International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 4, July-Aug-2020, ISSN (Online): 2395-566X

Experimental Study of Pervious Concrete

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Abstract- Pervious concrete is a special type of concrete with a high porosity used for concrete flat work applications that allows water from precipitation and other source stop as directly through. By this, the runoff from the site is minimized and groundwater is enhanced. It is also called porous concrete, permeable concrete, no fines concrete and porous pavement fines. Pervious concrete can be made with little to no fine aggregates utilizing large aggregates. The concrete paste then covers the aggregates and helps the water to move through the concrete slab. A form of concrete with a high void content of about 30 percent is now becoming common due to its ability to minimize the runoff to drainage systems that can provide a water flow rate of about 0.34 cm / second. It is an important sustainable building technology and is one of the low-impact production techniques used by builders to protect water quality. Pervious concrete often finds its successful use in pavements, footpaths, walkways and highways for low loading intensity parking. The Environmental Protection Agency (EPA) has stated that the pervious concrete is considered to provide pollution control, storm management, and adequate growth. It is a composite substance that is created by combining cement, inert sand and gravel matrix or crushed stone. This concrete has a light color and open-cell structure which prevents them from absorbing heat from the sun; they also do not radiate the heat back into the atmosphere, which reduces heating in the environment. The pervious concrete has low cost of construction. It removes the storm water while reducing the number of contaminants that reach the rivers and ponds. Also, pervious concrete improves tree growth. The action of pervious concrete has been examined experimentally in the present research. The water-cement ratio was maintained at various ratios 0.35, 0.40, and 0.45. Different properties of pervious concrete were experimentally tested, e.g. workability, compressive strength, split tensile strength, flexural strength at 7, 14 & 28 days. Mixing proportions with aggregate sizes (4.75 mm to 10 mm) give greater strength compared to mixes with aggregate sizes (10 mm to 20 mm) and (4.75 mm to 20 mm), respectively.

***Keywords*– Pervious, flatwork, inert sand, drainage system, runoff, storm management.**

I. INTRODUCTION

1. General

Over time, the technology of building has seen a dramatic improvement. Within a month of length several traditional structures can be constructed using advanced building techniques. Through this it is proved that without using concrete no construction can be made economically. The word "concrete" has its roots in the Latin verb "concretes" which means growing together. Concrete is a construction material consisting of cement, mortar, and water. Concrete solidifies and hardens by a chemical cycle known as hydration after mixing and positioning. The water reacts with cement which binds together the other components and ultimately creates a stone material. It is used to render pavement, architectural structure, base, overpasses, parking structure, etc. The concrete is a durable material with high compressive strength and low tensile resistance. Reinforcing bars improve tensile strength. Fresh concrete is a freshly mixed material which can be formed into any form. The relative amounts of cement, aggregate and water mixed together influence the properties of concrete in both wet and hardened state. The strength of concrete depends primarily on the ratio of cement to water. When the water cement ratio increases, the concrete bleeding occurs too much and the concrete strength also decreases. The high-performance concrete usually includes ordinary Portland cement.

In concrete industry, the use of different types of sub-products into cement-based materials has become a common practice. Pervious concrete is an innovative material that is a mixture of coarse aggregate, cement, water and little to no sand that contains a network of holes or voids to allow the passage of air and water. It allows water to flow into it naturally, which allows groundwater to be replenished as standard concrete does not. This groundbreaking material has often been also called as No Fines Concrete.The lack of sand or fine aggregate enables the properly positioned perpendicular concrete to have approximately 15 to 30 percent of void

International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 4, July-Aug-2020, ISSN (Online): 2395-566X

space, the pores will range from 0.08 to 0.32 inches (2 to 8 mm), allowing water to move through without doing any harm to the porous concrete matrix. In the recent past due to climate change land is drying up doing serious problems. Instead of constructing them with traditional concrete or asphalt, growing numbers of cities, municipalities and businesses are turning to perennial concrete or porous pavements.Product that provides the inherent resilience and low life-cycle costs of a conventional concrete pavement while preserving the runoff of storm water and replenishing local water courses.

