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Evaluation of Engineering properties of pervious concrete

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A B S T R A C T

Pervious concrete is a zero-slump, open graded material consisting of hydraulic cement, coarse aggregate, admixtures and water. Because pervious concrete contains little or no fine aggregates such as sand, it is sometimes referred to as "no-fines" concrete.When pervious concrete is used for paving, the open cell structures allow storm water to filter through the pavement and into the underlying soils. 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, and by suitable technique that includes installing a perforated heavy duty piping system beneath the concrete surface the water percolating through it can be transferred to a filtration system and that water can be used in various non drinking purposes like in construction, gardening, and even for bathing.

I. INTRODUCTION

Pervious Concrete is a homogeneous mixture of cement, aggregate / gravel and water. One of the new parameterin designing a structure is concrete durability when assessing the condition of existing structures. The concrete had a lesser compressive strength (5 to 20 mpa) than the traditional concrete and it was found that the filtration capacity is inversely proportional to the strength of the concrete.In order to provide stability to the system a system odf subgrade and reinforcement has to be provided. We know that mix design of conventional concrete is done as per the steps given in IS 10262:2009 [7]. The mix proportion for conventional concrete is 1:1.5:3 (M20). Based upon trial mixes the cement content of 375 kg/m3 was finalized. The mix proportion for pervious concrete is considered in the study was 1:4 with 0 % of fine aggregates. The size of course aggregate was taken as 50% 12.5 mm aggregates, 50% 10 mm aggregates so as to have sufficient voids. Water cement ratio of 0.3 was adopted for all the samples. The mixing of all ingredients is carried by tilting drum concrete mixer to ensure uniform mixing.

The filter had four layers with 6.3, 2.0, 1.18 mm sized, and powdered charcoal responsible for the filtration process, and it will be connected to the exit pipe installed under the concrete pavement and with the help of hydraulics the filter water will be stored in a tank and then can be used accordingly.It will show high odour, hardness, and chloride removal efficiencies. However, an increase in conductivity will be observed in the filtered samples which may be correlated to the ability of charcoal to enrich the water with elements like sodium and potassium. In addition to these the pH value of the sample before filtration was acidic (i.e5.7) but increased to 7.7 after filtration which is suitable for drinking water. Hence, it is recommended here that charcoal filters can be used to produce high-quality water.

(b)

Objectives of the Project:
The main objective of this project is to develop a strong and durable pervious cement concrete (pcc) mix.
In addition, it is also aimed to compare the properties of these pcc mixes.
When pervious concrete is used for paving, the open cell structures allow storm water to filter through the pavement and into the underlying soils.
Pervious concrete can be used in a wide range of applications, although its primary use is in pavements.
It can be done by suitable technique that includes installing a perforated heavy duty piping system beneath the concrete surface the water percolating through it can be transferred to a filtration system and that water can be used in various non drinking purposes like in construction, gardening, and even for bathing.

II. MATERIAL AND TEST METHODS:

Cement
OrdinaryPortlandcement53grade,asperIndianSpecificationswasusedforthisinvestigation.Thespecificgravityof OPCcement was 3.15. Other properties of OPC were tested as per IS 12269which includes fineness, soundness, initial setting time, final setting time, specific gravity and consistency.

Test name	**Value**	**Remarks**
Consistency test	28%	workable
Fineness test	7%	Good quality
Soundness test	1.4 mm	sound
Specific gravity	3.1g/cc	Good quality
Initial setting time	120min	More than standard
Final setting time	240min	More than standard

Aggregate
Locally available 4.75 mm–10 mm coarse aggregates were used. As per Indian Standard specifications mentioned in IS 383 , the testingofcoarseaggregateswasundertaken.Table representsthephysicalpropertiesofcoarseaggregatesthatwereusedforthe present investigation and testing was done according to IS 2386.

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Test name	Value	Remark
Sieve analysis	50.6%	Retained on 10mm sieve
Impact test	8.11	Exceptionally strong
Crushing test	25.6%	Within the limits
Specific gravity	2.66	Standard
Water absorption	.20%	Standard

Mixing Proportion for Experimental block:

Materials Pervious concrete uses the same materials as conventional concrete, with the exceptions that the fine aggregate typically is eliminated entirely, and the size distribution (grading) of the coarse aggregate is kept narrow, allowing for relatively little particle packing. This provides the useful hardened properties, but also results in a mix that requires different considerations in mixing, placing, compaction, and curing. The mixture proportions are somewhat less forgiving than conventional concrete mixtures.

