Experimental investigation on the properties of Pervious concrete

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***Abstract*: Pervious concrete also called porous concrete, permeable concrete or no fines concrete is a special type of concrete which is made using coarse aggregates with little or no fine aggregates for high porosity. Pervious concrete is a special type of concrete which allows water from precipitation and other sources to percolate directly through it, thereby reducing the runoff and allowing groundwater recharge. Pervious concrete has open pore structure and hence used in low loading parking areas, areas with light traffic, residential streets, pedestrian walkways and greenhouses etc. It is an important application for sustainable construction to protect water resources. The aim of this project is to increase the mechanical properties of pervious concrete by the addition of Polypropylene fibers. In order to increase the permeability, aggregates of 16mmand 20mm sizes are used. Compression test, split tensile test, void ratio and permeability tests along with the basic tests were conducted for two different mixes of concrete i.e., i)Coarse aggregates, cement and water ii) Coarse aggregates, cement, water and Polypropylene fibers. Each mix of concrete was carried out for 16mm and 20mm sizes of coarse aggregates separately and tested for 7 days and 28 days of curing. A comparative study of the results obtained is also done in order to know the change in the mechanical properties of the pervious concrete for different mixes.**

***Keywords*: Pervious concrete, Permeability, void ratio, Polypropylene fibers.**

I. INTRODUCTION

Pervious concrete which is also known as no fines, porous, gap graded, and permeable concrete and enhance porosity concrete has been found to be a reliable storm water management tool. By definition, pervious concrete is a mixture of gravel or granite stone, cement, water, little to no sand (fine aggregate). When pervious concrete is used for paving, the open cell structures allow storm water to filter through the pavement and into the underlying soils. In other words, pervious concrete helps in storm water management and recharging of aquifers. Pervious concrete has the same basic constituents as conventional concrete that is 15% - 30% of its volume consists of interconnected void network, which allows water to pass through the concrete. It can allow the passage of 0.014-0.023 m3 of water per minute through its open cells for each square foot 0.0929 m2 of surface area which is far greater than most rain occurrences. Pervious concrete is rough textured, and has a honeycombed surface, with moderate amount of surface ravelling which occurs on heavily travelled roadways. Carefully controlled amount of water and cementitious materials are used to create a paste. The paste then forms a thick coating around aggregate particles, to prevent the flowing off the paste during mixing and placing. Using enough paste to coat the particles maintain a system of interconnected voids which allow water and air to pass through. The lack of sand in pervious concrete results in a very harsh mix that negatively affects mixing, delivery and placement. Also, due to high void content pervious concrete is light in weight (about 1600 to 1900kg/m3). Pervious concrete void structure provides pollutant captures which also add significant structural strength as well. It also results in very high permeable concrete that drains quickly. Pervious concrete can be used in a wide range of applications, although its primary use in pavements which are in: residual roads, alleys and driveways, low volume pavements, low water crossings, sidewalks and pathways, parking areas, tennis courts, slope stabilization, sub-base for conventional concrete pavements etc.

Advantages of Pervious concrete:

- Pervious concrete allows for increased site optimization because in most cases, its use should totally limit the need for detention and retention ponds, swales and other more traditional storm water management devices that are otherwise required for compliances with the Federal storm water regulations on commercial sites of one acre or more. By using pervious concrete, the ambient air temperature will be reduced, requiring less power to cool the building.

- In addition, costly storm water structures such as piping, inlets and ponds will be eliminated. Construction scheduling will also be improved as the stone recharge bed will be installed at the beginning of construction, enhancing erosion control measures and preventing rain delays due to harsh site conditions.

- Apparently, when compared to conventional concrete, pervious concrete has a lower compressive strength, greater permeability, and a lower unit weight (approximately 70% of conventional concrete). However, pervious concrete has a greater advantage in many regards.

- Nevertheless, it has its own limitation which must be put in effective consideration when planning its use. Structurally when higher permeability and low strength are required the effect of variation in aggregate size on strength and permeability for the same aggregate cement ratio need to be investigated.

II. POLYPROPYLENE FIBER (RECRON 3S)

Recron 3s polypropylene fibers are used in this project to increase the strength and durability of pervious concrete. Concrete is widely used because of its valuable properties. It has high compressive strength and stiffness, low thermal and electrical conductivity, besides being non-combustible and non-toxic. It improves resistance to plastic & drying shrinkage/cracking. It inhibits propagation of micro-cracks and provides stability to concrete. It improves flexural toughness/increases split tensile strength. Enhances abrasion resistance and increases energy absorption of concrete, thereby improving impact resistance. It also aids in making concrete more homogenous. It reduces permeability in concrete. It improves durability and enhances the longevity of the structure.

III. MATERIALS AND PROPERTIES

This paper describes a procedure to achieve concrete mix using pervious concrete with polypropylene fibers. In addition, the test results for acceptance characteristics for concrete mix such as Workability characteristics (Slump flow), Mechanical characteristics (compressive strength test, split tensile test, permeability test, void ratio) are presented. The materials used in this research are:

1. Cement (OPC 43 grade) Ordinary Portland Cement is the most common type of cement in general use around the world because it is a basic ingredient of concrete, mortar & stucco. Ordinary Portland cement of 43 grade Jk super Cement conforming to IS: 10262-2009 has been used and properties are presented in Table 1.