2. Objectives

The effects of varying the components of pervious concrete on its compressive force are studied in this study. The goal is to achieve optimum compressive strength without inhibiting the characteristics of the pervious concrete's permeability. That will be achieved by comprehensive experiments produced for that purpose on test cylinders. Experiments include detailed tests on gravity, tests on permeability and tests on compression. Loadings on pervious concrete are an area of concern as well. Existing pavements of pervious concrete are being examined.

3. Benefits

The benefits from its use are its potential to
•Diminish the volume of runoff water
• Boost quality of water
• Improve pavement skid resistance, particularly through rapid drainage of rain water during storm events
• Decreases noise levels caused by traffic

II. MATERIAL AND DESIGN METHODOLOGY

1. General

This chapter deals with the presentation of the results obtained from different tests carried out on material used for concrete. An experimental program was designed to investigate the usage of polyvinyl chloride on compressive strength and break concrete tensile strength to achieve the objectives of the present research. The various measures in our study are as follows

1. Need for Security
2. A review of the literature
3. Product Detection
4. Material collection
5. Content Examination
6. Preparation of design mixes.
7. Casting specimen
8. Test and End

2. Materials

The properties of materials used to make concrete mixes are calculated according to applicable codes of practice in laboratory. Apart from broken PVC pipes, different materials used in the present study were cement, coarse aggregates and fine aggregates.The purpose of studying different material properties is used to test the appearance with codal requirements and allow an engineer to develop a concrete mix for a specific strength.

3. Ordinary Portland cement

Ordinary Portland cement is the most important form of cement and is a fine powder made from Portland cement grinding the clinker. The OPC is graded into three grades based on the frequency of 28 days, namely 33 grade, 43 grade, 53 grade. Upgrading the quality of cement has been possible by using high-quality calcareous materials, modern equipment, maintaining better distribution of particle size, finer grinding and better packaging. Using high quality cement typically provides many advantages for making concrete stronger. Ordinary 53 Grade (Ambuja cement) 2082 Portland cement (OPC) was used during the investigation. Cement was carefully stored to prevent deterioration of its properties due to contact with the humidity. The different cement properties are initial and final setting time, basic gravity, fineness, and compressive strength.

4. Aggregates

Aggregates are the bulk of a concrete mixture, which offer concrete dimensional stability. The aggregates are often used in two or more sizes to maximize the density of the resulting blend. The fine aggregate's most significant role is to assist in the development of workability and mixed uniformity. The fine aggregate helps in keeping the coarse aggregate particles in suspension for the cement paste. This action encourages plasticity in the mixture and prevents the possible segregation of paste and coarse aggregate, especially when a certain distance is required to transport the concrete from the mixing plant to placement. The aggregates provide about 75 percent of the concrete's body, and are therefore extremely essential in its impact. Therefore, if the concrete is to be workable, solid, robust and economical they should meet certain specifications. The aggregate has to be formed properly, clean, smooth, solid and well graded.

5. Coarse Aggregates

The aggregates that are holding over IS sieve 4.75 mm re called coarse aggregates. The coarse aggregates can be of the following kinds

1. Crushed gravels or stones obtained by crushing gravel or hard stone.
2. Uncrushed gravel or stone resulting from the natural disintegration of rocks.
3. Partially crushed gravel obtained as a combination of these two kinds.

The usual maximum size is progressively 10-20 mm; however, particle sizes up to 40 mm or more were used in self-compacting concentrations. With regard to the

International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 4, July-Aug-2020, ISSN (Online): 2395-566X

characteristics of different types of aggregates, crushed aggregates tend to improve strength due to the interlocking of angular particles while rounded aggregates improved flow due to lower internal friction. In this study, coarse local aggregates with a maximum size of 20 mm were used. To extract dust and soil, the aggregates were washed and dried to dry surface condition. The aggregates had been measured according to IS: 383-1970. Specific gravity and other coarse aggregate properties are given in table 3.1 & 3.2. The sieve analysis was performed for the coarse aggregates.