* These proportions are given for information only. Successful mixture design will depend on properties of the particular materials used and must be tested in trial batches to establish proper proportions and determine expected behaviour.

*Admixtures. Chemical admixtures are used in pervious concrete to obtain special properties, as in conventional concrete. Because of the rapid setting time associated with pervious concrete, retarders or hydration-stabilizing admixtures are used commonly.

Material	Proportion
Cement	1.68kg
Aggregate	5.49kg
Water	759ml
Cement : aggregate	1:3
Water : cement	.45

TESTING AND RESULT OF CONVENTIONAL CONCRETE

Strength is the main property of concrete. Strength is defined as the ability of concrete to resist load. The hardened concrete should be therefore have sufficient strength to bear the load for which it is designed. The strength of hardened concrete mainly depends upon the water cement ratio, quality of water, quality of cement, degree of compaction and curing.

Compressive Strength:

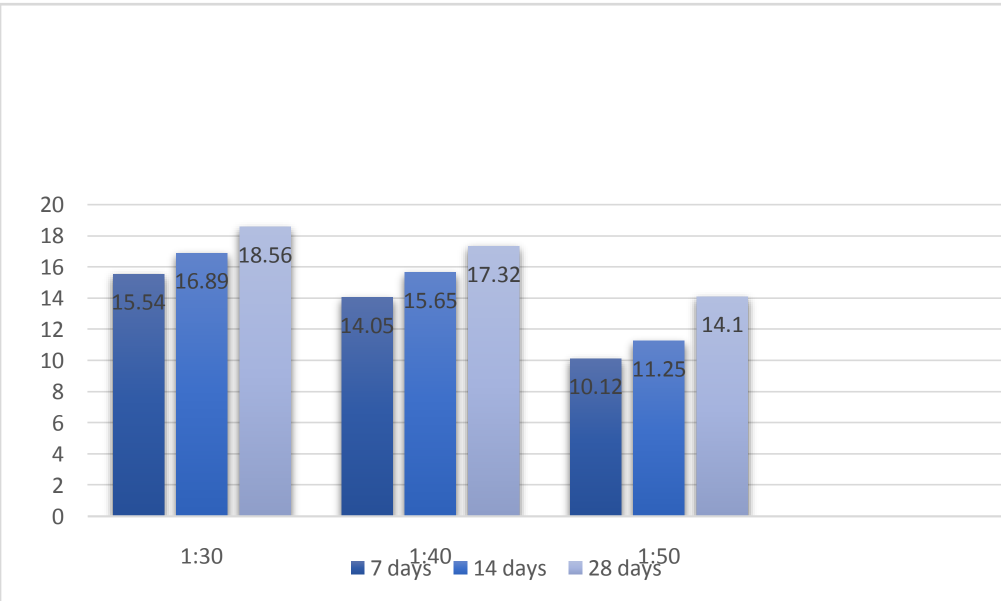
The most important property of concrete is its high compressive strength. The compressive strength is measured in N/mm2. Compressive Strength is influence by a number of factors, in addition to the water-cement ratio and degree of compaction, type of cement and its quality, texture of aggregates, curing method, temperature and the time of hardening.

Compressive Strength Test of Concrete Cubes:

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical moulds of size 15cm x 15cm x 15cm are commonly used.

