Use of Polypropylene Fibre To Increase The Strength of Pervious Concrete

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Abstract- *Pervious concrete is a composite material consisting of coarse aggregate, Portland cement and water. The aggregate usually consists of a single size and is bonded together at its points of contact by a paste formed by the cement and water. The result is a concrete with a high percentage of interconnected voids that, when functioning correctly, permit the rapid percolation of water through the concrete. Unlike conventional concrete, which has a void ratio anywhere from 3-5%, pervious concrete can have void ratios from 15-40% depending on its application. Porous concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows from precipitation and other sources to pass through it thereby reducing the runoff from site and therefore recharging ground levels. Pervious concrete is traditionally used in parking lots, area with light traffic, pedestrian walkways and greenhouses. It is an important application for sustainable construction. The interest in the use of fibers for the reinforcement of composites has increased during the last several years. A combination of high strength, stiffness and thermal resistance favorably characterizes the fiibres. In this study, the results of the Strength properties of Polypropylene fiber reinforced concrete have been presented. The compressive strength of concrete samples made with polypropylene fibers an amount varies from 1.5% and 2.0% were studied.*

Keywords- Pervious concrete, Polypropylene fibres, Compressive strength, Ground water recharge.

I. INTRODUCTION

Pervious concrete consists of cement, coarse aggregate and water with little to no fine aggregates. Water to cement ratio of 00.27 to 0.33 with a void content of 15 to 25 %. The correct quantity of concrete is critical. A low water to cement ratio will increase the strength of the concrete, but too little water may cause 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 sections are analysed under a microscope.

A pervious concrete mixture contains 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/sec. , which is 5 gal/sq.ft./min or 200 L/sq.m/min), although they can be much higher. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures, but sufficient strength for many applications is readily achieved. Pervious concrete pavement is a unique and effective means to address important environmental issues a support sustainable growth. By capturing rain water allowing it to seep into ground, porous concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting US Environmental Protection Agency (EPA) storm water regulations. The use of pervious concrete is among the Best Management Practices (BMPs) recommended by the EPA, and by other agencies and geotechnical engineers across the country, for the management of storm water runoff on a regional and local basis. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, pervious concrete has the ability to lower overall project costs on a first costs basis.

II. FIBRE USED IN CONCRETE

Polypropylene Fibre

Polypropylene is smooth, light weight and high strength. A synthetic fibre formed from a polypropylene melt.Polypropylene fibre was first used to reinforce in the in 1960's. Polypropylene is synthetic hydrocarbon polymer, the fibre of which is made using extrusion processes by hot-drawing the material through a die, polypropylene fibres are produced as continuous mono-filaments, with circular cross section that can be chopped to required lengths, or fibrillated films or tapes of rectangular cross section. Polypropylene fibre are hydrophobic and therefore have the disadvantages of poor bond characteristics with cement matrix, a low melting point, high combustibility and a relatively low modulus of elasticity. Long polypropylene fibres can prove difficult to mix due to their flexibility and tendency to wrap around the leading edges of mixer blades.Polypropylene fibres are tough but have low tensile strength and modulus of elasticity; they have plastic stress-strain characteristics. Monofilament polypropylene fibres have inherent weak bond with the cement matrix because of the relatively small specific surface area. Fibrillated polypropylene fibres are slit and expanded into an open network thus offering a larger specific surface area with improved bond characteristics.

III. MATERIAL USED

Specification of material used-

1. Cement

Cement is a fine grey powder. It is mixed with water and material such aggregates. The cement and water form a paste that binds other materials together as concrete hardens. In the present work 53 grade cement was used for casting of cubes for all concrete mixes. The cement was uniform colour i.e. grey with a light greenish shade and was free lumps. Ordinary Portland cement ULTRA TECH 53 GRADE was used.

2. Coarse Aggregate

Crushed granite stones from local queries were used as aggregate. The maximum size of aggregate used was 20 mm retained to the 12.5 mm. The broken stones are generally used as aggregate. The aggregate where washed to removed dirt and dust and were dried to surface dry condition.

