EXPERIMENTAL INVESTIGATION OF PERMEABLE CONCRETE'S HYDRAULIC PROPERTIES

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ABSTRACT
Due to the urban growth along with increasing population, there is huge demand for water resources especially groundwater for the needs of human. As construction activities are drastically increasing with impervious structures, groundwater levels are decreasing day by day. Many nations are facing water scarcity for their needs. It is required to improve groundwater levels byre charging the precipitated surface water. To percolate the surface runoff, pervious pavements can be suggested. Water Absorbing pavement is a technique in Pavement construction for the effective management of rain water runoff, groundwater recharge, Agricultural activities. Pervious concrete is a special type of concrete with high porosity. It is used for concrete flat works applications that allow the water to pass through it, thereby reducing the runoff from a site and allow in ground water recharge. Typically, pervious concrete has little or no fine aggregate and has just enough cementation paste to coat the coarse aggregate particles while preserving the inter connectivity of the voids and act as an eco-friendly paving material. In this connection, we have selected a case project using previous concrete for pavement. This introduction to previous concrete pavements reviews its applications and engineering properties, including environmental benefits, structural properties, and durability.

Keywords: *Pervious Concrete, Permeability, Groundwater Recharge, Light weight, Porosity.*

I. INTRODUCTION

Pervious concrete which is also known as the no-fines, porous, gap-graded, and permeable concrete and Enhance porosity concrete have been found to be a reliable storm water management tool. By definition, previous concrete is a mixture of gravel or granite stone, cement, water, little to no sand (fine aggregate). When pervious concrete is used for paving, the open cell structures allows to RM water to filter through the pavement and into the underlying soil. In other words, pervious concrete helps in protecting the surface of the pavement and its environment. As stated above, pervious concrete has the same basic constituents as conventional concrete; 15-30% of its volume consists of interconnected void network, which allows water to pass through the concrete. Pervious Concrete can allow the passage of 11.35-18.97 lit of water per minute through its open cells for each square foot (0.0929m) of surface area which is far greater than most rain occurrences. Apart from being used to eliminate or reduce the need for expensive retention ponds, developers and other private companies are also using it to free up valuable real estate for development, while still providing a paved park. 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 honey combed surface, with moderate amount of surface travelling which occurs on heavily travelled roadways. Carefully controlled amount of water and cementation material are used to create a paste. 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.

II. LITERATUREREVIEW

- *KIAN et.al, (2022):* Performed experiments studying the effects of entrained air on the strength and durability of conventional concrete. Although never utilizing the number of voids seen in pervious concrete (15-35%), his research clearly shows the impact the presence of air has on the performance of concrete. He concluded that the reduction in compressive strength with the cement content decreases. These are both thanks to the reduction in water.

- *M.AAMER RAFIQUE BHUTTAA, K.TSURUTAB, J. MIRZA et.al, (2022):* He was studied on topic of Evaluation of high-performance porous concrete properties. The aim of this laboratory study was to evaluate the properties of high performance porous concrete. Tests carried out on this concrete were: slump, slump-flow, void ratio, and coefficient of permeability, compressive and flexural strengths, and strength development rate. Furthermore, a test was proposed to determine the effects of high water-

reducing and thickening (cohesive) agents on self-compaction of high performance porous concrete. It was meant to evaluate its hardened properties from the viewpoint of practical application. Use of combination of SP and cohesive agent could produce acceptable HPPC with good workability and strength properties. The addition of cohesive agent to HPPC mixture could decrease the total void ratio and permeability and significantly increase the compressive and flexural strengths. Regardless of types of porous concrete and aggregate size, results showed an almost linear relationship between the compressive strength and total void ratio, and between coefficient of permeability and total void ratio for all porous concretes in the range of 15-30% total void ratio.