6. Specific Gravity

For the construction measurement of concrete mixes variable specific gravity is used. With each constituent's specific gravity known, its weight can be transformed into solid volume, thereby measuring theoretical concrete yield per unit volume. We do need to remember common aggregate gravity when dealing with low weight and heavy weight concrete.

Specific gravity = (W2-W1) / (W4-W1) - (W3-W2)

Specific gravity = 2.76

7. Bulk Density

Empty weight of container (A) = 2.587kg
Weight of container + water (B) = 5.542 kg
Loose state,
Weight of Container + aggregate (C) = 7.954 kg
Dry rod bulk density = (C-A) / (B-A)
= (7.594-2.587)/ (5.542-2.587)
= 1816 kg/m3

Table 1 Specific Gravity of coarse Aggregates

S. No	Description	Trial–I (Kg)	Trial–2 (Kg)
1.	Weight of empty pycnometer (W1)	0.656	0.654
2.	Weight of pycnometer + coarse aggregate (W2)	1.262	1.252
3.	Weight of pycnometer + coarse aggregate + water (W3)	1.872	1.865
4.	Weight of pycnometer + water (W4)	1.487	1.485

Table 2 Properties of coarse Aggregates

Characteristics	Value
Colour	Grey
Shape	Angular
Maximum Size	20mm
Specific Gravity	2.76
Water absorption, %	0.5%
Flakiness index	26.9%
Elongation index	10.6%

8. Fineness Modulus (Sieveanalysis)

The sieve analysis is performed to determine the distribution of particle size in an aggregate sample, which we call gradation. The test comprises the basic process of dividing aggregates into fractions, each consisting of the same size particles. The sieve analysis on coarse aggregate was carried out in compliance with IS2386 (Part I) -1963 and the results are shown in table 2.3

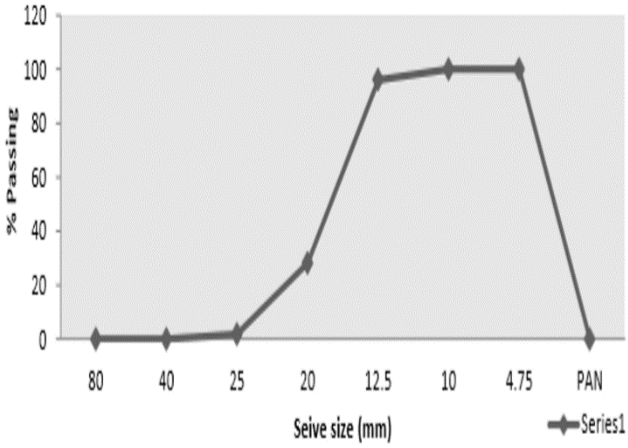

Fig. 1Fineness Modulus Graphfor Coarse aggregate.

9. Crushing strength on aggregate:

Dimension of mould = 15.10cm
Height of mould = (π x (15.1)2) / (4x13)
= 2328.02 cm3

Table 3 Crushing strength on aggregate

S. N.	Total weight of aggregate (W1) g	IS sieve 2.36mm passing materials(W2) g	Aggregate crushing value (W2/W1) x100g
1.	2500	400	16.00
2.	2500	350	14.00

International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 4, July-Aug-2020, ISSN (Online): 2395-566X

Calculation:
Total percentage = (16+14)/2
= 15%

10. Water absorption test

All aggregate particles contain small pores, which vary from particle to particle in size and amount. Oven-dry particles of aggregate which are exposed to water accumulate water in the pores. The rate of absorption into the particles depends on the size of the pores and the amount of water available for absorption. The substance is deemed to have consumed the full quantity of water for research purposes when it stays immersed in water for 48 hours at approximately 21°C (70°F).The absorption factor of a substance test sample is determined by dividing the difference in mass (weight) between the dry material of the submerged body and the dry material of the oven by the dry weight (oven)

Table 4 water absorptiontest

S.N.	Weight of oven dry specimen(g)	Weight of standard specimen(g)	Weight of water observed $W_3=W_2-W_1$g	% of water absorption $=W_3/W_1$x100 %
1.	200	210	10	5%
2.	200	210	10	5%

