# Pervious Concrete Pavement

Mrs V. Saritha M.TECH)
Civil Engineering
J.N.T.U.C.E.Kalikiri
Kalikiri-517234,Andhraprdesh

Mr K. Sriramsaran, Ms Kusuma Kumari,
Mr M. Rajkumar,
Ms B. R Rajeswari And
Mrsp.Anantha Raju B.Tech
Civil Engineering,J.N.T.U.C.E.Kalikiri,

***Abstract*—The use of pavement materials like Bitumen, Asphalt concrete seals the soil surface which restricts the rain water from infiltration& natural ground recharge .In this project the parameters such as compressive strength, flexural strength, drainage conditions of various mix proportions of pervious pavement layer will be studied. Pervious concrete is a special type of concrete with high porosity used for concrete flat work applications that allow water from precipitation and other sources to pass directly through, there by reducing the runoff from a site and allowing ground water recharge. Pervious concrete is an important application for the sustainable construction and is one of many low impact development techniques used by builders to protect water quality.**

***Keywords— Cement, Polivinyl alcohol (PVA) & silica fume,Zeolite as admixture***

## I. INTRODUCTION

Pervious concrete which is also known as no fines, porous, gap graded, and permeable concrete and enhance porosity concrete has been found to be a reliable storm water management tool. Pervious concrete has the same basic constituents as conventional concrete that is 15% -30% of its volume consists of interconnected void network, which allows water to pass through the concrete. It can allow the passage of 0.014-0.023 m3 of water per minute through its open cells for each square foot 0.0929 m2 of surface area which is far greater than most rain occurrences. Pervious concrete can be used in a wide range of applications, although its primary use in pavements which are in: residual 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.

### *A. Limitations*

- The parking areas are limited to auto parking and occasional trucks.
- If reinforcement is needed then epoxy coated bars should be used.
- Over vibration significantly reduces permeability of concrete.
- Runoff from adjacent areas onto pervious concrete needs to be prevented.
- It is still a new material that requires acceptance from cities and states.

### *B. Applications*

The high flow rate of water through a pervious concrete pavement allows rainfall to be captured and to percolate into the ground, reducing storm water runoff, recharging groundwater, supporting sustainable construction, providing a solution for construction that is sensitive to environmental concerns, and helping owners comply with EPA storm water regulations. This can be of particular interest in urban areas, or where land is very expensive. Although pavements are the dominant application for pervious concrete in the U.S., it has also been used as a structural material for many years in Europe. Applications include walls for two-story houses, load-bearing walls for high-rise buildings (up to ten stories), and infill panels for high-rise buildings, sea groins, roads, and parking lots. Table 1 below lists examples of applications for which pervious concrete has been used successfully. All of these applications take advantage of the benefits of pervious concrete's characteristics. However, to achieve these results, mix design and construction details must be planned and executed with care.

## II TEST RESULT OF MATERIALS

In order to design the pervious concrete pavement, we have to conduct some tests regarding the materials used in its construction. So, therefore we have to conduct some mandatory tests or rather say experiments regarding the materials used. The tests regarding cement, aggregates, and soil for sub grade purpose are to be conducted.
The list of tests (experiments) for the materials is Specific Gravity test of Cement
The Standard value is 2.74 to 3.15 gm/cc
Water Absorption Test
The average value is 0.2085%. The standard value is 0.2%

*Impact Value*
The average calculated value is 28.89%. The standard value is 29.33%.

*Compaction Test*

*Dry density = [m / v] / [1 + w%]*

Compaction test observations and calculations
Volume of compaction cylinder = (3.14x225x13) / 4 = 2.29x103 cm3.
Optical moisture content = 11.9%
*CBR Test*
CBR is the ratio of force per unit area requirement to penetrate a soil with standard circular piston of 1875.9 mm cross section at ratio of 1.25 mm/min to that required sample of compacted stone was defined as having CBR of 100%. The standard sample was found to be 1370 kg and for 5mm penetration was found to be.