- *KARTHIK H.OBLA et.al, (2021):* Pervious Concrete: An Over view, flatwork applications that allows water from precipitation Pervious concrete is a special high porosity concrete used for and other sources to pass through, thereby reducing the runoff from a site and recharging ground water levels. Its void content ranges from 18 to 35% with compressive strengths of 400 to 4000 psi (28 to 281 kg/cm2). The infiltration rate of pervious concrete will fall into the range of 2 to 18 gallons per minute per square foot (80 to 720 lit per minute per square meter). Typically, pervious concrete has little or no fine aggregate and has just enough cementations paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids.

- ***JAVIER CASTRO et.al, (2021):*** This has mainly to the use of pervious concrete in place of conventional concrete. Pervious concrete has been used as an effective method for handling and reducing negative environmental impacts. The voids are creates in the concrete for passing the water from concrete, also reducing the problem of water logging and make a road surface skid resistance and increasing the water table, The performance of pervious concrete was compared with the material used for the construction of concrete road pavements. t was found that Pervious concrete pavements possesses some positive features like increased skid resistance and high permeability. Pervious concrete has proven to have properties suitable for use in low volume traffic areas. If pervious concrete pavements can be implemented, it will have various positive effects on the environment.

- *MD. ABID ALAM AND SHAGUFTA NAZ et.al, (2020):* The purpose of this project is to analyze the feasibility of producing highly sustainable no-fine concrete mixtures and evaluating the effect of fine aggregate on their properties. No-fine concrete is produced by using ordinary Portland cement, coarse aggregates, and water. This concrete is tested for its properties, such as slump value, porosity and compressive strength the results showed that porosity has significant effect on compressive strength of no-fine concrete.

- *MOHAMMED SONEBIA, MOHAMED BASSUONIB, AMMAR YAHIACIN et.al, (2019):* This type of porous Concrete can help minimizing flooding risks, recharging groundwater table, reducing runoff and peak flows, and improving water quality. In addition, PCPC can be reduce the absorption of solar radiation power and urban heat storage Potential which can lead to temperate urban conditions, in which protecting the environment and health and safety of living things. This increases the potential for excess Surface run off, which can lead to downstream flooding, bank and control the pollution.

- *M.AAMERRAFIQUEBHUTTAA,K. TSURUTAB,J. MIRZA et.al, (2019):* Was studied on topic of Evaluation of high- performance porous concrete properties. The aim of this laboratory study was to evaluate the properties of high performance porous concrete. Tests carried out on this concrete were: slump, slump-flow, void ratio, and coefficient of permeability, compressive and flexural strengths, and strength development rate. Furthermore, a test was proposed to determine the effects of high water-reducing and thickening (cohesive) agents on self-compaction of high performance porous concrete. It was meant to evaluate its hardened properties from the viewpoint of practical application. Use of combination of SP and cohesive agent could produce acceptable HPPC with good workability and strength properties. The addition of cohesive agent to HPPC mixture could decrease the total void ratio and permeability and significantly increase the compressive and flexural strengths. Regardless of types of porous concrete and aggregate size, results showed an almost linear relationship between the compressive strength and total void ratio, and between coefficient of permeability and total void ratio for all porous concretes in the range of 15-30% total void ratio.

- *Y.AOKI, R. SRI RAVINDRARAJAHAND H .KHABBAZ et.al, (2019):* Carried out study on Properties of pervious concrete containing fly ash. In this paper, the findings of an experimental investigation on properties of pervious concrete are reported and discussed. The amount of general purpose Portland cement has been reduced by introducing fly ashes a cementations agent in pervious concrete samples. The properties of various pervious concrete samples including density, porosity, compressive strength, water permeability and drying shrinkage have been carefully measured. In addition, the relationships among these properties are explored. Properties include density, porosity, 7-dayand 28-

daycompressive strengths and permeability of samples at three different water heads.

