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An Experimental Analysis on Strength of Pervious Concrete

With Partial Addition of Glass Fibre and Polypropylene Fibre

A.B.Khemalapure1, Prof.A.R.Vasatkar2

[1]ME (CM) student Department of Civil Engineering, TSSM's BSCOER Narhe, Pune, Maharashtra, India
[2]Assistant Professor, Department of Civil Engineering, TSSM's BSCOER Narhe, Pune, Maharashtra, India *Department*

Abstract — *Pervious Concrete is a light-weight concrete produced by omitting the fines from conventional concrete. Also known to as "No-fine Concrete" or "Porous Concrete" is material comprised of narrowly graded coarse aggregates, cement materials, water and admixture and in some cases fibres. Today in the present world we are very much fond of sustainable and eco-friendly means of Construction. Particularly in a country like India where flooding and waterlogging problems are the Major environmental issues sustainable development has become a necessity. Various sustainable and eco-friendly means are being implemented to these problems where pervious concrete pavement is one of them. In this paper pervious concrete using the fibres of sandwiched combination is used to analyze the strength property*

Keywords- *Pervious Concrete, Fibres Sandwiched Proportion, Glass and Polypropylene Fibre, Compressive strength, permeability.*

I. INTRODUCTION

Pervious Concrete is a light-weight concrete produced by omitting the fines from conventional concrete. Also known to as "No-fine Concrete" or "Porous Concrete" is material comprised of narrowly graded coarse aggregates, cement materials, water and admixture and in some cases fibres. Today in the present world we are very much fond of sustainable and eco-friendly means of Construction. Particularly in a country like India where flooding and waterlogging problems are the Major environmental issues sustainable development has become a necessity.[1]Various sustainable and eco-friendly means are being implemented to tackle these problems where pervious concrete pavement is one among them. Working on „rain-drain" concept Pervious concrete allows a significant amount of storm water to seep into the ground, thereby recharging the groundwater and reducing the storm water runoff. Pervious Concrete is a light-weight concrete produced by omitting the fines from conventional concrete. [3]

It has its origin in late1940s and now been widely used in United States, Japan and Europe because of its various environmental benefits such as controlling storm water runoff, restoring groundwater supplies and reducing water and soil pollution. Apart from this it has the potential to reduce urban heat island effects and can be used to reduce acoustic noise in roads. Pervious concrete has been in use for more than 50 years in a variety of applications, recent EPA regulations are causing many owners and designers to re-examine applications of this unique material. Pervious concrete pavement is recognized as a structural infiltration BMP by the EPA for providing first flush pollution control and storm water management. The US green building council (USGBC) through its Leadership in Energy and Environmental design (LEED) Green Building rating system promotes sustainable construction of buildings. A pervious concrete pavement qualifies for LEED credits and is therefore sought by owners desiring for a high LEED certification an innovative/modified form of cement concrete (also known as pervious concrete) is a environment–friendly and lower cost material which can be used for the construction of Several types of structures with great advantages. Low loading intensity parking pavements, foot paths and walkways have been built on a large scale in many developed countries and their performance has been found excellent. Recognized as the best management practice by US Environment Protection agency(EPA), it is capable of controlling first flush pollution and storm/rain water overflow by allowing the received water to percolate down to earth and then seeping down to the ground water table.[5],[7]

India is facing a typical problem of ground water table falling at a fast rate due to reduced recharge of rainwater into subsoil and unplanned water withdrawal for agriculture and industry by pumping. NFC if adopted for construction of pavements, platform/walkways, parking lots designed for lighter load, can help in improving recharging of rainwater. It can be– come a component of rainwater harvesting schemes being prepared by Government of India on a Priority basis