Calculation:
To find W_3
$W_3 = W_2 - W_1$= 210-200 g=10g
%ofwater absorption = W_3/W_1x100g = 5%

11. Loss angel's abrasion test on coarse aggregate:

Table 5. Abrasion test

Description	% of loss angle test(or) abrasion test
Let the original weight of aggregates (W_1) g	5000g
Weight of aggregate retained on 1.7mm IS sieve after test (W_2) g	4785g
Loss in weight due to wear (W_1-W_2) g	215 g
% of wear	((W_1-W_2)/w)x100 (5000-4785)/5000)x100= 4.3%

12. Impact test on coarse aggregate:

Table6.Impact test on coarse aggregate

S.N.	Details of Sample	Trial-I	Trial-II
1.	Total weight of aggregate sample filling the cylinder measure (W_1)g	440	370
2.	Weight of aggregate passing 2.36 mm sieve test(W_2)g	80	84
3.	Weight of aggregate retained 2.36 mm sieve (W_3)g	360	286
4.	(W_1-W_2+W_3)	0	0
5.	Aggregate impact value(W_2/W_1)x100	18.18	22.70

Calculation:
= (18.18+22.70+21.02)/3=20.63)

13. Water

Water which is suitable for drinking is usually suitable for use in concrete. Also, water from lakes and streams containing marine life should be avoided, as water quality can change due to low water or the use of intermittent tab water for casting. The potable water in the material research laboratory is usually considered appropriate for mixing and curing concrete. It was safe from any harmful contaminants, and was of decent drinking consistency.

III.MIX DESIGN

While pervious concrete contains the same basic ingredients as traditional concrete, the component proportions differ. The necessity of increased void content inside the pervious concrete is one big difference. The amount of void space is directly associated with the pavement's permeability. The requirement for void space within the mix design corresponds with the usage of minimal or no fine aggregates. The porous concrete mix designs implemented for this analysis were focused on materials readily available in the metropolitan region.

The blend was made from 200 lbs. of no.8 Stone (Millville), small to no fine aggregates, Type I-/II cement, and macro / micro fibers. The mix also contained admixtures including an Air Conditioning Agent, Viscosity Enhancing Admixture (VMA) and a High-Range Water Reducer (HRWR). These admixtures are used to potentially improve the bond between the cement and the coarse aggregate and improve the workability as well as the concrete's flexural properties. Also included was a retarder, as the low water content of porous concrete pavement mixes allows them to dry quickly. For all the mixes the sand content was varied. Sample batches for suitable unit

International Journal of Scientific Research & Engineering Trends
Volume 6, Issue 4, July-Aug-2020, ISSN (Online): 2395-566X

weights and percent of voids were prepared and checked

Table 7 Mix proportions

Water cement ratio	Cement (kg/m3)	Fine aggregates	Coarse aggregates (kg/m3)	Water content (kg/m3)
0.45	437.78	-	1050	197
0.4	450	-	1147.53	197
0.35	450	-	1020	197

Mix Design Calculations – Mix Proportion For M30 Grade of Pervious Concrete:
Mix Proportion
Cement= 450 kg/m3
Water= 197kg/m3
Coarseaggregate= 1050kg
Watercementratio= 0.35
Ratio= (C:S:A)= (1:0:2.33)

IV. TESTMETHODS

The procedure of method used for testing cement, coarse aggregate, fine aggregate and concrete are given below:

1. Slump conetest
Slump is a measure of the workability of concrete or its fluidity. It is an indirect measure of concrete strength or rigidity. A slump check is a tool used to evaluate concrete strength. The strength or stiffness means how much water was used in the mix. The concrete mix's stiffness should be adjusted to the finished quality requirement.