III. METHODOLOGY

The following methodical approach is used to accomplish the aforementioned goals:

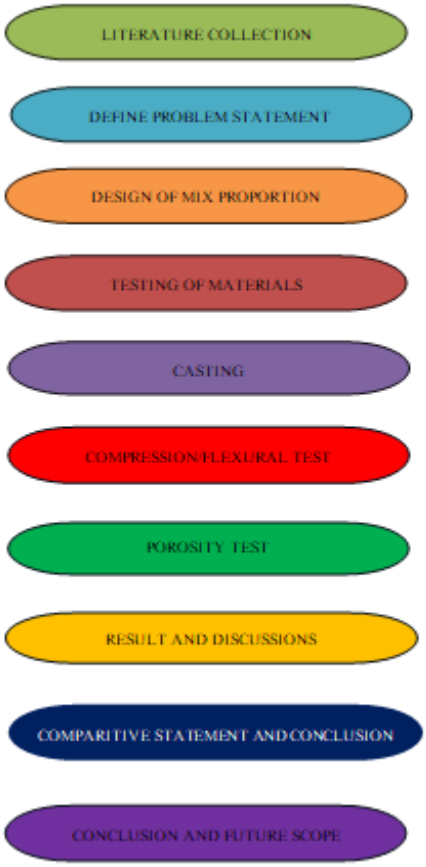


Figure methodology

We caste pervious concrete model as per IS code 10262-2019.Model size is 300mm*300mm*100mm taken. We mix concrete properly with a specific W/C ratio 0.3, and then we fill into the model tray in three layers. At every layer we did 25 times tempering through tempering rod (16 mm diameter and 0.6m long). Sample is placed before 30 minutes; The test specimens are stored in place free from vibration for 24 hours from the time of adding of water. And After this period remove from mould and submerged into the clean fresh water for curing. Curing of concrete play, a significant role in strength of concrete. Water is poured on the model to Test whether it is pervious or not.

IV. PROCEDURE FOR CASTING CUBES

We caste pervious concrete in 1:3 mix proportion. Cube specimen size is 150mm 150mm*150mm taken, we mix concrete properly with a specific W/C ratio, then we fill into the mould in three layers. At every layer we did 25 times tempering through tempering rod (16 mm diameter and 0.6m long). Sample is placed before 30 minutes; the test specimens are stored in place free from vibration for 24 hours from the time of adding of water. And After this period remove from mould and submerged into the clean fresh water unless for required for test and at the time of test remove the specimen from water and wipe out excess water take the dimension nearest 0.2cm. Curing of concrete play, a significant role in strength of concrete. For strength of pervious concrete, we test cubes on Compressive testing machine under various consideration such as one day of curing, 7 day and 28 days of curing. For compressive testing we place specimen into the Compressive testing machine and apply the load gradually and continuously 14N/mm2 per minute pressure rate until the cracking and record maximum load and note the reading and calculate the strength of pervious concrete cubes.

Figure cubes

Preparation of cube mould:

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

Figure cube mould

Concrete mixing:

Mix the cement and aggregate on a water tight none-absorbent platform until the mixture is thoroughly blended and is of uniform color (Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch (in) Add

water and mix it until the concrete appears to be homogeneous and of the desired consistency.

Figure concrete mixing

Figure casting of rectangular prism

Figure rectangular prism

V. CHARACTERIZATION OF MATERIALS

- ***CEMENT:*** In this investigation, cement serves as the principal binding agent. 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.

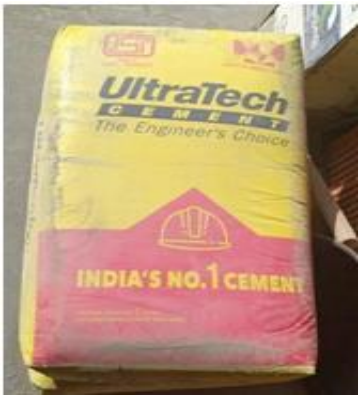


Figure Ordinary Portland cement used in study.

- ***AURAMIX 300:*** AURAMIX 300 is a unique malty purpose super plasticizer that is particularly suitable for the production if ready mixed concrete. With it is outstanding cast/ performances Aura mix 300 is used for the following a wide range of application where excellent workability is requested.

