PERVIOUS CONCRETE

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Abstract

Pervious concrete is a tailored-property concrete with high water permeability which allow the passage of water to flow through easily through the existing interconnected large pore structure. This paper reports the results of an experimental investigation into the development of pervious concrete with reduced cement content and recycled concrete aggregate for sustainable permeable pavement construction. High fineness ground granulated blast furnace slag was used to replace up to 70 % cement by weight. The properties of the pervious concrete were evaluated by determining the compressive strength at 7 and 28 days, void content and water permeability under falling head. The compressive strength of pervious concrete increased with a reduction in the maximum aggregate size from 20 to 13 mm. The relationship between 28-day compressive strength and porosity for pervious concrete was adversely affected by the use of recycled concrete aggregate instead of natural aggregate.

However, the binder materials type, age, aggregate size and test specimen shape had marginal effect on the strength–porosity relationship. The results also showed that the water permeability of pervious concrete is primarily influenced by the porosity and not affected by the use of recycled concrete aggregate in place of natural aggregate. The empirical inter-relationships developed among porosity, compressive strength and water permeability could be used in the mix design of pervious concrete with either natural or recycled concrete aggregates to meet the specification requirements of compressive strength and water permeability.

In recent times, major cities around the world have experienced frequent flooding due to the combination of increased rainfall and reduced in permeable surface areas. With the increasing amount of built infrastructures such as residential and commercial buildings and decreasing permeable unpaved open areas, the stormwater runoff is rapidly increased. As a consequence, the drainage system gets overloaded and flash flooding becomes inevitable, thus causing disruption to the road transport and flooding of basement car parks and shopping centres. In order to manage the stormwater runoff in urban areas, an engineered solution is needed to avoid flash flooding.

With a combination of structural and hydrological design with the use of pervious concrete for pavement construction provided the best solution to stormwater management, as recognized by the US Environmental Protection Agency (Storm water management handbook, US Environmental Protection Authority 2009

Pervious concrete system has advantages over impervious concrete in that it is effective in managing run-off from paved surfaces, prevent contamination in run-off water, and recharge aquifer, *repelling salt water intrusion, control pollution in water seepage to ground water recharge thus, preventing subterranean storm water sewer drains, absorbs less heat than regular concrete and asphalt, reduces the need for air conditioning. 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 rechargebed will be installed at the beginning of construction, enhancing erosion control measures and preventing rain delays due to harsh site conditions.*

HYPOTHESIS

The basic scientific and engineering principle involved is hydrological cycle,water management and concrete technology.

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 protecting the surface of the pavement and its environment.

PREPARATION OF PERVIOUS CONCRETE

CONSTITUENTS OF CONCRETE

If a constituent is to be suitable for a particular purpose, it is necessary to select the constituent materials and combine them in such a manner as to develop the special qualities required as economical as possible. The selection of materials and choice of method of construction is not easy, since many variables affect the quality of the concrete produced, and both quality and economy must be considered. The characteristics of concrete should be evaluated in relation to the required quality for any given construction purpose.

1.CEMENT

Ordinary Portland cement, 53 grade conforming to IS: 269 – 1976. Ordinary Portland cement, 53 grade was used for casting all the specimens. Different types of cement also will produce concrete have a different rates of strength development. The choice of brand and type of cement is the most important to produce a good quality of concrete. The type of cement affects the rate of hydration, so that the strengths at early ages can be considerably influenced by the particular cement used.

2.COARSE AGGREGATE

Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS: 383-1970. Several investigations concluded that maximum size of coarse aggregate should be restricted in strength of the composite. In addition to cement paste – aggregate ratio, aggregate type has a great influence on concrete dimensional stability.

3.WATER

Casting and curing of specimens were done with the portable water which is available.

STRUCTURAL PERFORMANCE OF PERVIOUS CONCRETE

For the evaluation of the structural performance of the pervious concrete in civil engineering construction, the effects of varying the aggregate size on thecompressive strength and permeability and durability of pervious concrete were studied. This study covers the simple use of pervious concrete as pavement material in the construction of pedestrian walkways and parking lots.

