Pervious Concrete – An Approach For Sustainable Urban Roads

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Abstract- *Pervious concrete is a eco friendly concrete in which surface eater is easily penetrates into the ground. This is emerging technology and popular now a days. Under this project, results are good and accepable for the future use*

Keywords- Pervious concrete, Compressive strength, Sustainable roads.

I. INTRODUCTION

Porous concrete which is also known as pervious concrete, gap graded concrete or no fines concrete. It is a special type of concrete with high porosity used for concrete flat work applications that allows the water from precipitations and other sources to percolate directly through it, thereby reducing the runoff and allowing ground water discharge.

In recent years, porous concrete is widely gaining popularity as a viable paving material and a tool of sustainable development because of its environmental merits. Concern has been growing in recent years among public agencies, planers and developers, towards reducing the pollutants in water sources and environment. Recharging of the ground water sources, reducing the quantity of storm water generated from developed areas, improving the storm water quality, reducing the discharge of pollutants in water sources and minimizing the effect of development on water sheds have become the primary focus area while developing a natural land.

Porous concrete is made up of cement, water, coarse aggregate with little to no fine aggregates which creates an interconnected void system that allows the water to pass through it. Pervious concrete has only sufficient cementations paste to just coat the coarse aggregate particles thus preserving the interconnectivity of voids. Due to the high void content, porous concrete is light in weight (about 1600 to 1900 kg/m3). The void structure in porous concrete provide pollutant capture which as add significant structural strength as well.

Porous concrete can be used in wide range of applications, although its primary use is in parking areas, pavements with light traffic, pedestrian walkways, residential streets and greenhouse.

POLYPROPYLENE FIBRE

Fiber reinforced concrete is a concrete containing fibrous materials which increases its structural integrity. Fibres include steel fibers, glass fibers, synthetic fibers and natural fibers each of which lend varying properties to the concrete. In addition, the character of fiber rein forced concrete changes with varying content of, fiber materials, geometries, distribution, orientation and densities. Some fibers also produce greater resistance to impact, abrasion and shatter in concrete. In most of the applications, the fiber does not increases the overall strength of concrete (although the increase of tensile strength is consequence), but just to control and delay the early failure of concrete due to widening of cracks fiber reinforced concrete were preferred.

ADVANTAGES

The advantages of porous concrete over conventional concrete are as follows:

- Reduce quantity of runoff.
- Prevent contamination of storm water and improves water quality.
- Enhance skid resistance, especially during storm events by rapidly draining rain water.
- In rainy days, porous concrete pavement has no plash on the surface and does not glisten at night.
- Reduce traffic induced noise level, which creates quiet and comfortable environment.
- Reduces urban heat island.
- Control pollution in water seepage to ground water recharge.
- Absorbs less heat than regular concrete and asphalt, thus reduces the need of air conditioning.
- The costly storm water structures like piping, inlets and retention ponds will be eliminated.

- The rainwater can quickly filter into ground, so the groundwater resources can renew in time. As the pavement is air permeable and water permeable, the soil underneath can be kept wet.

OBJECTIVE OF THE STUDY

The main objectives of this study are as follows:

1. To study the basic strength properties of the porous concrete with fibre reinforcement.
2. To determine the effect of different sizes of fine aggregate on the strength and porosity of porous concrete.
3. To evaluate the effect of variation of fine aggregate content on porous concrete mix.
4. To study the properties of porous concrete with single sized coarse aggregate.

II. MATERIALS AND PROPERTIES

This chapter reviews the basic test and properties of materials used as concrete ingredients in the mix.

CEMENT

Cement is a fine mineral powder used as binding material in construction that sets and hardens. It's the economical and high quality of binding material widely used in construction projects. It is the main ingredient of concrete. For the present study pozzolanic Portland cement (fly ash based) conforming to IS 1489(part-1): 1991 was used. The properties of concrete is mainly influenced by the properties of cement, hence it worth importance to know the properties of cement.

TESTS ON CEMENT

Following are some of the basic tests conducted to know cement properties.