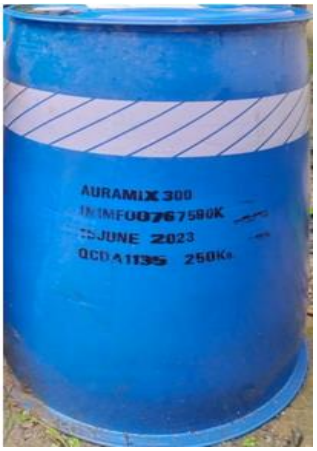


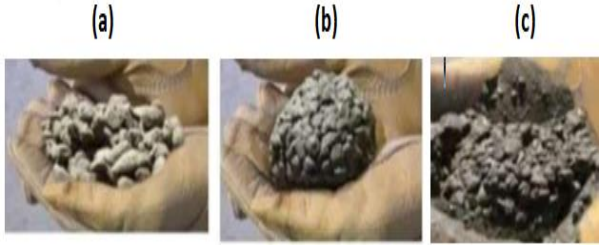
Figure AURAMIX 300

- ***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 numerous individual aggregate particles appear fractured after the Concrete specimen has been crushed.

Figure Coarse Aggregate

- ***WATER:*** While any potable water can be used for mixing, the amount of water is critical for the formation of the voids in pervious concrete. Water-to-cement ratios can range from 0.27 to 0.30 with ratios as high as 0, 40. Careful control of water is critical. A mix design with little water can create a very weak binder. This will create a very dry mix that is susceptible to sapling and crumbling. As seen in Figure, the specimen in Figure

  a) Has too little water, the specimen in Figure
  b) Has the correct amount of water, and the specimen in Figure
  c) Has too much water.



In this project we need to do experimental tests on previous concrete, Cubes and Rectangular prism was used as samples in these experiments. There were used may types of tests some of them are as follows.

VI. HYDRAULIC TESTS

Hydraulic tests measure the ability of pervious concrete to manage storm water runoff and infiltrate water.

- **Infiltration Test**
  Purpose: Measures the infiltration capacity of pervious concrete.
  - Formula: Infiltration rate (IR) = Volume of water infiltrated / Time
  - Unit: mm/h or $m^3/m^2/h$

Figure infiltration testing equipment

Figure infiltration test

- **Percolation Test**
  Purpose: Measures the percolation rate of pervious concrete.
  - Formula: Percolation rate (PR) = Volume of water percolated / Time
  - Unit: mm/h or $m^3/m^2/h$

- **Hydraulic Conductivity Test**
  Purpose: Measures the hydraulic conductivity of pervious concrete.
  - Formula: Hydraulic conductivity (K) = (Volume of water flowed) / (Time * Cross-sectional area * Hydraulic gradient)
  - Unit: m/s or m/d

VII. COMPRESSION STRENGTH TEST

To determine the compression strength of pervious concrete**.**

- Specimen size and shape
- Curing period and conditions
- Loading rate and procedure
- Calculation of compressive strength

Equipment:

- Universal Testing Machine (UTM)
- Permeable concrete test specimens (150 mm x 150 mm x 150 mm)

Figure Compression test

Concrete Mix	7 Days Load N/M		Strength (N/Mm2)
		m²	
Conventional Pervious Concrete	289.10	12.84	12.93
	293.19	13.12	
	297.31	13.21	
Pervious Concrete with superplasticiser	320.14	14.22	14.31
	324.12	14.40	
	322.16	14.31	

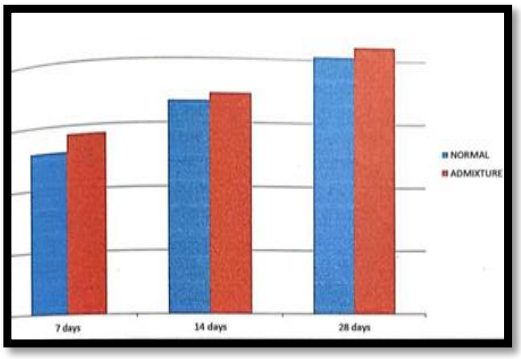
Table compressive strength of concrete @ 7days