The pervious concrete system and its corresponding strength are as important as its permeability characteristics. The strength of the system not only relies on the compressive strength of the pervious concrete but also on the strength of the soil beneath it for support. Pervious concrete consists of cement, coarse aggregate and water with little to no fine aggregates. Water to cement ratio of 0.28 to 0.40 with a void content of 15 to25%.[1][8] The correct quantity of water in the concrete is critical. A low water to cement ratio will increase the strength of the concrete, but too little water may causes surface failure. As this concrete is sensitive to water content, the mixture should be field checked. Entrained air may be measured by a Rapid Air system, where the concrete is stained black and ns little or no sand (fines), creating a substantial void content .Using sufficient paste to coat and bind the aggregate particles together creates a system of highly permeable, interconnected voids that drains quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through pervious concrete are typically around 480 in./hr (0.34 cm/s, which is 5 gal/ft²/ min or 200 L/m²/min), although they can be much higher.[7] The advantages of this type of concrete which is made up of experimenting different % (0.1%,0.15%,0.2%,0.25%) addition of Glass & Polypropylene Fibre by volume of concrete gives better results compared to ordinary Pervious concrete. By this we can helps to improve the properties of Pervious Concrete

II. REVIEW OF LITERATURE

Amanda Lidia Alaica (2010) Is focused on evaluating the performance of different pervious concrete mixtures in an endeavour to achieve an optimized mix with adequate tensile strength and porosity. In addition, a relationship was investigated between permeability and porosity of different mixtures. This is done in an attempt to use the porosity as a quick and easy quality control test for evaluating the permeability of pervious concrete. The mix design variables investigated in this study included aggregate-to-cementing materials ratio (A/CM), aggregate gradation and cementing materials blends; ternary blends of silica fume/slag and Met kaolin/Slag were examined. Single and hybrid fibre systems were also evaluated. These included Wollastonite natural fibres and polypropylene macro-fibres. Modifications to the permeability test proposed by ACI522R, "Pervious Concrete", were made to evaluate permeability of the specimens

B.Harish Nayak (2015) They studed to develop a strong and durable pervious cement concrete (PCC) mix u Polyester Fiber .In addition, it is also aimed to compare the properties of these PCC mixes to lay concrete pavers. The properties such as compressive strength, flexural strength, and Tensile strength tests were performed. Compressive strength of specimens for 1:3 ratio with Glass fiber and polyester fiber increased by 17.17% & 4.65% at 28 days when compared with control specimens. Tensile strength of specimens for 1:3 ratio with Glass fiber and Polyester fiber increased by 16.47% & 8.97% at 28 days when compared with control specimens. Flexural strength of specimens for 1:3 ratio with Glass fiber and Polyester fiber increased by 12.12% & 6.45% at 28 days when compared with control specimens. . Compressive strength, tensile strength and Flexural strength of specimens with glass fiber increased when compared with specimens with polyester fiber.

Md. Abid Alam,& Shagufta Naz (2015)They conducted study on 3 batches of no-fine concrete each with two different sizes of aggregate were prepared to find the mix that generated high compressive strength and study the effect of percentage of fine aggregate on the compressive strength of no-fine concrete. The purpose of this project is to analyze the feasibility of producing highly sustainable no-fine concrete mixtures and evaluating the effect of fine aggregate on their properties. No-fine concrete is produced by using ordinary Portland cement, coarse aggregates, and water. This concrete is tested for its properties, such as slump value, porosity and compressive strength. However 10 to 20% fine aggregate is Used to partially replace coarse aggregate. The results showed that porosity has significant effect on compressive strength of no-fine concrete. Replacement of coarse aggregate with fine aggregate up to 20% had significant effect on the porosity and compressive strength of the no-fine concrete.

Nader Ghafoori, Member ASCE, and Shivaji Dutta Student Member, ASCE (1995) This Paper traces the Development and applications of no-fine concrete for building and non-pavement applications. When compared with conventional concrete, no-fines concrete exhibits substantially different properties. Some of the noted characteristics of no-fines concrete are (1) lower unit weight and drying shrinkage; (2) higher permeability; (3 higher thermal insulation values; (4) lower compressive, tensile, and bond strengths; (5) lower pressure on formwork during construction and longer curing time required prior to form removal; (6) elimination of capillary attraction, and (7) economy in materials (Malhotra 1976). No-fines concrete? As been used in a variety of application

