

Efficient working of road side drains for stormwater management using pervious concrete

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ABSTRACT

Pervious concrete is a very special type of concrete with high porosity used for flat work application basically that's allow water from precipitation and other sources to pass directly through thereby reducing the runoff from the site and allowing ground water recharge. And in this concrete porosity is attain by a highly interconnected void content. Also in permeable or pervious concrete has no fine aggregate and has just enough cementing paste to coarse aggregate particles while preserving the interconnectivity of the voids .permeable or pervious concrete is traditionally used in parking area with lo traffic ,walkways in park and garden residential , green house, basketball court , volleyball house .Main objective of pervious concrete are :-

1. To help restore ground water supply.
2. Reduce pollution of coastal water;
3. To pave parking, Recharge ground water table.
4. Reduces runoff water
5. Reduces risk of flooding and topsoil wash away.

Key Words: No fine aggregates , permeable, runoff ,pave parking, ground water, interconnectivity etc.

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I. INTRODUCTION

Pervious concrete is also a unique and effective means to address important environmental issues and sustainable growth. When it rains, pervious concrete automatically acts as a drainage system, thereby putting water back where it belongs. Pervious concrete is rough textured, and has a honeycombed surface, with moderate amount of surface raveling which occurs on heavily travelled roadways (Concrete network, 2009). Carefully controlled amount of water and cementitious materials are used to create a paste (Dan, 2003). The paste then forms a thick coating around aggregate particles, to prevent the flowing off of 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 the

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 a very high permeable concrete that drains quickly.

Pervious concrete can be used in a wide range of applications, although its primary use is in pavements which are in: residential 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.

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.

II. PROBLEM STATEMENT

It is somewhat of a balancing act to develop a pervious concrete mix that places easily, performs well, and has good durability.

Generally problems with pervious concrete mixtures are related to water content, mixture proportions, or admixture dosing. Some material-related issues can be remediated by changing construction practices, but this article only covers suggested changes from the concrete producer's perspective.

1. This recent interest in porous surfaces as a substitution for impervious surfaces can be attributed to desirable benefits such as storm water retention, which includes storm water treatment.
2. Increased regulations for storm water management, there has been a need for pavements that minimize surface runoff.

III. MATERIALS USED

Constituents of concrete

If a concrete 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. The closest practicable approach to perfection in every property of the concrete would result in poor economy under many conditions, and the most desirable structure is that in which the concrete has been designed with the correct emphasis on each of the various properties of the concrete, and not solely with a view to obtaining of maximum possible strength.

Cement

Cement is a key to infrastructure industry and is used for various purposes and also made in many compositions for a wide variety of uses. Cements may be named after the principal constituents, after the intended purpose, after the object to which they are applied or after their characteristic property.

Cement used in construction are sometimes named after their commonly reported place of origin, such as Roman cement, or for their resemblance to other materials, such as Portland cement, which produces a concrete resembling the Portland stone used for building in Britain. The term cement

is derived from the Latin word *Caementum*, which is meant stone chippings such as used in Roman mortar not-the binding material itself. suppliers.

Aggregates

Aggregates were first considered to simply be filler for concrete to reduce the amount of cement required. However, it is now known that the type of aggregate used for concrete can have considerable effects on the plastic and hardened state properties of concrete. They can form 80% of the concrete mix so their properties are crucial to the properties of concrete.

Aggregates can be broadly classified into four different categories: these are heavyweight, normal weight, lightweight and ultra-lightweight aggregates. However in most concrete practices only normal weight and light weight aggregates are used. The other types of aggregates are for specialist uses, such as nuclear radiation shielding provided by heavy weight concrete and thermal insulation using lightweight concrete.

Classification of aggregates

The alternative used in the manufacture of good quality concrete, is to obtain the aggregate in at least two size groups, i.e.:

1. fine aggregate often called sand not larger than 5mm in size.
2. course aggregate, which comprises material at least 5mm in size.

On the other hand, there are some properties possessed by the aggregate but absent in the parent rock: particle shape and size, surface texture, and absorption. All these properties have a considerable influence on the quality of the concrete, either in fresh or in the hardened state. It has been found that aggregate may appear to be unsatisfactory on some count but no trouble need be experienced when it is used in concrete

Aggregate properties

By selecting different sizes and types of aggregates and different ratios of aggregate to cement ratios, a wide range of concrete can be produced economically to suit different requirements. Important properties of an aggregate which affect the performance of a concrete are discussed as follows:

Sampling

Samples shall be representative and certain precautions in sampling have to be made. No detailed procedures can be laid down as the conditions and situations involved in taking samples in the field can vary widely from case to case. Nevertheless, a practitioner can obtain reliable results bearing in mind that the sample taken is to be representative of the bulk of the material. The main sample shall be made up of portions drawn from different parts of the whole. The minimum number of these portions. In the case of stockpiles, the sample obtained is variable or segregated, a large number of increments should be taken and a larger sample should be dispatched for testing.