Concrete Mix	14 Days Load N/M		Strength (N/Mm2)
		m²	
Conventional Pervious Concrete	374.21	16.63	16.72
	378.25	16.81	
	376.40	16.72	
Pervious Concrete with superplasticiser	396.11	17.60	17.70
	414.16	18.40	
	385.21	17.12	

Table compressive strength of concrete @ 14days

Concrete Mix	28 Days Load N/M		Strength (N/Mm2)
		m²	
Conventional Pervious Concrete	445.50	19.80	20.27
	433.30	19.25	
	490.12	21.78	
Pervious Concrete with superplasticiser	472.15	20.98	21.07
	489.26	21.74	
	472.17	20.98	

Table compressive strength of concrete @ 28days



Graph compressive strength of concrete @ 7, 14 and 28 days

VIII. FLEXURAL STRENGTH TEST

To determine the flexural strength of permeable concrete.

- Beam size and shape
- Curing period and conditions
- Loading rate and procedure
- Calculation of flexural strength

Concrete Mix	7 Days Load N/M		Strength (N/Mm2)
		m²	
Conventional Pervious Concrete	7.25	0.0015	0.00158
	8.62	0.00178	
	7.14	0.00148	
Pervious Concrete with superplasticiser	9.14	0.00189	0.00213
	10.65	0.00220	
	10.11	0.00230	

Table flexural strength of concrete @ 7days

Equipment:

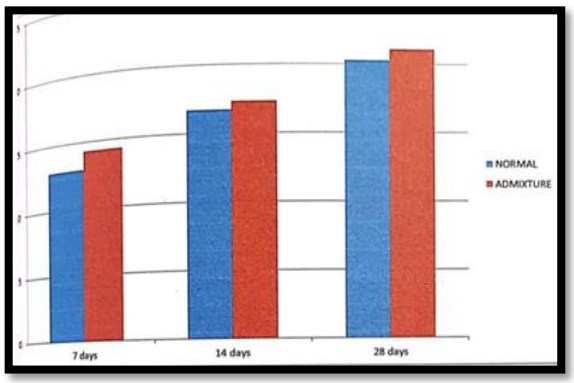
- Universal Testing Machine (UTM)
- Permeable concrete test specimens (100 mm x 100 mm x 500 mm)

Concrete Mix	14 Days Load N/M	m²	Strength (N/Mm2)
Conventional Pervious Concrete	10.18	0.00211	0.00229
	11.34	0.00235	
	11.68	0.00242	
Pervious Concrete with superplasticiser	12.74	0.00264	0.00272
	13.84	0.00287	
	12.90	0.00267	

Table flexural strength of concrete @ 14days

Concrete Mix	28 Days Load N/M	m²	Strength (N/Mm2)
Conventional Pervious Concrete	15.09	0.00312	0.00293
	14.28	0.00296	
	13.15	0.00272	
Pervious Concrete with superplasticiser	17.21	0.00350	0.00350
	16.44	0.00340	
	17.40	0.00360	

Table flexural strength of concrete @ 28days



Graph flexural strength of concrete @ 7, 14 and 28 days

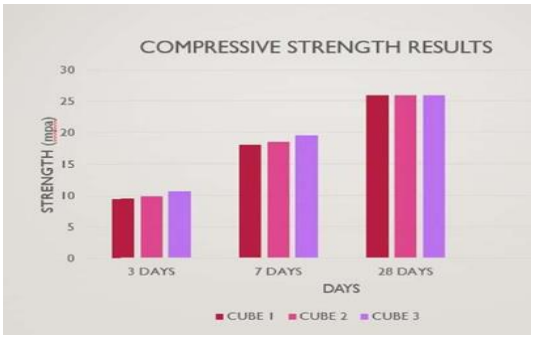
IX. RESULTS AND DISCUSSIONS

Optimized Mix Design of Pervious Concrete (With 20mm Aggregates, No Sand), Tested At concrete technology laboratory

