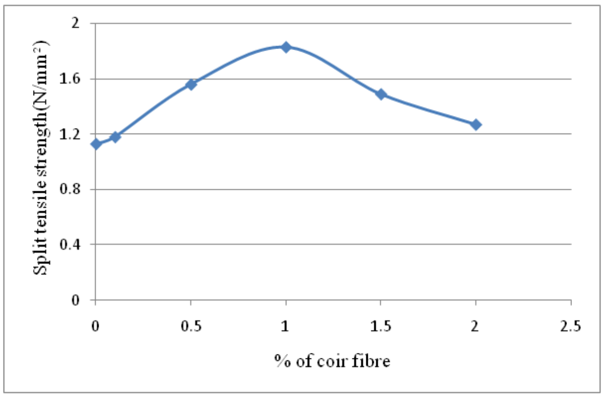

Fig 5 Split Tensile Strength CFRPC

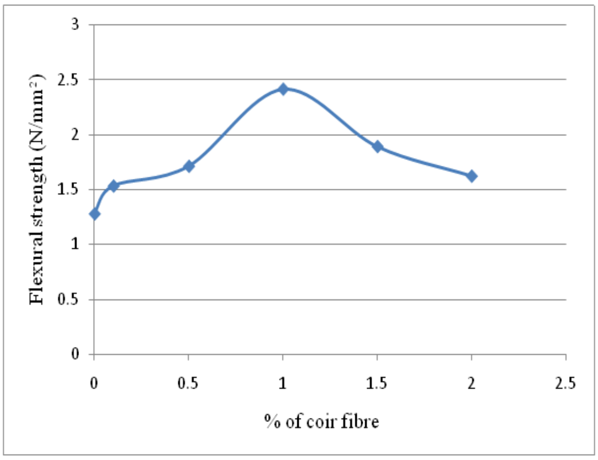

Fig 6 Flexural Strength CFRPC

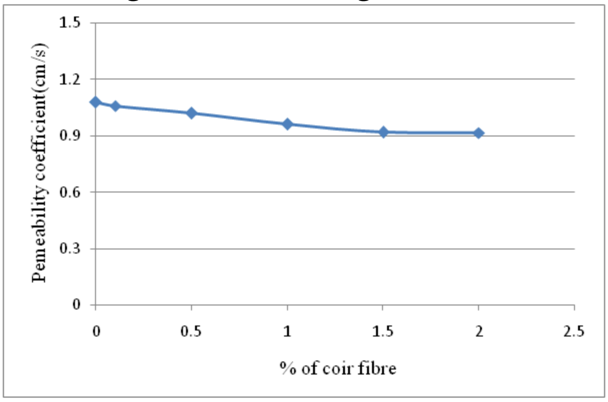

Fig 7 Permeability Coefficient Graph

The results show that addition of coir fibres increases the strength characteristics of pervious concrete but decreases the permeability slightly. The optimum percentage of coir fibre which gives maximum strength is 1% of weight of cement with 64.9% increase in compressive strength as compared to conventional pervious concrete and 17.9% decrease in permeability. Since reduction in permeability is comparatively less, CFRPC can be effectively used for pavement construction.

V. CONCLUSION

The compressive strength is found to be decreased and permeability is found to be increased by increasing aggregate content because higher aggregate: cement ratio do not supply enough cement and increase the void space.

The effect of permeability rates is studied by using falling head permeability apparatus. From the test results, the obtained optimum ratio is 1:6.

The coir fibres are added to the optimum mix by 0.1%, 0.5%, 1%, 1.5% and 2% of weight of cement. The optimum percentage of coir fibre is obtained as 1% of weight of cement by conducting the tests. The compressive strength is increased by 64.9% and the permeability is decreased by 17.9% compared to the conventional pervious concrete.

Hence pervious concrete of aggregate:cement ratio of 1:6 with 1% of coir fibre shows higher compressive strength and better permeability coefficient.

The method can be considered as sustainable and eco-friendly one where abundantly available natural coir fibres are used to improve the performance.

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