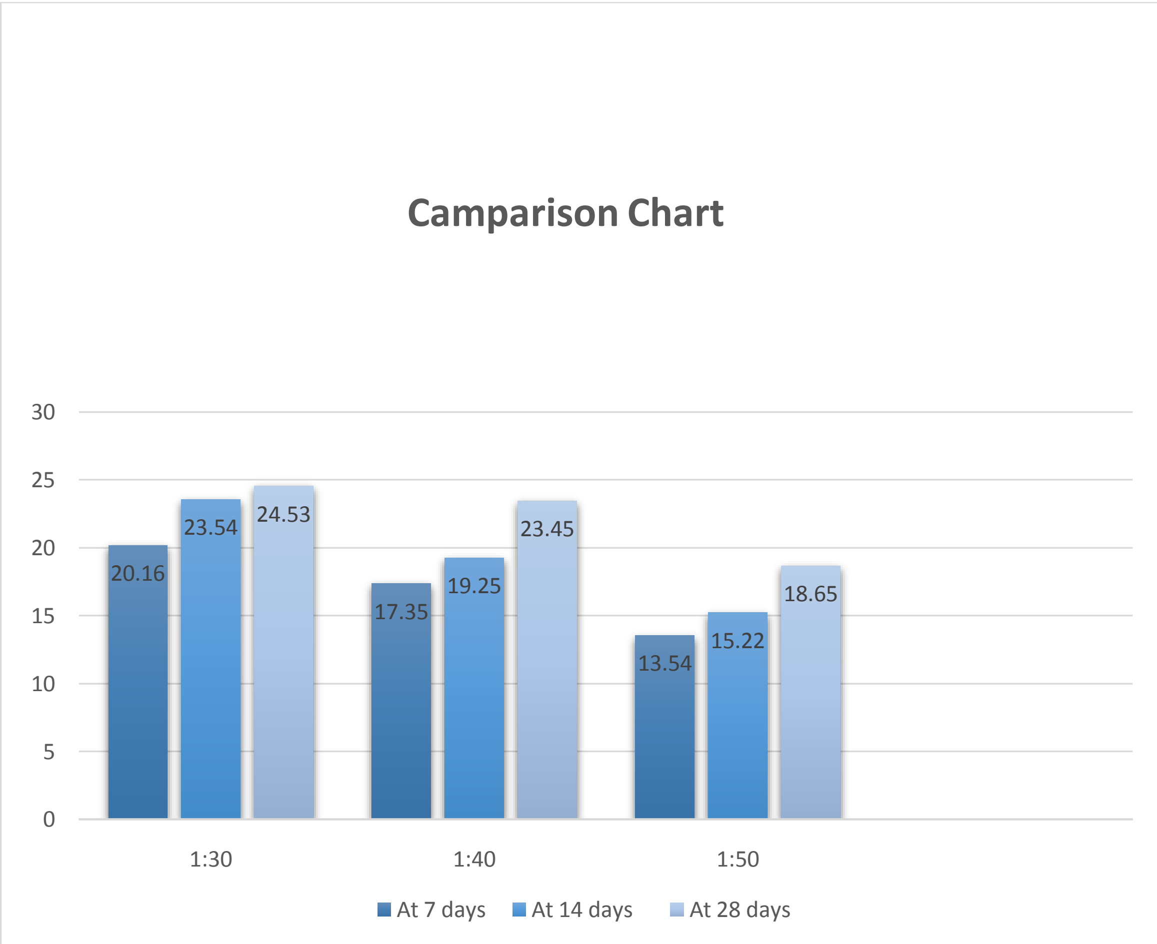
COMPRESSIVE STRENGTH OF PERVIOUS CONCRETE (CUBE)
As per IS code :516 (1959)

Ratio	Cube size mm^3	Strength after 7 days(N/mm^2)	Strength after 14 days(N/mm^2)	Strength after 28 days(N/mm^2)
1:3	150*150*150	20.16	23.54	24.53
1:4	150*150*150	17.35	19.25	23.45
1:5	150*150*150	13.54	15.22	18.65



Compressive Strength Of pervious concrete (Cylinder)
As per IS code :516 (1959)

Ratio	Dimension	Strength 7 days	Strength 14 days	Strength 28 days
1:3		15.54	16.89	18.56
1:4		14.05	15.65	17.32
1:5		10.12	11.25	14.10



Model Demonstration

Two factors determine the design thickness of pervious pavements: the hydraulic properties, such as permeability and volume of voids, and the mechanical properties, such as strength and stiffness. Pervious concrete used in pavement systems must be designed to support the intended traffic load and contribute positively to the sitespecific stormwater management strategy. The designer selects the appropriate material properties, the appropriate pavement thickness, and other characteristics needed to meet the hydrological requirements and anticipated traffic loads simultaneously. Separate analyses are required for both the hydraulic and the structural requirements, and the larger of the two values for pavement thickness will determine the final design thickness.

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Hydrological Design Considerations:

The design of a pervious concrete pavement must consider many factors. The three primary considerations are the amount of rainfall expected, pavement characteristics, and underlying soil properties. However, the controlling hydrological factor in designing a pervious concrete system is the intensity of surface runoff that can be tolerated. The amount of runoff is less than the total rainfall because a portion of the rain is captured in small depressions in the ground (depression storage), some infiltrates into the soil, and some is intercepted by the ground cover. Runoff also is a function of the soil properties, particularly the rate of infiltration: sandy, dry soils will take in water rapidly, while tight clays may absorb virtually no water during the time of interest for mitigating storm runoff.