- Specific gravity test
- Normal consistency test
- Initial and final setting time test
- Soundness test
- Fineness test
- Compressive strength test

AGGREGATES

Aggregates are the other important constituents of concrete and they constitute 75-80% total volume of concrete. They reduce shrinkage and effect economy to a great extent. As aggregate is the main ingredient of concrete, its properties affects the concrete characteristics o the great extent. Coarse aggregate is the granular material obtained from rocks and crushed stones. They may be also obtained from synthetic material like slag, shale, fly ash and clay for the usage of light weight concrete. The sand obtained from river beds and quarries are used as fine aggregates. The fine aggregate along with the hydrated cement paste fills the space between the coarse aggregate.

TESTS ON AGGREGATES

Locally available crushed stone aggregates were used in this investigation. The following basic tests were considered to characterize the aggregate.

- Specific gravity test
- Sieve analysis
- Water absorption test
- Aggregate crushing test
- Aggregate impact test

POLYPROPYLENE FIBRE

The synthetic polypropylene fibre of length 12mm and diameter of 40 µm was used in this experimental study. The aspect ratio of the polypropylene fibre used is 300.

WATER

Ordinary potable water was used in this investigation for mixing and curing of concrete.

SUPERPLASTICIZER

Commercially available sulphonated naphthalene formaldehyde(SNF) polymer bond water retarding admixture (Conplast SP 430) supplied by FOSROC Chemical India private Ltd. was used in this study.

III. CONCRETE MIX DESIGN

The concrete mix design was carried out based on the guidelines given in IS 10262:2009 and IS 456:2000. Depending upon the arbitrarily considered mix proportions, the constituents of the mix that is cement, fine aggregate, coarse aggregate and water are taken by weight and calculations are done for the quantities and the mix proportion are as follows

MIX PROPORTIONS

a) Cement = 430Kg/m^3
b) Water=175kg/m^3
c) Fine aggregate = 672.6720kg
c) Coarse aggregate = 1118.23 kg

Mix Proportion for Control mix: 1: 1.56:2.6: 0.4 with superplasticizer – 0.75%

(Cement: Fine aggregate: Coarse aggregate: Water)
The same mix was considered as control mix of M1, M2,M3,M4,and M5,M6 and replacing of fine aggregates from the coarse aggregates of 20%, 40%, 60%.

IV. SPECIMEN PREPARATION AND TESTS

This chapter describes the details of various mixes used in this experimental study, preparation of test specimens and test procedures of harden concrete after the desired periods of curing.

MIX DESIGN DETAILS

M45 grade of concrete was adopted in the present study according to the guide lines recommended by IS 10262-(2009). The mix proportion material details used per cubic meter of concrete are given in Table 5.1.

Water Cement Ratio	Cement (kg/m^3)	Mix Proportion	Super plasticizer (%)
0.4	430	1:1.56:2.6	0.75

BATCHING OF MATERIALS

Materials were batched based on weight batching and machine mixing was adopted to mix the ingredients in this experimental work.

MIX DESIGNATION

Different sizes of coarse aggregate, percentage replacement of fine aggregate by coarse aggregate and addition of polypropylene fibre to the concrete are shown in Table 5.2.

PREPARATION OF SPECIMENS

In the present experimental study, to determine various properties of porous concrete, 150mm cube specimens were prepared for compressive strength test, 150mm diameter and 250mm height cylindrical specimens were prepared for split tensile strength test and 150mm cube specimens for permeability test.

LABORATORY TEST

Several standard tests were conducted to determine the performance at fresh stage and characteristics at harden stage of porous concrete such as slump cone test, density test, compressive strength test, flexural strength test, split tensile strength.

SLUMP CONE TEST

Slump cone test is the commonly adopted method to measure the workability of fresh concrete mix. For each mixes the slump cone test is conducted and the workability is measured

DENSITY TEST

Density is defined as the ratio of mass of specimen by total volume of it. Then the average weight of cubes for each mixes were noted and the density of porous concrete is measured by using Eq. (1)

Density = Mass/Volume (kg/m^3) -------- (1)

COMPRESSION TEST

The compression test is quite resourceful since most of the desirable characteristic properties of porous concrete are qualitatively related to its compressive strength. The compressive strength test is carried out on the specimens of cubical or cylindrical shapes. In the present study cubical specimens are preferred. The compression test was conducted on cubes after 7,14 days and 28 days of curing according to IS 516-1959. After removing the cubes from curing tank, they are allowed to surface dry for an half an hour. The weight of cubes were noted.

