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Experimental Study of Behavior of Polymer Modified Pervious Concrete

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***Abstract*: Now a days Pervious concrete is widely considered as an one of the best material to manage storm waters in built environments as well as to provide several other environmental benefits. Causes are mainly related to poor design, inadequate construction techniques including compaction, and heavy vehicular traffic. Performance of pervious concrete can be furthermore improved by modifying the cement matrix through polymer modifications, for instance. Polymers use in the pervious concrete helps to improve the performance of the pervious concrete in terms of the strength and various properties of the concrete.**

Polymer modifications of pervious concrete material interested very few studies. Polymers cover a wide variety of applications due to their multiple peculiarities and have the potential to provide for resistance and durability without neglecting the ability to permeate. In this project we have studied the performance of pervious concrete with and without polymers

***Keywords*: Environmental benefits, pervious concrete, Polymer modifications of pervious concrete, improve strength of the pervious concrete without affecting the porosity.**

1. Introduction

The pervious concrete is of great use from the environmental aspect. The strength of the pervious concrete is very less. Therefore, the pervious concrete cannot be used for the transport roads. The pervious concrete has high porosity but has low strength. So to use the pervious concrete as the transport roads, the strength of the pervious concrete need to be increased. In this project deep study of the different polymers is done and appropriate polymer is chosen to improve the performance of the pervious concrete. After the studies of the polymers, polypropylene fiber is used to increase the strength of the pervious concrete.

2. Materials and methodology of work

A. Materials

The base constituent is cement, for the polymer modified pervious concrete the cement used will be ordinary Portland cement 53 grade. One of the important parameter in mix design is selection of the proper water cement ratio, so for the polymer modified concrete the adequate water cement is 0.30. After selection of the water cement ratio the selection of proper gradation of the aggregates is important.

Two aggregate gradations were adopted to prepare pervious concrete samples; namely, 2-6 mm and 4-11 mm. By mixing them at 80% and 20%, respectively. The most important constituent in preparing the polymer modified concrete is polymer. After the proper studying the

various polymers the adequate polymers are selected for pervious concrete.

The above section says how to prepare a subsection. Just copy and paste the subsection, whenever you need it. The numbers will be automatically changes when you add new subsection. Once you paste it, change the subsection heading as per your requirement.

B. Specification of material used

1) Polypropylene fibre

The raw material of polypropylene is derived from monomeric C3H6 which is purely hydrocarbon. Its mode of polymerization, its high molecular weight and the way it is processed into fibers combine to give polypropylene fibers very useful properties as explained below:

- There is a sterically regular atomic arrangement in the polymer molecule and high crystalline. Due to regular structure, it is known as isotactic polypropylene.
- Chemical inertness makes the fibers resistant to most chemicals. Any chemical that will not attack the concrete constituents will have no effect on the fiber either. On contact with more aggressive chemicals, the concrete will always deteriorate first.
- The hydrophobic surface not being wet by cement paste helps to prevent chopped fibers from balling effect during mixing like other fibers.
- The orientation leaves the film weak in the lateral direction which facilitates fibrillations. The cement matrix can therefore penetrate in the mesh structure between the individual fibrils and create a mechanical bond between matrix and fiber.

Fig. 1. Polypropylene fibre

The polypropylene fibre that will be used for test:
Type = polypropylene
Length = 40 mm
Diameter = 2 mm
Aspect ratio = 20

Properties	*Polypropylene fibre*
Density (g/cub.m)	0.905
Fibre cut length (mm)	40
Diameter (mm)	2
Aspect ratio (L /D)	20
Dosage of concrete	3 % by volume
Tensile strength (kg /cub. m)	330
Elongation (%)	12
Flexural modulus (Kg /cub. m)	13,500
Permeability	Good
Durability	Excellent

2) 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.

3) 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 test value = 1.3 %.

Specific Gravity:

Specific gravity of the sample is = 2.63.

Aggregate Impact Test:

Aggregate Impact Value of the sample is = 13.

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

Table 1
Criteria of Aggregate Impact Value

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

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

4) 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.

C. Methodology of work

We have prepared several cubes**,** beams and cylinder for testing the compressive strength**,** flexural strength and splitting tensile strength.

1) Batching

Batching is the process of measuring and combining the ingredients of concrete. Careful procedure was adopted in the batching, mixing and casting operations. The water cement ratio taken was 0.3 and the addition of the polymer was taken as the 3% of the cementatious material

2) Materials Quantities

The water cement ratio used throughout the test is 0.3.