Permeability:

In general, the concrete permeability limitation is not a critical design criteria. Consider a passive pervious concrete pavement system overlying a well-draining soil. Designers should ensure that permeability is sufficient to accommodate all rain falling on the surface of the pervious concrete. For example, with a permeability of 3.5 gal/ft2/min (140 L/m2/min), a rainfall in excess of 340 in./hr (0.24 cm/s) would be required before permeability becomes a limiting factor. The permeability of pervious concretes is not a practical controlling factor in design. However, the flow rate through the subgrade may be more restrictive (see discussion under “Subbase and Subgrade Soils”).

Storage capacity.

Storage capacity of a pervious concrete system typically is designed for specific rainfall events, which are dictated by local requirements. The total volume of rain is important, but the infiltration rate of the soil also must be considered. The total storage capacity of the pervious concrete system includes the capacity of the pervious concrete pavement, the capacity of any subbase used, and the amount of water which leaves the system by infiltration into the underlying soil.

The theoretical storage capacity of the pervious concrete is its effective porosity: that portion of the pervious concrete which can be filled with rain in service. If the pervious concrete has 15% effective porosity, then every 1 in. (25 mm) of pavement depth can hold 0.15 in. (4 mm) of rain. For example, a 4-in. (100-mm) thick pavement with 15% effective porosity on top of an impervious clay could hold up to 0.6 in. (15 mm) of rain before contributing to excess rainfall runoff.

Subbase and Subgrade

Soils Infiltration into subgrade is important for both passive and active systems. Estimating the infiltration rate for design purposes is imprecise, and the actual process of soil infiltration is complex

Subbase and Subgrade Soils

The design of a pervious pavement base should normally provide a 6- to 12-in. (150- to 300-mm) layer of permeable subbase. The permeable subbase can either be 1 in. (25 mm) maximum size aggregate or a natural subgrade soil that is predominantly sandy with moderate amounts of silts, clays, and poorly graded soil, unless precautions are taken as described in “Clays and Highly Expansive Soils”.

Curing and Protection

The open structure and relatively rough surface of pervious concrete exposes more surface area of the cement paste to evaporation, making curing even more essential than in conventional concreting. Water is needed for the chemical reactions of the cement and it is critical for pervious concrete to be cured promptly. In some regions, it is common to apply an evaporation retarder before compaction to minimize any potential for surface water loss. Because pervious concrete pavements do not bleed, they can have a high propensity for plastic shrinkage cracking. In fact, “curing” for pervious slabs and pavements begins before the concrete is placed: the subgrade must be moistened to prevent it from absorbing moisture from the concrete. After placement, fog misting followed by plastic sheeting is the recommended curing procedure, and sheeting should remain in place for at least seven days.

Generally,asperavailableinformationfromliteraturetheentireperviousconcretepavementsystemhastobesupportedonsoilas the infiltration capacity of soil is more. It was planned that water is to be collected through the pervious concrete pavement. But it is difficult to collect infiltrated water through the pervious concrete pavement if the system is directly supported on soil.So a layer of geotextile is laid on the soil surface.

The pipe collects the water in a sand based filter, that helps in general filtration of the water passing through it , the filter is made with 100% natural ingredients that are easily available in the market and are low in cost.