Observations and Calculations
Load factor = 1.17 kg
For 2.5 mm penetration, constant load = 1350 kg
For 5 mm penetration, constant load = 2055 kg

| S.No | Penetration dial gauge readings | Penetration (mm) (Dial gauge reading x 0.01) | Proving ring reading (n) | Load (kg) = n x 1.17 x 5 1 |
|---|---|---|---|---|
| 1 | 50 | 0.5 | 0.5 | 2.925 |
| 2 | 100 | 1 | 0.9 | 5.265 |
| 3 | 150 | 1.5 | 1 | 5.85 |
| 4 | 200 | 2 | 1.1 | 6.435 |
| 5 | 250 | 2.5 | 1.2 | 7.02 |
| 6 | 300 | 3 | 1.3 | 7.6 |
| 7 | 350 | 3.5 | 1.5 | 8.775 |
| 8 | 400 | 4 | 1.6 | 9.36 |
| 9 | 450 | 4.5 | 1.7 | 9.945 |
| 10 | 500 | 5 | 1.8 | 10.53 |

CBR value at 2.5 mm penetration = [load at 2.5 penetration] / [load] x 100
= 0.52
CBR value at 5 mm penetration = [load at 5 mm penetration] / [load] x 100
= 0.51

## *III MIX DESIGN*

Typical mix design of pervious concrete

| Materials | Proportions (kg/m3) |
|---|---|
| Cement | 270 – 415 |
| Aggregate | 1190 – 1480 |
| Water / cement ratio (by mass) | 0.27 - 0.34 |
| Fine Aggregate ratio (by mass) | 0 – 1:1 |

*Pavement Hydrological Design*

When designing pervious concrete storm water management systems, two conditions must be considered: permeability and storage capacity. Excess surface runoff—caused by either excessively low permeability or inadequate storage capacity—must be prevented.

### *A Storage Capacity*

Storage capacity of a pervious concrete system is typically 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 sub base 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 inch (25 mm) of pavement depth can hold 0.15 inches (4 mm) of rain. For example, a 4-inch (100-mm) thick pavement with 15% effective porosity on top of impervious clay could hold up to 0.6 inches (15 mm) of rain before contributing to excess rainfall runoff.
Another important source of storage is the sub base. Compacted clean stone (#67 stone, for example) used as a sub base has a design porosity of 40%; a conventional aggregate subbase, with a higher fines content, will have a lower porosity (about 20%). From the example above, if 4 inches (100 mm) of pervious concrete with 15% porosity was placed on 6 inches (150 mm) of clean stone, the nominal storage capacity would be 3.0 inches (75 mm) of rain:
(15%) 4 in. + (40%) 6 in. = 3.0 in.
The effect of the sub base on the storage capacity of the pervious concrete pavement system can be significant.

*NRMCA procedure for Pervious Concrete Mixture Proportioning*

The following NRMCA (National Ready Mixed Concrete Association) mixture proportioning approach can be used to quickly arrive at pervious concrete mixture proportions that would help attain void content of freshly mixed pervious concrete when measured in accordance with ASTM C1688 similar to the target value.
(1) Determine the dry-rodded unit weight of the aggregate and calculate the void content.
Estimate the approximate percentage and volume of paste needed. The paste volume (PV) is then estimated as follows: Vp (%) = Aggregate Void Content (%) + CI (%) - Vvoid (%) Where, CI = compaction index and Vvoid = design void content of the pervious concrete mix.
The value of CI can be varied based on the anticipated consolidation to be used in the field. For greater consolidation effort a compaction index value of 1 to 2% may be more reasonable. For lighter level of consolidation a value of 7 to 8% can be used. NRMCA used a value of 5% to get similar values between measured fresh pervious concrete void content (ASTM C1688) and design void content. Using a smaller value for CI (%) will reduce the paste volume.
(2) Calculate the paste volume, Vp in ft3 per cubic yard of pervious concrete: Vp, ft3 = Vp (%) × 27
(3) Select the w/c ratio for the paste. Recommended values are in the range of 0.25 to 0.36.