Nader Ghafoori Member ASCE, and Shivaji Dutta Student In this Study the physical and engineering characteristics of various no fine concrete mixtures are investigated. No-fines concrete is made from a uniformly graded coarse aggregate and a cement-water paste. Because of its excellent drainage properties, no-fines concrete is found to be beneficial in areas that receive frequent and sometimes excessive rainfall. This paper discusses thickness design of no-fines concrete parking lot pavements. Based on the engineering properties of the no-fines concrete mixtures developed in the laboratory, and various traffic conditions and subgrade characteristics, the thickness requirement of no-fines concrete pavements was determined. Two design procedures, American Association of State Highway and Transportation Officials (AASHTO) and Portland Cement Association (PCA), were used for the thickness evaluation of no-fines concrete parking lots. Test results obtained in the laboratory indicate that, with proper proportioning and densification, no-fines concrete can be successfully utilized as a surface paving material for the construction of parking-lot pavements.

Navin.A.S, Hari Kumar.V.,Dheepan..K.R.,Kamal(March 2015) A miniature scale model is created in a pragmatic way so that the real time problems which are possible in the future may be realized. Thus, an area is chosen to create that pervious concrete pavement and tests are carried out in that particular area. This depiction of a miniature scale is highly related to the real-time applications in the field. The various procedures and processes are depicted in this section. The recent consciousness about the environmental protection and the birth of Leadership in Energy and Environmental Design (LEED) has encompassed even the roadways. This novel idea of using pervious concrete has generated huge interest in developing roadways and driveways considering environment as a factor too. By the tests carried out in this project, it is clear that the pervious concrete is capable of infiltrating water at a decent rate. The laying of pervious concrete has shown the practical issues of concreting immediately after the mix. The Infiltration rate of

312.64 inches/ hour is an indication about how useful these can be, if implemented properly adhering to the rules. The potential of pervious concrete as a whole is yet to be tapped. This material indicates just that on how useful socially it can be.

V.G.Khurd, Nitish M. Patil (2015) Based on the experimental investigation into the properties of pervious concrete, the following conclusions are made: Pervious concrete could be made with conventional concrete making materials to have permeability between 4mm/s and 8 mm/s. Cement replacement with fly ash contributed to the reduction in long term strength of pervious concrete similar to that noted with the conventional concrete. Since the water permeability as the main criterion for the pervious concrete, fly ash can be used in the production of pervious concrete to achieve an environmentally friendly concrete. The flexural strength of pervious concrete with fine aggregate is lower than the strength requirement of highway pavements therefore this concrete is suitable for light traffic pavements and can be a applicable for village roads in India)

V.R.Patil, A.K Gupta, (2013) Study of pervious concrete to investigation is to develop a strong and durable pervious cement concrete (PCC) mix using different types of fine aggregates with varying the quantity of fine aggregates. In addition, it is also aimed to compare the properties of these PCC mixes. In the present investigation, two types of fine aggregates are used viz., Crushed Stone (CS) and River Sand (RS) are used. The percentage of fine aggregates used in PCC mix is 15 per cent. The properties of PCC mixes investigated are compressive strength, flexural strength, abrasion resistance, permeability, and clogging potential. . The effects of two types of fine aggregates, i.e. Crushed Stone and River Sand, on various properties of pervious concrete were studied. The fine aggregate to coarse aggregate ratio were as 1:5.720, compared to conventional pervious cement concrete mixes. Cement content was varied from 300 kg/m3 to 340 kg/m3 with an increment of 10 kg/m3. In total 10 different pervious concrete mixes were prepared considering each level of cement content and each type of fine aggregate.Figure and table captions should be 10-point boldface and Italic times new roman

III. OBJECTIVE

1. To analysis different fibres for pervious concrete for identifying suitable fibres to partial addition.
2. To develop a strong pervious concrete mix with ACI reports

IV METHODOLOGY

The Methodology adopted carried out is presented in the form of flow chart After identification of problem and setting the objectives of the research, the research methodology has carefully design to achieve above mentioned objectives also the sequential activities involved in this study are presented in graphical form.