Table 1: Properties of Cement

Properties	Results	IS 10262:2009
Setting time *Initial	35 min	≥30 min
*Final	620 min	≤600 min
Standard Consistency	33%	≤ 40%
Specific Gravity	3.1	2.8 - 3.3

2. Coarse Aggregate of crushed stone of 20mm and 16mm aggregates has been used, obtained from the local market in Mysore, presented in Table 3.

Table 2: Properties of Coarse Aggregates

Properties	16mm	20mm
Water absorption	0.5%	0.5%
Specific gravity	2.75	2.71
Round or angular	angular	angular
Bulk density	1520 kg/m^3	1750 kg/m^3
Crushing value	25%	28%
Impact value	20%	22%

3. Polypropylene fibers: polypropylene is a 100% synthetic fiber which is transformed from 85% propylene. The monomer of polypropylene is propylene. It is available in 3 different sizes that is 6mm, 12mm and 24mm. In the present investigation 12mm fiber length is used.

Table 3: characteristics of polypropylene fiber

Properties	Values
Specific gravity	0.91
Tensile strength	550-700
Modulus of elasticity E	3.5-6.8
Elongation at failure	21%
Common V %	<2

IV. METHODOLOGY

Experimental investigation is carried out to study the properties of pervious concrete by adding polypropylene fibers for a mix design of M25 grade (IS 10262-2009) separately for 16mm and 20mm coarse aggregates.

Experimental Procedure

a) Collection of materials from various sources.

b) Basic tests on materials used.

c) Mixing the materials in definite proportions as per obtained mix proportions & testing for Workability separately for nominal mix and modified mix.

d) Addition of polypropylene fibers.

e) Testing the specimen for Compressive strength & Split Tensile strength for with and without fiber.

V. EXPERIMENTAL TESTS

1. Tests conducted for Fresh Properties

a. Slump Cone Test: Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or at site of work. It is not a suitable method for very wet or very dry concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch.

2. Tests conducted for Mechanical Properties

a. Compressive Strength Test: To calculate compressive strength, cubes are casted of 150mm*150mm*150mm size for the required mix design separately for with and without fiber. The sample is placed on the compressive testing machine properly and then applies the load gradually until the first crack will get appear. Note the load value corresponding to sample failure and differentiate.

b. Split Tensile Test: To calculate split tensile strength, cylinders are casted of 150mm*300mm size for the required mix design separately for with and without fiber. The sample is placed on the testing machine properly and then applies the load gradually until the first crack will get appear. Note the load value corresponding to sample failure.

c. void ratio test : To calculate void ratio cylinders are casted of 150mm*300mm by using ASTM D 7063 method.. It is checked finally computing wit theoretical density of the concrete computed on an air free basis. Cylinders was then weighed and the weight recorded to the nearest gram. The weight of the pervious concrete sample was found by subtracting the total weight of the cylinder and sample from the measured weight of the container.

d. permeability test : permeability was determined using the falling head method through a permeameter.sample used in this test were 5.8 in diameter and 11.81 inches in length. Using PVC pipe, permeability of the given sample is calculated for 28 days of curing.

VI. RESULTS

1. Tests conducted for Fresh Properties

a. Slump Cone Test

Table 4: Workability - Slump Cone Test

Sl. No	Aggregate size	Slump Test (mm)
1	16mm	0
2	20mm	0

2. Tests conducted for Mechanical Properties

a. Compressive Strength Test

Table 5: Compressive Strength test values

Sl. No	mixes	Curing period	Compressive Strength 16 mm aggregate	Compressive Strength 20 mm aggregate
1	with	7 days	18.79	15.10
	fiber	28 days	18.26	17
2	Without	7 days	14.57	10.53
	fiber	28 days	17.85	15.61

b. Split Tensile Strength Test

Table 6: Split Tensile Strength values

Sl. No	mixes	Curing period	Split tensile Strength 16 mm aggregate	Split tensile Strength 20 mm aggregate
1	with	7 days	1.93	1.75
	fiber	28 days	2.52	2.21
2	Without	7 days	2.07	1.93
	fiber	28 days	2.27	2.08

c. void ratio test:

Table 7: Void content results

mixture	Void content
20mm without fiber	16%
20mm with fiber	15%
16mm without fiber	14.8%
16mm with fiber	13.44%

d. permeability test:

Table 8: permeability test results

mixture	Permeability coefficient (k) in/s
20mm without fiber	1.95
20mm with fiber	0.88
16mm without fiber	1.58
16mm with fiber	0.79

VII. CONCLUSIONS

From the above results it can be concluded that the mixtures which did not contain fibers exhibited greater void content and permeability when compared to the mixtures which had incorporated fibers in their mix for same size of aggregates.

The mixes which contained fibers exhibited higher split tensile and compressive strengths compared to the other mixes which did not contain fibers and also showed acceptable permeability and void content results.

From this it can be concluded that the main moto of our project was met that was to increase the strength of our pervious concrete with acceptable permeability and void content values.

The mix with 16mm sized aggregates with fibers showed the highest results in strength and least in permeability and void content which was followed by the other mixes.

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