Test for Aggregate

Water Absorption

Water absorption value generally ranges 0.1 to about 2 % for coarse aggregate normally used in road surface course. Indian Road Congress (IRC) and Ministry of Road Transport and Highway (MORTH) have specified the maximum water absorption values as 1.0 % for aggregates used in bituminous surface dressing. As per MORTH specification, the maximum permissible water absorption value 2.0 % for the coarse aggregate to be used in bituminous macadam base coarse, dense bituminous macadam binder course, semi-dense bituminous concrete surface course and bituminous concrete surface course.

Calculations:

Size of aggregate= 10mm
W1 = weight of oven dried aggregate
W2= weight of saturated surface dry aggregate in air.
Water absorption in percentage= [(W1 W2)/W1] X 100
Example water absorption (%) =
[(2026– 2000)/2000] X 100= 1.3 %

Sr. No	W1	W2	%Water Absorption
1	2000	2026	1.3 %

Table no.1 Water Absorption Of Test Samples.

Water absorption of these sample is = 1.3 %.

Specific Gravity

Specific gravity is a ratio that relates of the coarse aggregate or compacted specimen, as in this study, to the density of water (Mindess et al., 2003).The specific gravity of coarse aggregate normally used in road construction ranges from about 2.5 to 3.2 with an average value of about 2.70. Though high specific gravity of an aggregate is considered as an indication of high strength, it is not possible to judge the stability of a stability of a sample of a road aggregate without finding the mechanical properties such as aggregate impact value and abrasion values.

Calculations:

Mass of empty pycnometer = w1 (gm)
Mass of pycnometer + dry sample= w2 (gm)
Mass of pycnometer + dry sample + water = w3 (gm)
Mass of pycnometer + water= w4 (gm)

Formula for the determination of specific gravity –

Specific gravity = [(W2 – W1) / (W2 –W1) – (W3 –W4)]

Sr. No	W1 (gm)	W2 (gm)	W3 (gm)	W4 (gm)	S.G
1	644	944	1650	1464	2.63

Table no.2 Specific Gravity of Aggregates Used in Pervious Concrete Mix

Specific gravity of the sample is = 2.63

Aggregate Impact Test

Aggregate impact test has been designed to evaluate the toughness or the resistance of the stones aggregates to breaking down under repeated application of impact. Aggregate impact value indicates a relative measure of the resistance of aggregate to impact. The aggregate impact test apparatus and the procedure have been standardized by the Bureau of Indian Standards (BIS).

Calculations:-

The aggregate impact value test (AIV) is expressed as the percentage of the fines passing 2.36 mm sieve expressed in terms of the total weight of the sample.

Let the original weight of the oven dry aggregate sample be W1 (gm) and the weight of the broken aggregate passing 2.36 mm IS sieve after the application of 15 blows of the hammer be W2 (gm).

Formula for the determination of aggregate impact value

Aggregate impact value (AIV) = [W2 X 100 / W1]

Sr. No	W1 (gm)	W2 (gm)	AIV
1.	400	54	13.5

Table no.3 Aggregate Impact Value

AIV of the sample is = 13.

Aggregate impact values are used to classify the stone aggregate with respect to toughness property, as indicated below:

Aggregate impact value, %	Toughness property
Less than 10	Exceptionally tough / strong
10 to 20	Very tough / strong
20 to 30	Good for pavement surface course
Above 35	Weak for pavement surface

Table no.4 Criteria of Aggregate Impact Value

According to these criteria our aggregate sample is very tough and strong, so we can use this aggregate in our construction.

3. Water

Portable water free from salts was used for casting and curing of concrete as per IS 456-2000 recommendation. Water quality used in pervious concrete should be the same as that used in conventional concrete: potable water, recycled water, or tap water. Due to the sensitivity of pervious concrete, water quality control is very important.