PREPARATION OF TEST SPECIMEN

Three batches of test specimen were produced from each of the aggregate size representing aggregate cement ratios of 6:1, 8:1 and 10:1 with no fines in the mixes. The materials were batched by weight as in Table3.1. As earlier stated, two different sizes of coarse aggregate (crushed stone or granite) were used in this study. The sizes are 3/8-inch (9.375mm) and 3/4-inch (18.75mm) granite. The specific gravity test carried out on the two aggregate sizes gave average value of 2.7. For the two aggregate sizes, the mix proportions were done by weight. From each of the batches, 8 of 150mm concrete cubes were taken. The mix proportioning are as shown in Table 3.1.

Table 3.1 Mix Proportion by Weight of Aggregate and Cement

Ratio	Weight of aggregate(kg)	Weight of cement (kg)	Volume produced (m^3)
6:1	37.5	6.25	0.0025
8:1	50.0	6.25	0.029
10:1	62.5	6.25	0.033

The batched materials are thoroughly hand-mixed with water so as to obtain uniform and homogenous pervious concrete. Water/cement ratio of 0.4 was added to form a cement paste, ACI 211.3R (2002) stipulates that the ratio should be between 0.35 and 0.45. A total of 24 cubes were produced for each aggregate size for different mix ratio of 6:1, 8:1 and 10:1 of coarse aggregate and cement.

COMPRESSIVE STRENGTH TEST

The aim of the test is to determine the compressive strength of pervious concrete. The test was carried out in accordance with BS1881-108: 1983 and ACI 522R-10. The cubes were tested for compressive strength (Fig 3.2) at specify ages of 7, 14, 21 and 28 days of curing. The compressive strength of pervious concrete is calculated thus:

Compressive strength = (crushing load, kN)/(area of cross section, m2)

PERMEABILITY TEST

The permeability of pervious concrete was determined using a falling head permeability set up Fig 3.6. Water was allowed to flow through the sample, through a connected standpipe which provides the water head. Before starting the flow measurement, the samples were wrapped with polythene inside the cylinder. Then the test started by allowing water to flow through the sample until the water in the standpipe reached a given lower level. A constant time of 5 sec was taken for the water to fall from one head to another in the standpipe. The standpipe was refilled and the test was repeated when water reached a lower level as shown in Fig 3.6. The permeability of the pervious concrete sample was evaluated from the expression given below:

$$K = 2.303\, {aL}/{A}(t_2 - t_1)\log\left({h_1}/{h_2}\right).$$

Where,

a = the sample cross section area

A = the cross section of the standpipe of diameter (d) = 0.95cm2

L = the height of the pervious concrete sample

(t2- t1) = change in time for water to fall from one level to another (5secs.)

h1= upper water level

h2= Lower water level

D= diameter of sample (10.5 cm)

d= diameter of standpipe (1.1 cm)

CONSTRUCTION OF PERVIOUS PAVEMENT

As with any pavement, proper subgrade preparation is important. The subgrade should be properly compacted to provide a uniform and stable surface. It is important to examine carefully the soils present on each project for both structural and drainage capacities before specifying a compaction range since soils differ in the way *compaction* affects infiltration rate. The level of compaction

is typically 90% of Standard Proctor Maximum Dry Density (SPMDD). In some cases, pavement will be placed on a sub base of clean gravel or crushed stone, which may be used as a storm water storage basin. Proper curing is essential to the structural integrity of a pervious concrete pavement. The open structure and relatively rough surface of pervious concrete exposes more surface area of cement paste to evaporation, making curing even more essential than in conventional concreting. Curing ensures sufficient hydration of the cement paste to provide the necessary strength in the pavement section to prevent raveling. Curing should begin within 20 minutes after final consolidation and continue through 7 days. Plastic sheeting is typically used to cure pervious concrete pavements.

CONCLUSION

Pervious concrete is a cost-effective and environmental friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground waterwhile reducing storm *water runoff enables pervious concrete play a significant role. Due to its potential to reduce the runoff, it is commonly used as pavement material. The smaller the size of coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate. The mixtures with higher aggregate/cement ratio 8:1 and 10:1 are considered to be useful for a pavement that requires low compressive strength and high permeability rate. The ideal pervious concrete mix is expected to provide the maximum compressive strength, and the optimal infiltration rate.*