1.1 Slump types
- Slump collapse
- Shear slump
- Real slump

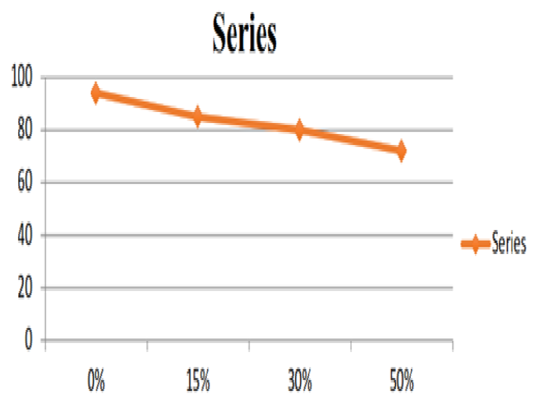

Fig 2. Graph for Test on slump value.

2. Compaction Test on Concrete
It is a test used to assess the compacting factor of the ability to prepare concrete mix.

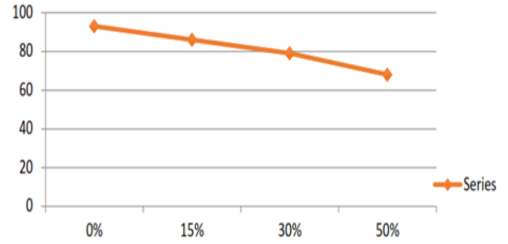

Fig 3 Graph for compaction test on concrete.

V. RESULTSANDDISCUSSION

The experimental method included:
- Properties examination of materials used for concrete construction.
- Mix design (M30).
- Setting the specimens and curing them.
- Check to assess compressive force.

1. Compressive Strength

Samples of scale 150 mm x 150 mm x 150 mm x 150 mm were prepared and tested using the compressive test tool. In compliance with ASTM C39, Standard Test Method for Compressive resistance of Concrete Specimens, 28-day compressive strength tests were carried out.

Fig 4. scale 150 mm x 150 mm x 150 mm x 150 mm.

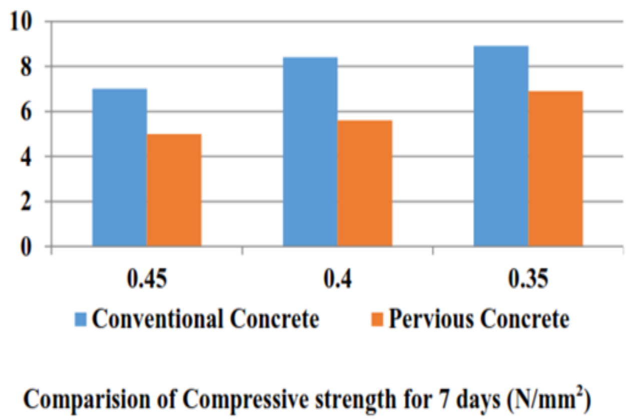

Fig.5 Compression Test Subjected to Compression.

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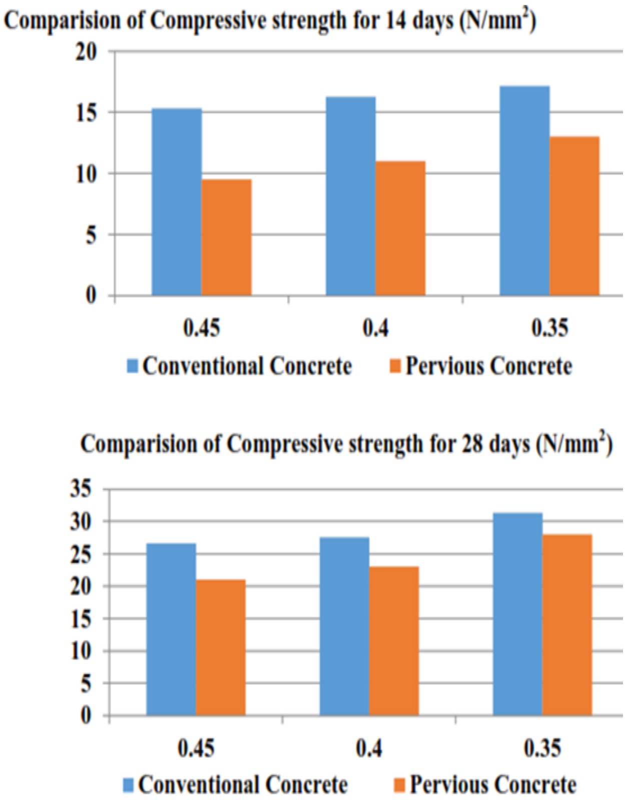

Fig.6 28-day compressive strength tests.