IV. MIX DESIGN

Method

While pervious concrete contains the same basic ingredients as the more common conventional concrete [i.e. Aggregate, Portland cement, water, and a variety of admixtures], the proportioning of ingredients is quite different. One major difference is the requirement of ingredients is quite different. One major difference is the requirement of increased void space within the pervious concrete. The amount void space is directly correlated to the permeability of the pavement. 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 associated with pervious concrete are listed below. These ranges are based on previous research.

Design void content: 15% to 25%

Water to cement ratio: 0.27 to 0.33

The goal for the final mix design was to provide a strong, durable pervious concrete design which allowed for adequate drainage of rainwater. Reviewing the literature and past research, a 15% design void content would have allowed for higher strength and durability in the previous concrete samples but not allowed adequate drainage based on Maryland peak storm events. A 25% void content would have allowed more than enough void space in the samples to accommodate a peak storm even in Maryland but have provided the strength and durability that was required for the research project.

ACI mix design method.

NRMCA Mix design method.

ASTM Mix design method.

IS recommended mix design method.

These all are very useful method to mix design of pervious concrete.

V. METHODOLOGY

We will prepare several cubes for testing the compressive strength.

Batching:

Batching is the process of measuring and combining the ingredients of concrete. Careful procedure was adopted in the batching, mixing and casting operations.

For compressive strength with water cement ratio 0.36% and different percentage of admixtures by volume of concrete.

Dosage of fibres and their calculation

1. **Calculation for volume of cube:**

Volume of one cube = [0.15 X 0.15 X 0.15] m^3= 0.003375 m^3
Weight of one cube = 0.003375 X 2362(concrete density)= 7.972 kg

2. **Calculation of volume of concrete for M20 grade:**

Cement to aggregate ratio = 1:4
a.Volume of cement for one meter cube = 1/ (1+4)= 0.2 m^3
Weight of cement per meter cube = 0.2 X 1440(bulk density)= 288 kg
Volume of cement for one cube = 0.003375/(1+4) = 0.000675 m^3

Weight of cement for one cube = volume X bulk density = 0.000675 X 1440 = 0.972 kg

b.Volume of aggregate for one meter cube =4/ (1+4)= 0.8 m^3
Weight of aggregate per meter cube = 0.8 X 1450(bulk density) =1160 kg
Volume of aggregate for one cube = 0.003375 X 4/(1+4) = 0.0027 m^3

Weight of aggregate for one cube = 0.0027 X 1450 = 3.915 kg
Water cement ratio = 0.36

c. Weight of water = 288 X [1/0.36] = 800 kg
Weight of water in one cube = 0.972 X (1/0.36) = 2.7kg

Density of concrete = [weight of [cement +sand +aggregate +water]] per meter cube
= [288+1160+800] = 2248 kg/m^3

Weight of concrete for one cube = 2248 X 0.003375 = 7.980 kg

3. **Weight of polypropylene fibre:**
0.15% of polypropylene fibre =7.980X 0.0015 = 0.01197kg

Curing:

The specimens were allowed to remain in iron mould for 24 hours under ambient condition. After that, these were remoulded with care so that no edges were broken and were placed in curing tank at the ambient temperature for curing. The ambient temperature for curing was 27+2 degree calicoes or 27-2 degree calicoes.

VI. TESTING OF SPECIMEN

Slump Cone Test:-

Fill the cone with concrete in three layer and tamper 25 blows evenly in each layer with 5/8’ diameter and 24’ long hemisphere steel rod. Remove the excess concrete from top of the cone, using tampering rod, clean overflow from base of cone. Lift the cone vertically with slow and even motion. Lay a straight edge across the top of the slump cone. Measure the amount of slump in the inches from the bottom of straight edges to top of slump concrete at a point over original centre of base. Discrete concrete and do not use in any other tests.

Fig no.1 Slump Cone Test

Compressive Test:-

Fig no.2 Compressive Strength Machine

The specimen after a fixed curing period of 7 days, 14 days and 28 days were tested for compressive strength 2000 KN compressive testing machine (UTM). The specimen is placed on bearing surface of the testing machine and compressive load was applied on opposite face axially and slowly

Permeability Test:-

The property of the concrete which permits water (fluids) to percolate through its continuously connected voids is called its permeability.