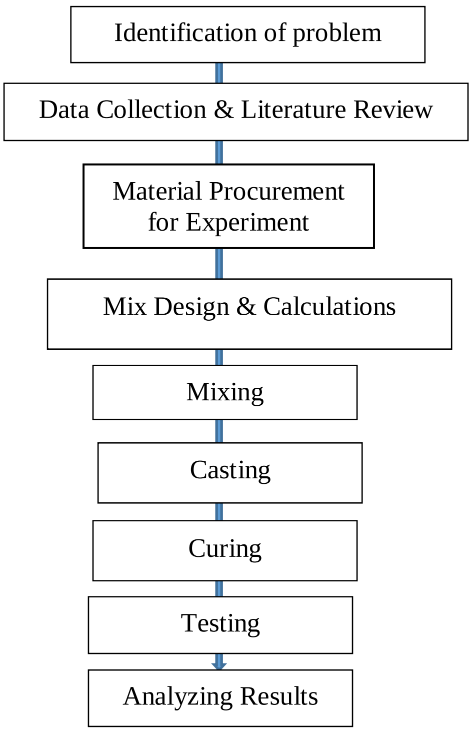

Figure1: Methodology

Figure shows the methodology adopted for experimental study.

V: EXPERIMENTAL PROGRAM

5.1Materials for experiment

Cement:
Ordinary Portland cement (OPC) of M53 grade going along with IS: 10262-2009 was used for casting the pervious concrete.
Aggregate:
The coarse aggregate was natural gravel of 10mm-20mm maximum size was selected. For Experimentation work a single 20mm size aggregate are used.
Water:
Drinkable clean water that is good for making ordinary concrete should be used. For Mixing, Casting and Curing Purpose
Fibres:
Glass fibres: Glass fibres provide improvements in shrinkage characteristics, fatigue characteristics, impact, erosion resistance, serviceability, tensile strength, durability of concrete. In this study chopped strand mat glass fibre is used with properties- Type: Emulsion roded, Material: chopped strand MAT glass fibre, Density: 450/300 GSM (Grams per square meter), Length: 40 to 50 mm, Tensile strength: 108 Mpa, Flexural strength: 204 Mpa, Mechanical properties: good bonding.
Polypropylene fibres:
In the study Fibrillated 12 mm cut length fibres were used. These polypropylene fibres. Tensile strength 500-750 Mpa.

5.2MixDesign and proportions:

The cement: aggregate ratio by volume is in the range of 1:4 to 1:6 by volume[8]. The water- cement ratio needs to be kept low, 0.3- 0.5, to secure the cement paste coats the aggregates and does not run off[3].

Mix Design by ACI 522R_10

- Assume percentage of voids by volume = 20 %
- Specific Gravity of coarse aggregate = 2.75
- Water cement ratio = w/c = 0.38
- Size of coarse aggregate = No. 67 (3/4’’) as per C33/ C33m (i.e. 4.75 mm to 19 mm)
- Dry rodded density = 1741.2069 Kg /M3
- Water absorption of course aggregate = 1.2 %
- No fine aggregate.

The trial batch weights per M^3 are as follows.

Cement = 323.4 Kg/M^3

Water = 122.94 Kg/M^3

Aggregate = 1333.956 Kg/M^3

Proportion = Cement: Aggregate = 1: 4.1

Table 5.1.Typical ranges of material proportions in Pervious Concrete (ref ACI 522R-15 Table no 6.2)

	Proportions (kg/m^3)
Cement	270 to 415
Aggregate	1190 to1480
w/cm ratio	0.27 to 0.34
Aggregate : Cement ratio	4 to 4.5:1
Fine: Coarse Aggregate ratio	0to 1:1

Percentage Variation of fibre in mix:-

The proportions of two fibre (Glass & Polypropylene) used in concrete mix were at volume of 0%, 0.1%, 0.15% and 0.2% and 0.25%for each proportion equal amount of fibre are added to the mix by the weight of concrete

5.3Casting, Curing & Demoulding

The moulds of 150x150x150 Mm were well cleaned and the internal faces were completely oiled to avoid adhesion with the concrete after hardening. The casting was carried out in one layer without compaction. The specimens were demoulded after 24 hours. After demoulding, the specimens were completely immersed in water.