(4) Calculate the absolute volume of cement VC, ft3 = VP/ [1+ (w/c*RDc)]
Where: RDc is the specific gravity of cement (typically 3.15)
(5) Calculate the volume of water, Vw, ft3 = Vp – Vc (6) Calculate the volume of SSD aggregate (Vagg) Vagg = 27 – (Vp +Vvoid) Where: Vvoid is the design void content for the pervious concrete mix.
Convert the volumes to weights of ingredients per cubic yard and for trial batches: Cement (lb/yd3) = Vc × RDc × 62.4 Water (lb/yd3) = Vw × 62.4 SSD Coarse Aggregate (lb/yd3) = Vagg × RDagg × 62.4
Trial batches are prepared to evaluate mix characteristics of the pervious concrete mixture. Make appropriate adjustments are made to account for aggregate moisture content. If paste is high, pick a lower value or change CI (%). Avoid excessive cementitious content should be avoided. The consistency of the paste can be evaluated separately to ensure that it is not too dry or causes paste run down by being too wet. The density of the mixture should be measured in accordance with ASTM C1688

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

from which the void content is calculated to ensure that values are in line with the design void content. Then evaluate mixture for consistency, specification requirements and placement method used by the pervious concrete contractor.

## IV TEST MODELS PREPARATION

In order to attain our construction goals by using pervious concrete in pavement design, we need to perform some tests before we finally proceed to construction. The tests that we conduct to the pervious concrete are ―Compressive Strength test, Permeability Test, Durability Test, and Flexural Strength test‖. But flexural strength test is not that importance when it is compared to the rest of the tests.

So, therefore we prepare test moulds according to these tests to obtain our result goals. First of all we need to know what type of test moulds should be prepared for each type of tests.

The type of tests moulds prepared for each type of test is as follows

(a) For Compressive Strength Test Two types of test specimens can be used either cubes of 150 mm x 150 mm x 150 mm or 100 mm x 100 mm x 100 mm. But generally we prefer cubes of 150 mm x 150 mm x 150 mm.

(b) For Permeability Test For this test small cylindrical PVC pipes are taken with diameter of 10 cm and height of about 15 cm. Test sample of pervious concrete is poured into this mould and after the hardening of the sample, the test is conducted using falling head method.

(c) For Durability Test Cylindrical test moulds are used to prepare the moulds. The dimensions of the specimens are 100 mm in diameter and 200 mm height.

(d) For Flexural Strength Test The test samples are prepared using beam moulds of 100 mm x 100 mm x 500 mm.

Permeability Test

The permeability of the pervious concrete sample was evaluated from the expression given below:

K = 2.303 [(a x L) / A] x [t2 – t1] x log [h1 / h2]

### *A Ratio Proportions of the Materials*

*Cement Aggregate Ratio*

The cement aggregate ratio while preparing the test samples are 1:4, 1:6, 1:8, and 1:10. But generally we prepare the samples using 1:4, 1:6, and 1:8.

*B Water Cement Ratio*

Generally, the water cement ratio ranges from 0.35 to 0.4. But we prefer 0.4 ratio.

*Special Cementitious Materials*

(a) Silica Fume can replace cement by 5-12%, but we use 10% replacement for better results. So, the ratio of silica fume to cement will be 1:9.

(b) Zeolite can replace cement by 10%. So, the ratio of zeolite and cement will be 1:9.

(c) Fly Ash replaces cement by 5-65%. We prepare test cubes with 10%, 15%, 25%, 35%, 50% replacements with fly ash in cement mix to test for which percentage of replacement of fly ash gives better results.

(d) Blast Furnace Slag is occasionally used as replacement for cement in pervious concrete. It can replace 20-70% of cement. We generally test for 30%, 40%. Therefore the ratio of blast furnace slag to cement is 3:7 and 4:6. This usage material is very low profile due to its transportation issues.