The cement used is OPC 43 grade, grade of the concrete is M40. Target strength is 48.25 MPa. Cement to Aggregate ratio is taken as 1:3.

Table 2
Materials Quantities

	Cement (kg)	Coarse Aggregate(kg)	Polymer (gm)
Cube	2.124	4.828	65
Beam	8.70	26.95	265
Cylinder	2.933	6.928	90

3) 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.

4) Compressive test

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce size, as opposed to tensile strength, which withstands loads tending to elongate. In other words, compressive strength resists compression (being pushed together), whereas tensile strength resists tension (being pulled apart). In the study of strength of materials, tensile strength, compressive strength, and shear strength can be analysed independently. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures.

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.

5) Flexural strength test

Flexural strength it is also known as modulus of rapture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a materials ability to resist deformation under load. The flexural strength represents the highest stress experienced within the material at its moment of rupture. When an object formed of a single material, like a wooden beam or a steel rod, is bent, it experiences a range of stresses across its depth. At the edge of the object on the inside of the bend (concave face) the stress will be at its maximum compressive stress value. At the outside of the bend (convex face) the stress will be at its maximum tensile value. These inner and outer edges of the beam or rod are known as the 'extreme fibers'. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength.

The specimen after a fixed curing period of 7 days, 14 days and 28 days were tested for flexural strength 2000 KN universal testing machine (UTM). The specimen is placed on bearing surface of the testing machine and the specimen shall then be placed in the machine in such manner that the load shall be applied uppermost surface as cast in the mould along two lines spaced 20.0 or 13.3cm apart. The axis of the specimen shall be carefully aligned with the axis of loading device.

6) Splitting tensile strength test

In direct tensile test it is impossible to apply true axial load. There will be always some eccentricity present. Another problem is that stresses induced due to grips. Due to grips there is a tendency for specimen to break at its ends. The determination of the splitting tensile strength of cylindrical concrete samples such as molded cylinders is outlined in this procedure. A diametral compressive load will be applied along the length of the sample at a continues rate until failure occurs. This loading induces tensile stresses on the plane containing the applied load, causing tensile failure of the sample. This splitting tensile strength will be determinate by dividing the maximum applied load by the appropriate geometrical factors.

3. Results

The tests have been conducted on the pervious concrete and polymer modified pervious concrete. The test indicates comparison between the conventional pervious concrete and polymer modified pervious concrete. The comparison is in terms of the strength and various properties of the concrete. The test performed and their results are presented below in the tabular form.

Results for M40 Grade Pervious Concrete for all the test.

A. Slump cone test

Table 3
Slump cone test

Conventional pervious concrete	80mm slump
Polymer modified pervious concrete	50mm slump

B. Compressive test

Compression test of conventional pervious concrete and polymer modified pervious concrete is shown in table below.

Table 4
Compressive test

S. No.	No. of days	Compressive strength of Conventional pervious concrete (MPa)	Compressive strength of polymer modified pervious concrete (MPa)
1	3	7.0 7.5 7.5	10.0 10.5 10.6
2	7	15.2 15.0 15.4	22.4 22.0 23.0
3	28	22.0 22.0 23.0	31.9 32.0 33.3

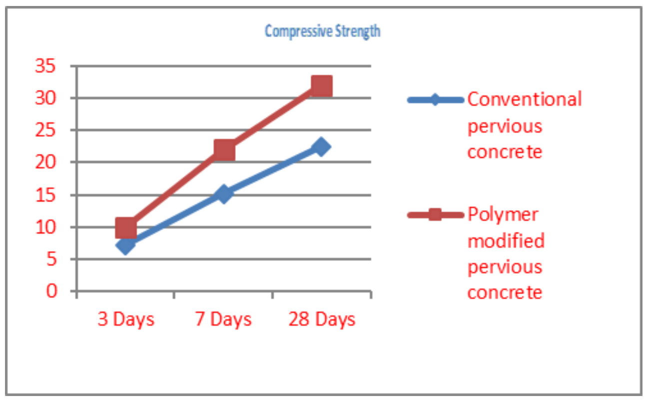

Fig. 2. Compressive strength

C. Flexural strength test

Flexural test of conventional pervious concrete and polymer modified pervious concrete is shown in table below.