Figure 2.1 Mixing of materials

Figure 2.2 Concrete Specimens

Figure 2.3 Concrete Specimens Weighting

Figure 2.4 Concrete Specimens Testing

V. EXPERIMENTAL RESULTS AND TABLES

The graph shows the compressive strength of the cubes with different % of Fibres for 3, 7, 14 and 28 days respectively . Results are the averages of 3cubes for each Proportions of Specimen (A0, A.1, A.15, and A.2and A.25)

28 Days Compressive strength on Cubes

Table: 5.1: compressive strength

Sr No	%of Addition of Fibre (GF+PPF)	Compressive Strength (mpa)
1	0 % Fibres	11.43
2	0.1 % Fibres	11.67
3	0.15% Fibres	12.8
4	0.2 % Fibres	14.15
5	0.25 % Fibres	13.61

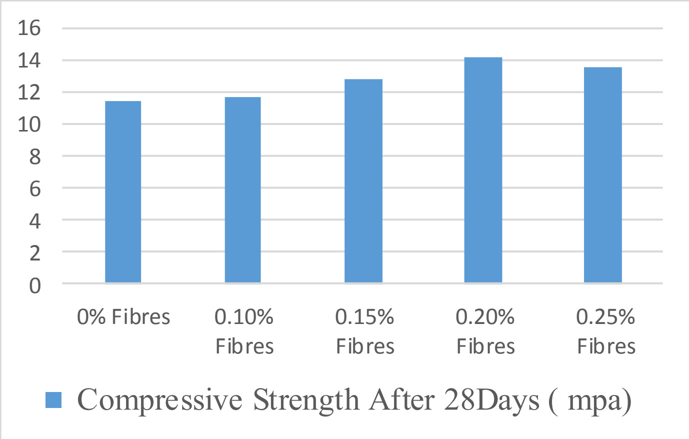

Figure: 5.4: compressive strength on 28 day Curing

Table: 5.6: Compressive Strength Percentage Variation and Days of Curing

Per of fibres	0% Fibres	0.10% Fibres	0.15% Fibres	0.20% Fibres	0.25% Fibres
Days of Curing	Compressive strength in mpa				
3 Day	3.18	3.2	3.26	3.342	3.312
7 Day	5.61	5.68	5.709	6.035	5.862
14 Day	8.304	8.541	8.715	8.84	8.22
28 Day	11.43	11.67	12.8	14.15	13.61

Figure 5.5: Concrete compressive Strengths

Figure 5.5 shows summarized results on relation between percentage fibres addition in concrete mix and compressive strength after 3days,7days,14days,28day curing. Compressive strength shows better results for 0.20% fibres addition mix 3.34 mpa,6.03mpa,8.84mpa,14.15mpa then it may falls .

Table: 5.1: compressive strength Comparison 0% and 0.20% Fibre

Days	Compressive Strength (mpa)	
	0%of Addition of Fibre (GF+PPF)	0.2%of Addition of Fibre (GF+PPF)
3	3.18	3.342
7	5.61	6.035
14	8.304	8.84
28	11.43	14.15

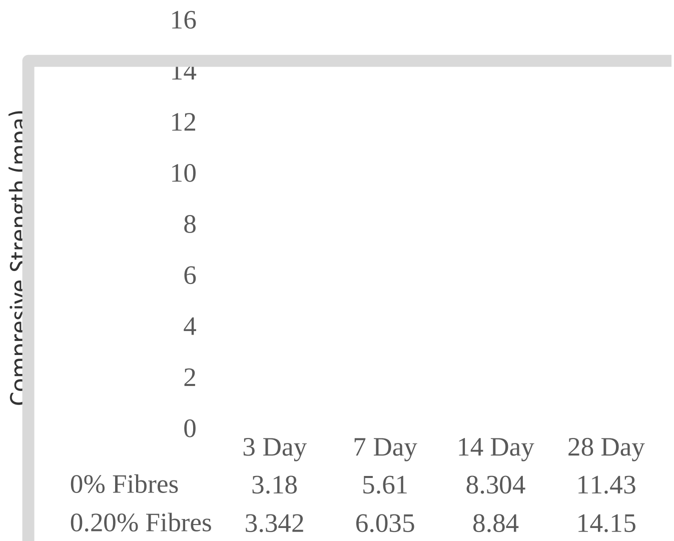

Figure: 5.6: Comparisons of compressive strength With 0% and 0.2% Fibre

Figure 5.6 shows comparative results on relation between percentage 0% and 0.20% fibres addition in concrete mix and compressive strength after 3days,7days,14days,28day curing.

