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An EXPERIMENTAL STUDY ON THE DURABILITY CHARACTERISTICS OF PERVIOUS CONCRETE

S. Deepa shri, N. Mohanraj and C. Krishnaraj
Faculty of Engineering, Karpagam College of Engineering, Coimbatore, India
E-Mail: ais.deepa@gmail.com

ABSTRACT

Pervious concrete or enhanced porosity concrete has a strictly gap graded coarse aggregate phase and little or no fine aggregates so as to facilitate the formation of an interconnected network of pores in the material. The material is designed with cementations material content just enough to coat the coarse aggregate particles so that a configuration that allows the passage of water at a much higher rate than conventional concrete. The pervious concrete has main advantages that improves city environment, recharge the ground by rain water and could be used as pavement for light vehicles, pedestrian pathways, parking lots, also it reduces the tire pavement interaction noise etc, the effectiveness of a pervious concrete pavement depends as the intrinsic permeability of the mass, and normally this is defined by the porosity. This paper presents a new method for determining the permeability or pervious concrete and provides design methodology to prepare pervious concrete based on experimental test values of pervious concretes.

Keywords: pervious concrete, porous concrete, no fines concrete, sandless concrete.

INTRODUCTION

Concrete is a construction material composed of cement, commonly Portland cement as well as other cementations materials such as fly ash and slag cement, coarse aggregate, fine aggregate such as sand, water, and chemical admixtures. Porous concrete is concrete which is designed to have many voids to trap water and allow it to penetrate through the concrete to the ground below. This concrete does not use fine aggregates in the mixture. Thats why it has more voids than conventional concrete. The materials used in making pervious concrete are coarse aggregates; cements and water thus totally eliminate the use of fine aggregates. There are a number of alternate names for porous concrete including permeable concrete, porous pavement, and pervious concrete. All of the names basically mean the same thing which is porous concrete. Porous concrete is made by mixing large aggregate material with mortar, creating lots of voids in the cast concrete. When water lands on the concrete, it flows through the voids and go to the ground below. Pervious concrete is an important application for sustainable construction.

There search on pervious pavement materials has Begun in developed countries such as the US and Japan since 1980s. However, the strength of the material is relatively low because of its porosity. The compressive Strength of the material can only reach about20–35 MPa. Such materials cannot be used as pavement due to low strength. The pervious concrete can only be applied To squares, footpaths, parking lots, and paths in parks .Using selected aggregates, fine mineral admixtures, and organic intensifiers and by adjusting the concrete mix Proportion, strength, and durability can improve the pervious concrete greatly. This project work was carried out to evaluate the performance of different pervious concrete mixtures to achieve an adequate strength and permeability. An attempt has done to use fly ash and GGBS as an admixture for evaluating the strength and durability of pervious concrete.

ASPECTS ON MIX DESIGN

Pervious concrete uses the same materials as conventional concrete, except that there is usually little or no fine aggregate. The quantity, proportions, and mixing techniques affect many properties of pervious concrete, in particular the voids structure and strength. Usually single sized coarse aggregate up to 20 mm size aggregates provides smoother surface that may be better suited for some application such as pedestrian pathways. Although the coarse aggregate size 6mm to 20mm are used, the most common being 12mm fairly uniform size is used. The aggregates may be rounded like gravel or angular like crushed stone.

Since the pervious concrete is highly permeable, the voids between aggregate particles cannot be entirely filled by cement paste. Use of smaller size aggregate can increase the number of aggregate particles per unit volume of concrete. As the aggregate particle increase the specific surface and thus increases the binding area. This result in the improved strength of pervious concrete.

A water-to-cementing material (W/CM) ratio of 0.35 was generall used; the absorption and moisture content of the aggregate on the day of mixing were determined and used to correct the mixing water.

Table-1. Typical range of materials used in pervious concrete [2].

Materials	**Proportions** (kg/ m^3)
Cemetious material	270-415
Coarse aggregate	1190-1480
w/c ratio	0.27-0.34

The binder normally used in Portland cement (OPC). Pozzolanic materials like fly ash, blast furnace slag and slica fume can also be used. Addition of fine aggregate will reduces the porosity and increase the strength of the concrete. The vibration impact must be kept as low as possible for sealing the surfaces from practical point of view.

Figure-1. Shows the cast specimen of pervious concrete.

Materials used

Six different pervious concretes were prepared as indicated in Table-2. The ordinary Portland cement (OPC) make conforming to IS8112, 43 grades was used. The coarse aggregate used was crushed, angular blue metal of uniform sizes namely 12mm, 20 mm. No grading of coarse aggregate adopted and no fine aggregate was used, because these factors will increase the strength of concrete and reduces the porosity of concrete drastically. Ordinary tap water was used from mixing. No chemicals admixtures used in this study. The water to cement ratio was kept constant for all the mix proportions as 0.35.

Table-2. Mix proportions of pervious concrete used.