SINO	PROPERTY	VALUE
1	SPECIFICGRAVITY	3.15
2	CONSISTENCY	36%
3	FINENESS	8%

Table Properties of cement tested at Concrete technology laboratory

- **Tests on Coarse Aggregates:** Coarse aggregates (locallyavailable1620mmsize aggregates). The pervious concrete which when tested by adding the admixtures gives desirable values in certain parameters which is discussed below. Based on the values and after testing in various aspects, the values are compared normal pervious concrete and the admixtures mixed pervious concrete.

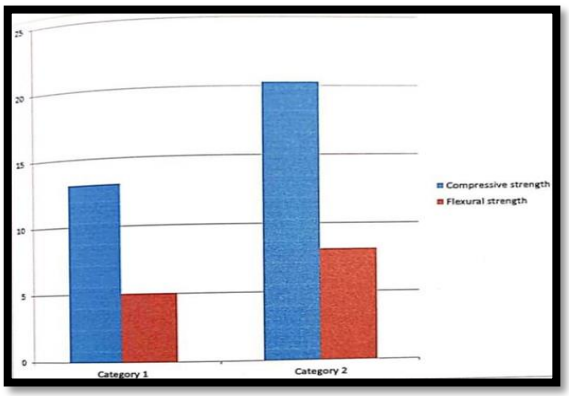


Graph compressive strength results

S.NO	DESCRIPTION	NORMAL PERVIOUS CONCRETE (28 DAYS STRENGTH N/mm²)	ADMIXTURE MIXED PERVIOUS CONCRETE (28 DAYS STRENGTH N/mm ²)	Percentage increase
1.	COMPRES SIVE STRENGTH	13.12	20.28	55%
2.	FLEXU RAL STRENGTH	5.05	8.13	61%

Table Final Results of Admixture Used and Normal Pervious and Percentage

- **General:** The pervious concrete which when tested by adding the admixtures gives desirable values in certain parameters which is discussed below. Based on the values and after testing in various aspects, the values are compared normal pervious concrete and the admixtures mixed pervious concrete.



Graph Total Comparison of Strength Increase by Mixing

X. CONCLUSIONS

Pervious concrete pavement construction is an exceptionally good method to improve sustainability of construction. It effectively recharges the ground water and also helps in control of urban heat island effect. Even though compression strength is low, it can be used for light traffic roads, pavements, parking lots, and paving the front of houses. Pervious concrete is a cost-effective and environmental friendly solution to support sustainable construction. Its ability to capture storm water and recharge ground water while 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.

- Compressive strength of concrete attained at an age of 7 days is about 60-75% of the compressive strength of the concert attained at an age of 28 days.

- The strength can be further increased by adding super plasticizer Sika plast 520 INS when the super plasticizer is added at a rate of 1.5% of the weight of cement.

- It was observed that there is an increment in compressive flexural and tensile strength of pervious concrete with super plasticizer when couponed with plain pervious Concrete Mix..

XI. FUTURE STUDIES

- The strength characteristics of previous concrete can be further studies by taking into account the following parameters:
- By varying the water cement ratio.
- By varying the amount of silica fume and addition of super plasticizers.
- By using some little amount of fine aggregates.
- By using recycled coarse aggregates in the concrete mix as replacement of coarse aggregates.
- Using the super plasticizers in the mixes only by removing silica fume.
- In the past due to the scarcity of cement, the pervious concrete has been used extensively.
- The pervious concrete has lost its importance after successful production of cement in large quantities.
- But now-a-days, the usage pervious concrete has gained its popularity due to many advantages.
- The urban areas all over the world have become CONCRETEJUNGLES. The discharge of storm water is very difficult problem in the present conditions.
- By using the pervious concrete we can able to recharge the ground water table and the storm water disposal can also be done.
- So, in future to tackle afore said problems and to protect people from flood prone areas, the pervious concrete is one effective solution.

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