Table 5.9 shows the Permeability test results of concrete cubes with variations in 0%,0.10%,0.15% and 0.20% addition of fibres after 28Days curing of different trial mixes and results are of average of cubes for each

Table: 5.9: permeability results of specimens

Percentage addition of fibres	Avg. Permeability (lit/m2/min)
0% Fibres	150
0.10% Fibres	143
0.15% Fibres	138.5
0.20% Fibres	139
0.25% Fibres	121

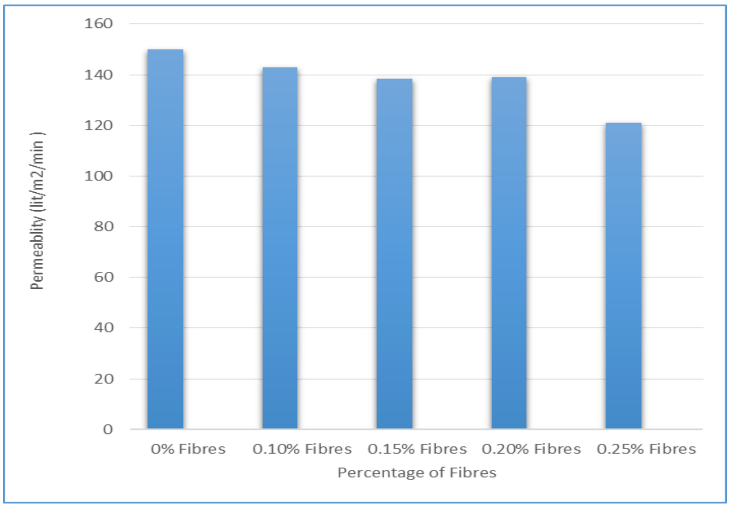

Figure 5.18: Permeability test results after 28days curing

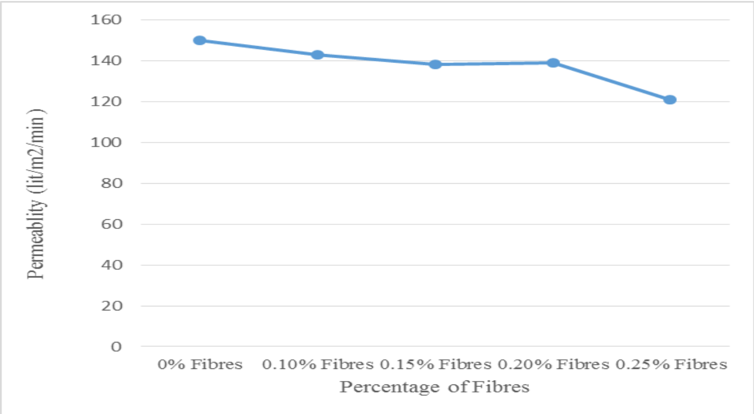

Figure 5.17 shows summarized results on relation between percentage fibres addition in concrete mix and permeability (lit/m^2/min) after 28day curing.

VI CONCLUSION

The test carried out at 3 days , 7 days, 14 days and 28 days, the comparison is made between the plain pervious concrete ,pervious concrete with Glass fibre and polypropylene fibre .

a) The compressive strength of Glass fibre and Polypropylene fibre mixed with pervious concrete is increased as comparison to the plain pervious concrete.
b) When we used the Glass fibre and polypropylene fibre in pervious concrete in different proportion 0.1 %, 0.15%,0.2% and 0.25% of volume of concrete the result Received by the compressive strength of Glass fibre and polypropylene fibre up-to 0.2 % of used result get increased.
c) Compressive strength of specimens for 1:4.1 ratio with Glass fibre and polypropylene fibre increased by 22.15% at 28 days when compared with control
d) Permeability of pervious concrete varies on percentage addition of fibres

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