Mix	**OPC** (Kg/m^3)	**Coarse aggregate** (kg/m^3)	**Fly ash** (kg/m^3)	**GGBS** (Kg/m^3)
12mm aggregate				
1	400	1200	0	0
2	320	1200	80	0
3	320	1200	0	80
20mm aggregate				
4	400	1200	0	0
5	320	1200	80	0
6	320	1200	0	80

EXPERIMENTAL

Pervious concretes designed and proportioned in the laboratory were cast into 150 x 150 x 150 mm cubes for the determination of cube compressive strength under uniaxial compression testing machine. Specimen of size 100 x 100 x 500 mm long beam was cast to find out the flexural tensile strength of the pervious concretes. Cylindrical specimens of size 100 mm diameters x 100 mm long were used for the determination of hydraulic conductivity (permeability) of pervious concretes. Cylinder 150 mm diameter x 300 mm long for the determination of compressive strength split tensile strength, and the relationship for cube and cylinder compressive strengths.

Table-3. Properties of pervious concretes.

MIX	**Cube compressive strength** (MPa)	**Hydraulic conductivity** (m/s)
1	35.33	0.0092
2	38	0.0070
3	33.33	0.0041
4	32.67	0.0149
5	33.55	0.0085
6	31.55	0.0066

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Measurement of hydraulic conductivity (permeability):

As it has been stated that the pervious concrete has a large inter connected pore network, and hence the conventional method used for evaluating hydraulic conductivity of normal concrete is not applicable.

Therefore to evaluate or to estimate the hydraulic conductivity of pervious concrete, a falling head permeability test apparatus has been fabricated as shown in the Figure-2 and Figure-3. The way by which the water gets percolated through pervious concrete when poured from top is shown in Figure-4.

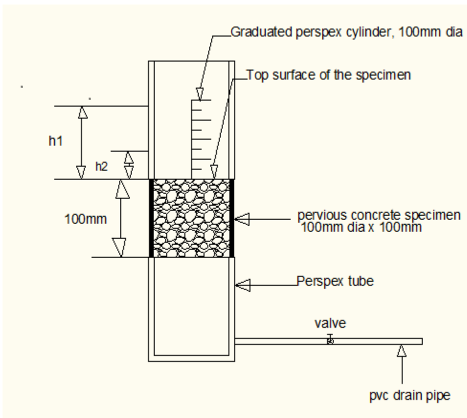

Figure-2. Falling head permeability test setup.

Figure-3. Falling head permeability test setup.

Figure-4. Percolation of water through pervious concrete.

The pervious concrete of cylindrical specimen size 100 mm diameter and 100 mm long is placed in between Perspex tube and another graduated Perspex tube as shown in Figure-2. The dimensions of the tubes and the placement of drain pipe are as shown in figure. The specimen to be tested is clamped tightly so that only vertical flow takes place. The graduated top cylinder is used to monitor the water level during the test. The water is added to the graduated cylinder kept at the top of the specimen to fill up specimen and drain pipe.

This eliminates any air pockets in the specimen, and ensures that the specimen is completely saturated. By closing the valve in the drain pipe, the graduated Perspex cylinder is filled with water. The valve is then opened, and the time taken for the water to fall from the initial head to a final head (h1 to h2) is measured in seconds (t). This procedure is repeated for three times, and an average value of t is taken. According to Darcys law, the coefficient of permeability (K) is calculated as:

$$K = \{(A1 \times l) / (A2 \times t)\} \times \log(h1 / h2)$$

Where l is the length of the specimen, the cross sectional area of specimen is A1 and that of drain pipe A2,. The measured hydraulic conductivity is shown in Table-3.

RESULT AND DISCUSSION

Six types of pervious concrete were prepared with various size of coarse aggregate and replacement of cement with fly ash and GGBS are used. From the result shown in Table-3, it is clearly concluded that as the coarse aggregate size increases, the compressive strength of the material decreases. The hydraulic conductivity of the material (K) increases with increase in size of coarse aggregate. This can be attributed to the facts that these pores are well connected since there is no sand. The reason for increase in porosity with increase in coarse aggregate is poor packing density and higher pore sizes. The strength of pervious concrete can be improved by the replacement of cement with 20 percentage of fly ash but permeability has been reduced. In case the replacement of cement with 20 percentages of GGBS the strength and permeability both have been reduced in pervious concrete.

CONCLUSIONS

From the results obtained, the following conclusions may be drawn:

- Cube compressive strength of pervious concrete drops down as the size of coarse aggregate is increased.
- Due to voids in pervious concrete, it is difficult to
- Obtain high-strength by using the common material and proportion of mixture.
- The hydraulic conductivity increases as the size of coarse aggregate is increased.
- Replacement of fly ash will improve the mechanical strengths but at the same time the hydraulic conductivity will be reduced.

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- Replacement of GGBS will not give any improvement in the mechanical strengths and at the same time the hydraulic conductivity will be reduced.

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