Particle shape and texture

Roundness measures the relative sharpness or angularity of the edges and corners of a particle. Roundness is controlled largely by the strength and abrasion resistance of the parent rock and by the amount of wear to which the particle has been subjected. In the case of crushed aggregate, the particle shape depends not only on the nature of the parent rock but also on the type of crusher and its reduction ratio, i.e. the ratio of the size of material fed into the crusher to the size of the finished product. Particles with a high ratio of surface area to volume are also of particular interest for a given workability of the control mix. Elongated and flaky particles are departed from equi-dimensional shape of particles and have a larger surface area and pack in an isotropic manner. Flaky particles affect the durability of concrete, as the particles tend to be oriented in one plane, with bleeding water and air voids forming underneath. The flakiness and elongation tests are useful for general assessment of aggregate but they do not adequately describe the particle shape. The presence of elongated particles in excess of 10 to 15% of the mass of coarse aggregate is generally undesirable, but no recognized limits are laid down. Surface texture of the aggregate affects its bond to the cement paste and also influences the water demand of the mix, especially in the case of fine aggregate. The shape and surface texture of aggregate influence considerably the strength of concrete. The effects of shape and texture are particularly significant in the case of high strength concrete.

The full role of shape and texture of aggregate in the development of concrete strength is not known, but possibly a rougher texture results in a larger adhesive force between the particles and the cement matrix. Likewise, the larger surface area of angular aggregate means that a larger adhesive force can be developed.

The shape and texture of fine aggregate have a significant effect on the water requirement of the mix made with the given aggregate. If these properties of fine aggregate are expressed indirectly by its packing, i.e. by the percentage voids in a loose condition, then the influence on the water requirement is quite definite. The influence of the voids in coarse aggregate is less definite. Flakiness and shape of coarse aggregates have an appreciable effect on the workability of concrete.

Bond of aggregate

Bond between aggregate and cement paste is an important factor in the strength of concrete, but the nature of bond is not fully understood. Bond is to the interlocking of the aggregate and the hydrated cement paste due to the roughness of the surface of the former. A rougher surface, such as that of crushed particles, results in a better bond due to mechanical interlocking; better bond is not usually obtained with softer, porous, and minor logically heterogeneous particles. Bond is affected by the physical and chemical properties of aggregate. For good development of bond, it is necessary that the aggregate surface be clean and free from adhering clay particles. The determination of the quality of bond of aggregate is difficult and no accepted tests exist. Generally, when bond is good, a crushed specimen of normal strength concrete should contain some aggregate particles broken right through, in addition to the more numerous ones pulled out from their

sockets. An excess of fractured particles, might suggest that the aggregate is too weak.

Strength of aggregate

The compressive strength of concrete cannot significantly exceed that of the major part of the aggregate contained. If the aggregate under test leads to a lower compressive strength of concrete, and in particular if numerous individual aggregate particles appear fractured after the concrete specimen has been crushed, then the strength of the aggregate is lower than the nominal compressive strength of the concrete mix. Such aggregate can be used only in a concrete of lower strength.

The influence of aggregate on the strength of concrete is not only due to the mechanical strength of the aggregate but also, to a considerable degree, to its absorption and bond characteristics. In general, the strength of aggregate depends on its composition, texture and structure. Thus a low strength may be due to the weakness of constituent grains or the grains may be strong but not well knit or cemented together.

A test to measure the compressive strength of prepared rock cylinders used to be prescribed. However, the results of such a test are affected by the presence of planes of weakness in the rock that may not be significant once the rock has been comminuted to the size used in concrete. In essence the crushing strength test measures the quality of the parent rock rather than the quality of the aggregate as used in concrete. For this reason the test is rarely used. Crushing value test BS 812: part 105:1990, measures the resistance to pulverization. The crushing value is a useful guide when dealing with aggregates of unknown performance, when lower strength may be suspected. There is no obvious physical relation between this crushing value and the compressive strength, but the results of the two tests are usually in agreement.

Deleterious substances of aggregate

For satisfactory performance, concrete aggregates should be free of deleterious materials. There are three categories of deleterious substances that may be found in aggregates: impurities, coatings and weak or unsound particles.