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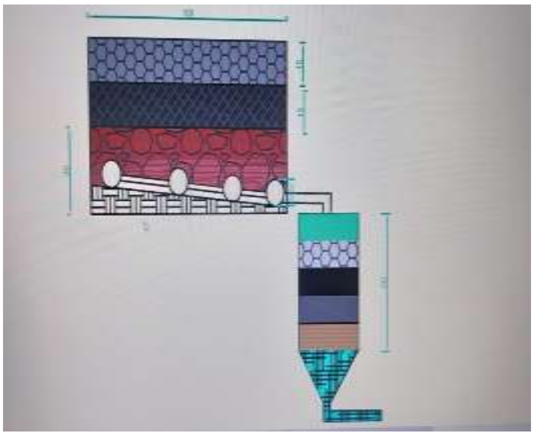
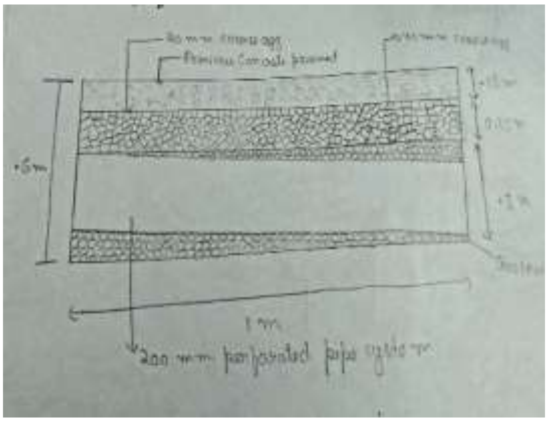
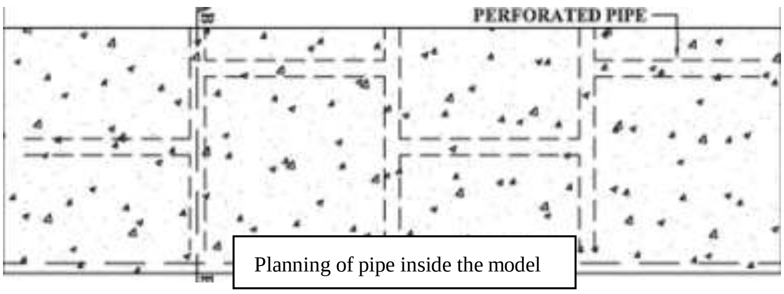


Side View of model



Sketch Plan



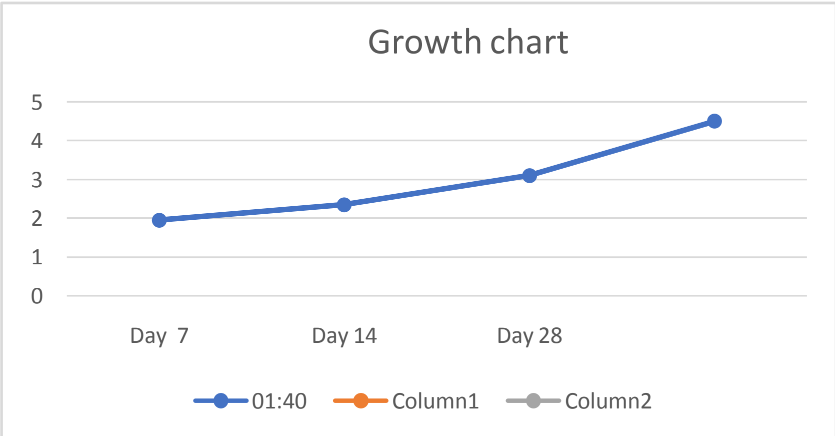
Planning of pipe inside the model

Flexural Strength

Flexural test evaluates the tensile strength of concrete indirectly. It tests the ability of unreinforced concrete beam or slab to withstand failure in bending. The results of flexural test on concrete expressed as a modulus of rupture which denotes as (MR) in MPa or psi. The flexural test on concrete can be conducted using either three point load test (ASTM C78) or centre point load test (ASTM C293). Test method described in this article is according to ASTM C78.

The flexure strength of the concrete is tested in case the concrete can be used as a cantilever in any structure. Although the flexural strength of the pervious concrete was less then the conventional concrete but it was such that, it would handle a significant amount of flexural stress and can be used in areas where less live load is present.

Ratio	**Dimension (mm)**	**7 days Mpa**	**14day Mpa**	**28 days Mpa**
1:4	150*150*700	1.95	2.35	3.10



III. CONCLUSION

This project gives an depth study of pervious concrete though it appears a simple method of casting and laying.

The larger the size of coarse aggregate, the larger the total void ratio.

The compressive strength of pervious concrete drops down as the size of coarse aggregate is increased.

Addition of sand will improve the mechanical strengths but at the same time the hydraulic conductivity will be reduced.

The hydraulic conductivity increases as the size of coarse aggregate is increased.

The aspect of clogging of pervious concrete is discussed in detail, and expression to compute effective infiltration rate is also studied.

No fines concrete is an environmental friendly solution to support sustainable construction. In this project fine aggregate as an ingredient has not been used. Presently there is an acute shortage of natural sand all around.

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