Down and then placed in the loading platform of compression testing machine and load is gradually applied over the cube until it fails then the failure load is recorded. The compression test is shown in the Fig. 5.2. Load by cross sectional area of specimen gives the compressive strength. The compressive strength of cubes can be calculated by the Eq. (2)

Compressive strength= P/A MPa ----- (2)

Where,

P= Load (in N)
A= Cross sectional area of cube (in mm)

SPLIT TENSILE TEST

The split tensile test of porous concrete was conducted on cylinders of 100mm diameter and 200mm height after 28 days of curing period. Test was performed according to the IS: 5816-1999.

PERMEABILITY TEST

Permeability is another important characteristic of porous concrete. In this experimental study 150mm cubical specimens were used to determine the permeability of each mixes. The test is carried out as mentioned in code IS: 3085-1965. The permeability is calculated by following relation (Eq. 7).

$$K = \frac{Q}{A\,T\,\frac{H}{L}} \qquad \text{-----(7)}$$

Where,

K = co-efficient of permeability in cm/sec
Q = quantity of water in 'ml' percolating over the entire period of test after the steady state has been reached
A = area of the specimen face in cm2
T = time in seconds over which Q is measured
H/L = ratio of the pressure head to thickness of specimen

V. RESULTS AND DISCUSSIONS

GENERAL

This chapter gives the test results obtained by several test conducted on the concrete mix at fresh and harden state and the discussion is made based on the results obtained.

SLUMP CONE TEST

For each mix slump value was recorded after the mixing of concrete is done. Slump recorded for each mix are shown in the Table 6.1. The slump higher value of 120mm was obtained for M-1, M-2, and M-3 mixes, thereafter slump value of 60mm was obtained due to the replacement of 20mm down size coarse aggregate by 10mm down size.

Table 6.1: Slump values

Sl. no.	Mix designation	Slump (mm)
1	M-1	180
2	M-2	160
3	M-3	155
4	M-4	145
5	M-5	120
6	M-6	100

DENSITY

Density of normal concrete is 2400 kg/m3. Density of concrete depends upon the grading of aggregates, air entrapped, water cement ratio, mixing of concrete and degree of compaction achieved. The density of concrete affects the strength. Table 6.2 gives the 28 days density of concrete cubes. It is observed that the density of porous concrete decreases gradually for increase in the size of fine aggregate(10mm). The decrease in density of porous concrete is 10.9% when compared to that of control mix concrete. The density of different mixes is given in Table 6.2. The gradual reduction in the density of various concrete mixes is shown in the Fig 6.2.

Table 6.2: Density of Porous Concrete Cubes

Sl. no.	Mix designation	Density (kg/m^3)
1	M-1	2210
2	M-2	2260
3	M-3	2300
4	M-4	2275
5	M-5	2290
6	M-6	2320

COMPRESSIVE STRENGTH

Compressive strength results for various mixes of porous concrete are tabulated for curing periods of 7,14 days and 28 days. The porous concrete mix shows lesser compressive strength when compared to control mix.

SPLIT TENSILE STRENGTH

The split tensile strength obtained for different mixes are tabulated in table 6.4 for a curing period of 7,14 and 28 days. The reduction of 32% split tensile strength of porous concrete can be observed when compared to control mix concrete.

VI. CONCLUSION

This project gives brief idea of performance of porous concrete in various concrete flat work applications. Based on the results obtained from the tested specimens the following conclusions are drawn.

a. The compressive strength of porous concrete decreases gradually upto 11.2MPa which is sufficient for flat work applications like pedestrian walk way, residential streets, pavements with light traffic loads etc.

b. The decrease in compressive strength of porous concrete is mainly due to the increase in voids.

c. The maximum strength is obtained for M-6 mix, the increase in FA size(10mm) and replacement of FA by CA considerably reduces the strength of porous concrete.

d. It is more economical as compare to normal concrete. And optimize the sand also reduced the cost of pervious concrete.

e. Pervious concrete faction like a storm water retention basin and allows the storm water to infiltrate to soil over a large area.

f. The compressive strength of pervious concrete is 28.4 MPa. It is suitable for pedestrian walkways, footpaths and parking lots ,because of low strength of concerete.

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