Grading of fine and coarse aggregate

The actual grading requirements depend on the shape and surface characteristics of the particles. For instance, sharp angular particles with rough surfaces should have a slightly finer grading in order to reduce the possibility of interlocking and to compensate for the high friction between the particles

Maximum aggregate size

Extending the grading of aggregate to a larger maximum size lowers the water requirement of the mix, so that, for a specified workability and cement content, the water /cement ratio can be lowered with a consequent increase in strength. Experimental results indicated that above the 38 mm maximum size the gain in strength due to the reduced water requirement is offset by the detrimental effects of lower bond area (so that volume changes in the paste cause larger stresses at interfaces) and of discontinuities introduced by the very large particles. In structural concrete of usual

proportions, there is no advantage in using aggregate with a maximum size greater than about 25 or 40mm when compressive strength is a criterion.

Water

Water is a key ingredient in the manufacture of concrete. Water used in concrete mixes has two functions: the first is to react chemically with the cement, which will finally set and harden, and the second function is to lubricate all other materials and make the concrete workable. Although it is an important ingredient of concrete, it has little to do with the quality of concrete. One of the most common causes of poor-quality concrete is the use of too much mixing water. Fundamentally “the strength of concrete is governed by the nature of the weight of water to the weight of cement in a mix, provided that it is plastic and workable, fully compacted, and adequately cured”.

IV. PREPARATION OF CUBE SPECIMN

The proportion and material for making these test specimens are from the same concrete used in the field.

Mixing

Mix the concrete either by hand or in a laboratory batch mixer

1. Mix the cement and fine aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform colour
2. Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch
3. Add water and mix it until the concrete appears to be homogeneous and of the desired consistency



Figure: Mixing of pervious concrete



Figure : Prepared mix

Sampling

1. Clean the moulds and apply grease.
2. Fill the concrete in the moulds in 3 equal layers
3. Compact each layer with not less than 35 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)
4. Level the top surface and smoothen it with a trowel

Curing

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

Procedure:

1. Remove the specimen from water after specified curing time and wipe out excess water from the surface.
2. Take the dimension of the specimen to the nearest 0.2m
3. Clean the bearing surface of the testing machine
4. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
5. Align the specimen centrally on the base plate of the machine.
6. Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
7. Apply the load gradually without shock and continuously at the rate of 140kg/cm²/minute till the specimen fails
8. Record the maximum load and note any unusual features in the type of failure.

Table : Compressive strength of concrete at various ages

Age	Strength per cent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE:

In the laboratory, pervious concrete mixtures have been found to develop compressive strengths in the range of 3.5 MPa to 28 MPa, which is suitable for a wide range of applications. Typical values are about 17 MPa. As with any concrete, the properties and combinations of specific materials, as well as placement techniques and environmental conditions, will dictate the actual in-place

strength. However, currently there is no ASTM test standard for compressive strength of pervious concrete. Testing variability measured with various draft test methods has been found to be high and therefore compressive strength is not recommended as an acceptance criterion. Rather, it is recommended that a target void content (between 15% to 25%) as measured by ASTM C 1688: Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete be specified for quality assurance and acceptance.



Figure : Cubes for compressive strength testing

DENSITY AND POROSITY:

The density of pervious concrete depends on the properties and proportions of the materials used, and on the compaction procedures used in placement. In-place densities on the order of 1600 kg/m³ to 2100 kg/m³ are common, which is in the upper range of lightweight concretes. A pavement 125 mm thick with 20% voids will be able to store 25 mm of a sustained rainstorm in its voids, which covers the vast majority of rainfall events in the U.S.

PERMEABILITY OF PERVIOUS CONCRETE:

The permeability of pervious concrete was determined using a falling head permeability set up. 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 5seconds 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. The permeability of the pervious concrete sample was evaluated from the expression given below:

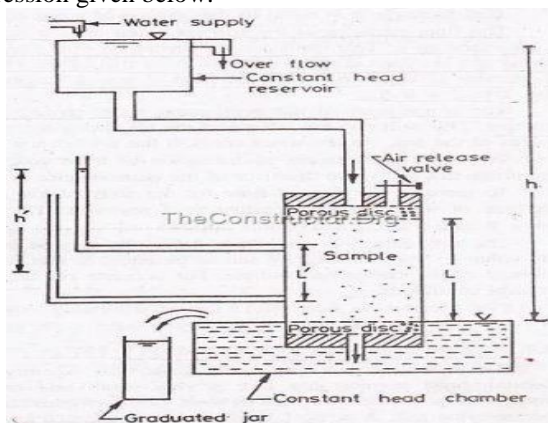


Figure : Variable head permeability test apparatus

Formula: $K=2.303 aL/A (t2-t1) \log (h1/h2)$

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

(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 (10.5cm)

d= diameter of standpipe (1.1cm)

Theoretically, the coefficient of permeability generally in the order of 1mm/sec for a void ratio of 20% and the rate of flow is in the range of 120 litres/min/m² to 200 litres/min/m²

V. EXPERIMENTAL VALUES

RESULTS OF EXPERIMENTS CONDUCTED ON MATERIALS

1. CEMENT (OPC 53 GRADE CEMENT)

- Specific gravity :3.02
- Fineness of cement :3.15
- Consistency :35%
- Initial setting time : 120min.