2. Freeze-Thaw Resistance

The resistance of pervious concrete in the field to freeze-thaw seems to depend on the degree of saturation of the voids in the concrete at the time of freezing. In the field it appears that saturation is prevented by the rapid draining characteristics of pervious concrete. Anecdotal evidence also indicates that snow-covered pervious concrete clears quicker, likely because its vacuums allow the snow to thaw quicker than traditional pavements would. Indeed, some continuous concrete placements have been in operation in North Carolina and Tennessee for more than 10 years.

Note that in a freeze-thaw setting, the porosity of pervious concrete from the large voids is markedly different from the tiny air voids that provide protection for the paste in traditional concrete. When the wide-open voids are frozen, complete freezing can in just a few cycles cause serious harm. Standardized ASTM C 666 testing does not accurately reflect field conditions, as the wide-open voids are kept saturated in the test, and as the freezing and thawing rate is rapid.

It has been shown that even after 80 cycles of slow freezing and thawing (one cycle / day), perennial concrete mixtures retain more than 95 per cent of their relative dynamic modulus, whereas the same mixtures display less than 50 per cent when tested at a faster rate (five to six cycles / day). Because of the rapid draining characteristics of pervious concrete, it was noted that better performance could also be expected in the field. Research indicates that entrained air in the paste greatly enhances the freeze-thaw protection for pervious concrete. In addition to the use of air-training agents in the cement paste, it is usually advised to position the pervious concrete on a minimum of 6 inches (150 mm), and sometimes up to 12 (300 mm) or even 18 inches (450 mm) of a drainable rock foundation, such as 1-inch (25 mm) crushed stone, in freeze-thaw environments where some significant moisture is present during freezing conditions.

3. Sulfate Resistance

Aggressive soil or water contaminants, such as acids and sulfates, are both a problem for traditional concrete and pervious concrete and the mechanisms for attack are identical. Nevertheless, the open pervious concrete framework can make it more prone to attack over a larger area. When removed from them, pervious concretes can be used in areas with high-sulfate soils and groundwater. Placing the pervious concrete over a 1-inch (25-mm) average top-size aggregate 6-inch (150-mm) layer provides a pavement foundation, storm water storage, and pervious concrete insulation. If these precautions are taken in hostile settings, ACI 201 guidelines on the water-to-cement ratio and content types / proportions should be strictly followed.

4. Abrasion Resistance

Due to the rougher surface texture and open structure of pervious concrete, abrasion and aggregate particle raveling can be an issue, particularly when snow plows are used to clear pavements. This is one reason why typically applications such as highways are not appropriate for pervious concretes. Anecdotal evidence, however, suggests that perennial concrete pavements allow snow to melt faster and require less plowing. Most pervious concrete pavements would in the early weeks after opening to traffic have a few loose aggregates on the road. Such rocks were originally closely attached to the water, then appeared due to traffic filling. The surface raveling rate is decreased significantly within the first few weeks, and the concrete condition is even more stable. Proper procedures of compaction and cure increased the frequency of surface raveling.

VI. CONCLUSION

This study illustrates that the angularity number with coarse aggregates influences the properties and behavior of pervious concrete. It is expected that the ideal pervious concrete mix will provide the maximum compressive strength and optimum rate of infiltration. Particularly for pervious concrete used on roadways, it needs to be able to withstand specific traffic loads while having sufficient insulation to minimize surface run-offs. The control system combination showed a cumulative compressive power of 31N / mm2, with a permeability coefficient ranging between 57.8 and 299.5 in/hr. The standard method of compaction of the Proctor Hammer seems to be the optimum procedure for the preparation of the pervious concrete. The water should have driven the cement completely into the aggregate under actual conditions and into the subsoil, leaving the aggregate with no cement for bonding. While having produced a broad variety of compressive forces, none of the mixtures have strength equal to that of standard concrete.

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