Table 5
Flexural strength test

S. No.	No. of days	Flexural strength of Conventional pervious concrete (MPa)	Flexural strength of polymer modified pervious concrete (MPa)
1	3	2.0 2.5 2.8	2.8 3.2 3.2
2	7	3.1 3.0 3.0	4.4 4.2 4.4
3	28	3.8 3.5 3.8	5.4 5.0 5.3

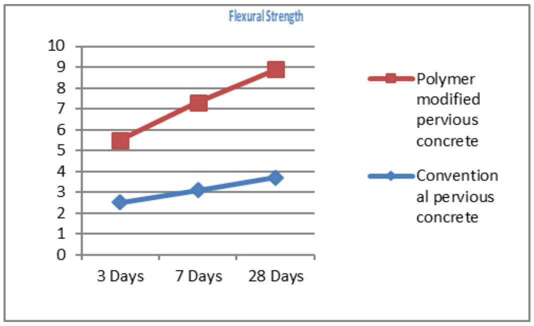

Fig. 3. Flexural strength

D. Splitting tensile strength test

Split Tensile test of conventional pervious concrete and polymer modified pervious concrete is shown in table below.

Table 6
Splitting tensile strength test

S. No.	No. of days	Compressive strength of Conventional pervious concrete (MPa)	Compressive strength of polymer modified pervious concrete (MPa)
1	3	1.2 1.0 1.1	1.7 1.7 1.6
2	7	1.5 1.7 1.6	2.1 2.1 2.2
3	28	1.9 2.2 2.3	2.7 3.2 3.3

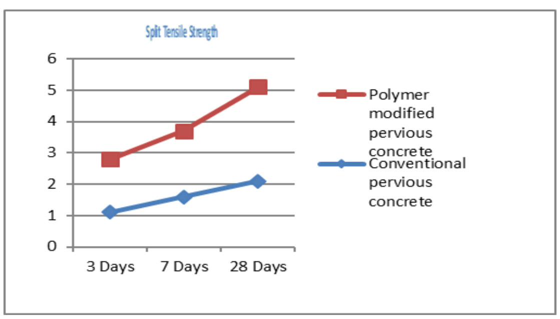

Fig. 4. Split tensile strength

4. Conclusion

The following conclusions are made from the experimental investigation in present thesis:

- The compressive strength of the polymer modified pervious concrete is improved as compared to the conventional pervious concrete.
- The flexural strength of the conventional pervious concrete is increased as compared with the conventional pervious concrete.
- There is no significant increase in the split tensile strength of the polymer modified pervious concrete as compared with conventional pervious concrete but it is found to be increased.
- The slump of the polymer modified pervious concrete is found to be less as compared to the slump of the conventional pervious concrete. It indicates that the stiffness of the polymer modified pervious concrete has been increased, but it is found to be workable.

Percentage increase in strength of polymer modified pervious concrete as compared to conventional concrete can be represented in terms of bar chart, following bar graph shows the percentage increase in strength of polymer modified pervious concrete.

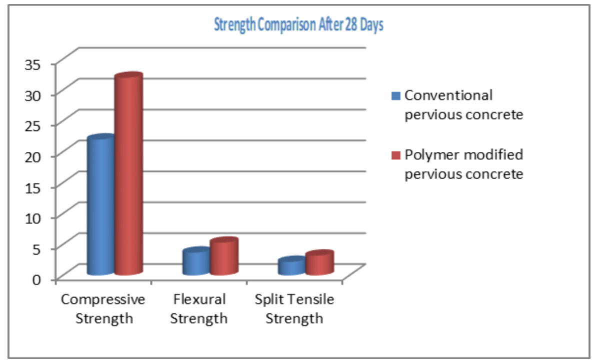

Fig. 5. Strength comparison after 28 days

5. Summary and Limitations

A. Summary

From the results was clear that the permeability was not affected. the strength of the pervious concrete was increased by using the polymer polypropylene. as the permeability is not affected by using the polymer we can use it as admixture to increase its strength such as compressive strength, flexural strength, splitting tensile strength. The polymer added was 3% of the cement.

We concluded that the polymer choose polypropylene can increase the compressive strength, flexural strength and split tensile strength without affecting the permeability of the pervious concrete, hence it can be chosen as a alternative for conventional concrete to increase the ground water recharge and used for road pavements.

B. Limitations

There are not much limitations in the experimental study of the polymer modified pervious concrete, some of the limitations are as follows;

- There is not significant improvement in the split tensile strength.
- The abrasion resistance of the polymer modified pervious concrete is also less.
- As the pavement surface is not smooth using the polymer modified pervious concrete there can be wear and tear of the concrete surface.
- Polymer modified pervious concrete pavement cannot be used on the highways where the speed of the vehicle is more, there can be wear and tear of the tyres of vehicles.

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