2. COARSE AGGREGATE

- Specific gravity :3.00
- Bulk density :1.50

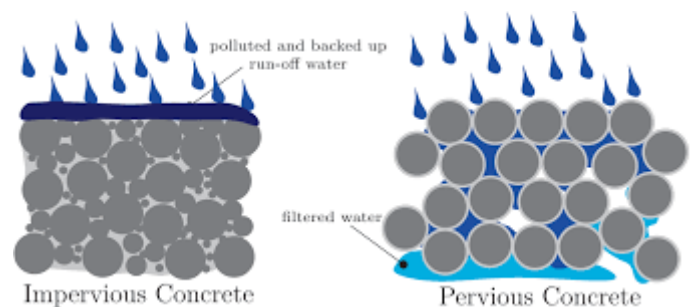
Compressive strength of 20mm aggregates size cubes

SR NO	AGE OF CONCRETE	COMPRESSIVE STRENGTH (MPA)
1	7 days	16.26
2	14 days	19.72
3	28 days	21.06

Water absorption and Porosity of cubes

Aggr. types	Water absorption after immersion (%)	Porosity (%)
	w/c-0.4	w/c-0.4
Cube-1	5.9	11.9
Cube -2	6.5	12.5
Cube -3	7.1	12.9

Table : Compressive strength, water absorption, and porosity of hardened concrete.





VI. SCOPE OF THE WORK

1. Pervious concrete can be used in building for rainwater harvesting as well as for cooling purpose by providing permeable wall.
2. In the presence of clayey soil, water can be percolated through providing borehole at every 1-2km with the help of drainage system.
3. Flaky aggregate can be used to provide easy passes of water without any extra drainage system provided. (Flaky aggregate have more strength).
4. Water can be filtered and stored as fresh water below the ground.
5. We can also give direction to water specifically according to need. By providing certain angle to the flaky aggregate water which gets drained will make its way to the slope going down towards the sewer line or any other drainage arrangement.

VII. MAINTENANCE

Prevent the surface from becoming clogged which reduce permeability. most site function well without regular maintenance if protected from sand. Vacuuming or power blowing may be necessary if the site become clogged.

Pressure washing has shown to improve permeability of clogged pavement to 80% to 90% of the original permeability.

The chance of clogging is highest during and just after construction and the site must be protected by an erosion control until vegetation has been established on the adjacent ground.

However pervious concrete work good in little or no maintenance but the main reason being debris and residue lodging on top of void structure maintenance is required.

Maintenance requirement cannot be determined because it changes with conditions and place to place and also on traffic condition.

VIII. LITERATURE REVIEW

In 2010, Omkar Deo, Narayanan Neithalath Studied that the properties of pervious concrete are strongly dependent on its pore structure features, porosity being an important

one among them. Several pervious concrete mixtures with different pore structure features are proportioned and subjected to static compression tests. The compressive stress-strain response of pervious concretes, a model to predict the stress-strain response and its relationship to several of the pore structure features are outlined. A statistical model was used to relate the compressive strength to the relevant pore structure features. It was observed that a proper understanding of the influence of pore structure features on compressive response can lead to optimized material design for the desired properties.

In 2003, Jing Yang and Guoliang Jiang

Studied that by using the common material and method, the strength of the pervious concrete is low. But using smaller aggregate, silica fume and super plasticizer in the previous concrete strength can be increased greatly. Also by increasing the cement paste binder area and enhancing the strength of cement binder pervious concrete strength can also be increased. The pervious pavement materials that composed of a surface layer and a base layer were made. The compressive strength of the pervious concrete can reach 50 MPa and the flexural strength 6MPa.

In 2004, D. Tennis Paul et. al.

Studied the replicated samples of pervious concrete formed from two rock sources for coarse aggregates and different size fractions to determine hydrologic relationships. Linear relationships were found between density and porosity, density and permeability, porosity and permeability, porosity and specific yield. The results suggest that properties such as permeability, porosity and specific yield are not significantly affected by different aggregate types.

In 2006 Luck J.D., Workman S.R.

They conducted laboratory study to evaluate the properties of high performance porous concrete. They used optimum mixture proportions in the preparation of high performance porous concretes containing three sizes of coarse aggregates with appropriate amount of high water-reducing and thickening agents. Its strength development rate was also examined at curing age 1, 3, 7, 14 and 28 days at 20o C and 60% relative humidity. Consequently high performance porous concrete exhibited good workability and cohesiveness with no segregation or bleeding and developed high strength compared to conventional porous concrete.

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