Case 1

We check the permeability of plain pervious concrete cube. 1000 ml water which is passed through the voids of the plain pervious concrete cube and the water is retained to another pan that stored water measures it is 860 ml.

Case 2

The permeability of 0.15% of polypropylene fibre mixed pervious concrete cube. 1000 ml water which is passed through the voids of the polypropylene fibre mixed pervious concrete cube and the water is retained to another pan that stored water measure it is 900 ml.

VII. RESULTS

Results for M20 Grade Pervious Concrete in Compressive Test:

Portland cement concrete:

For 7 days:

Cubes	Loads (KN)	Load (N)	$Stress = \frac{Load}{Area}$(N/mm2)
1	235	235000	10.44N/mm2
2	240	240000	
3	230	230000	

Table no.5

For 14 days:

Cubes	Loads (KN)	Load (N)	$Stress = \frac{Load}{Area}$(N/mm2)
1	240	240000	10.90N/mm2
2	250	250000	
3	245	245000	

Table no.6

For 28 days:

Cubes	Loads (KN)	Load (N)	$Stress = \frac{Load}{Area}$(N/mm2)
1	278	278000	12.02N/mm2
2	275	275000	
3	265	265000	

Table no. 7

Using polypropylene fibre in concrete (0.15%):
For 7 days:

Cubes	Loads (KN)	Load (N)	$Stress = \frac{Load}{Area}$(N/mm2)
1	255	255000	10.79 N/mm2
2	250	250000	
3	260	260000	

Table no.8

For 14 days:

Cubes	Loads (KN)	Load (N)	Stress = $\frac{Load}{Area}$ (N/mm2)
1	310	310000	11.57 N/mm2
2	300	300000	
3	305	305000	

Table no.9

For 28 days:

Cubes	Loads (KN)	Load (N)	Stress = $\frac{Load}{Area}$ (N/mm2)
1	315	315000	13.97 N/mm2
2	310	310000	
3	318	318000	

Table no.10

7.1. RATE ANALYSIS

FOR 1 CUBE OF PERVIOUS CONCRETE:

Weight of cement for one cube = volume X

bulk density = 0.000675 X 1440 = **0.972 kg**

Volume of aggregate for one cube = 0.003375 X 4/(1+4) = **0.0027 m3**

Sr.No	MATERIALS	QTY.	UNIT	RATE	AMOUNT
1	CEMENT	0.972	KG	6.6/KG	6.5 Rs
2	AGGREGATE	0.0027	M^3	$660M^3$	2 Rs
				TOTAL	**8.5 Rs**

Table no.11

FOR 1 CUBE WITH POLYPROPYLENE FIBRE 0.15%:

0.15% of polypropylene fibre =7.980X 0.0015 = **0.01197 kg**

Sr.No	MATERIALS	QTY.	UNIT	RATE	AMOUNT
1	CEMENT	0.972	KG	6.6/KG	6.5 Rs
2	AGGREGATE	0.0027	M^3	$660M^3$	2 Rs
3	FIBRE	0.01197	KG	380 Rs	4.5 Rs
				TOTAL	**13 Rs**

Table no.12

VIII. CONCLUSION

Compressive test (cube) of M20:

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

a. The compressive strength of polypropylene fibre mixed pervious concrete is increased as comparison to the plain pervious concrete.

b. When we used the polypropylene fibre in pervious concrete proportion 0.15% of volume of concrete the result obtained by the compressive strength of polypropylene fibre up to 0.15% of used result get increased.

Permeability test of M20:

Plain pervious concrete

1000 ml water which is passed through the voids of the plain pervious concrete cube and the water is retained to another pan that stored water measures it is 860 ml.

Polypropylene fibre mixed pervious concrete

1000 ml water which is passed through the voids of the polypropylene fibre mixed plain pervious concrete cube and the water is retained to another pan that stored water measures it is 900 ml.

Hence, the permeability of polypropylene fibre mixed pervious concrete is increased as compared to the plain pervious concrete.

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