*Flexural strength sample*

Durability test sample

The Durability of Concrete is the resistance of concrete to weathering action, chemical attack, abrasion and other degradation processes. Cylinders of size 100 mm diameter and 200 mm height are made for an experimental investigation of Durability of Pervious Concrete. Pervious Concrete has been casted with different concrete mix proportion such as 1:4, 1:6, and 1:8 with 18.75 mm and 9.375 mm gravel size with OPC 53 Grade Cement.

Durability test sample

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 05, May-2018

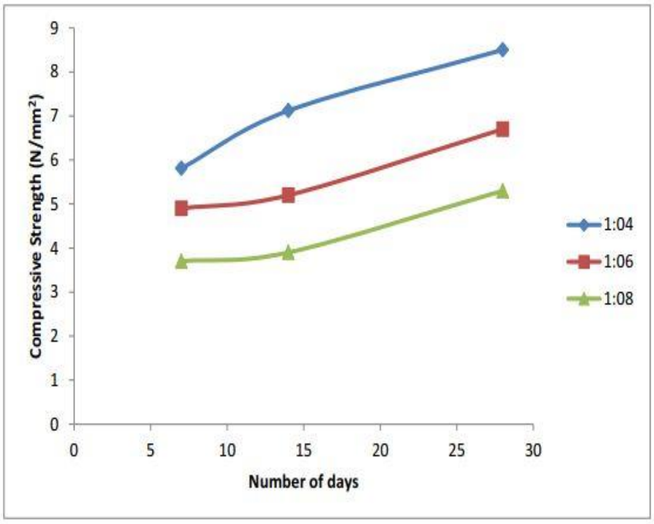
All test samples

Compressive Strength Test Results

Samples prepared using cement and coarse aggregate

| Age | Water/cement ratio | Cement/Aggregate ratio | Calculated value($N/mm^2$) |
|---|---|---|---|
| 7days | 0.4 | 1:4 | 5.81 |
| | | 1:6 | 4.9 |
| | | 1:8 | 3.7 |
| 14 days | 0.4 | 1:4 | 7.12 |
| | | 1:6 | 5.2 |
| | | 1:8 | 3.9 |
| 28 days | 0.4 | 1:4 | 8.5 |
| | | 1:6 | 6.7 |
| | | 1:8 | 5.3 |

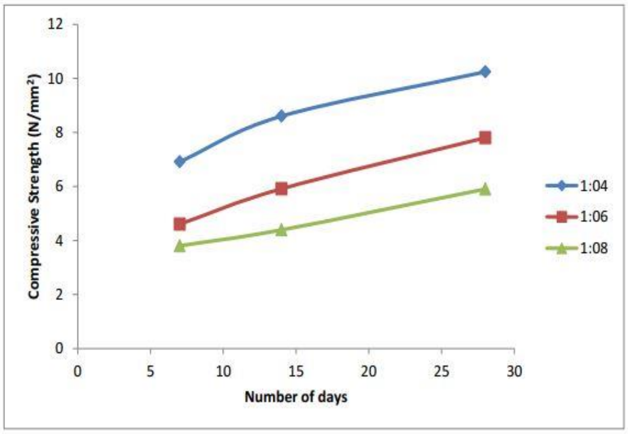
**Compressive Strength of cement and aggregate proportions**




Samples prepared by replacing cement with 10% zeolite

| Age | Water/cement ratio | Cement/Aggregate ratio | Calculated value($N/^{mm2}$) |
|---|---|---|---|
| 7days | 0.4 | 1:4 | 6.91 |
| | | 1:6 | 4.6 |
| | | 1:8 | 3.8 |
| 14 days | 0.4 | 1:4 | 8.6 |
| | | 1:6 | 5.91 |
| | | 1:8 | 4.39 |
| 28 days | 0.4 | 1:4 | 10.24 |
| | | 1:6 | 7.8 |
| | | 1:8 | 5.9 |

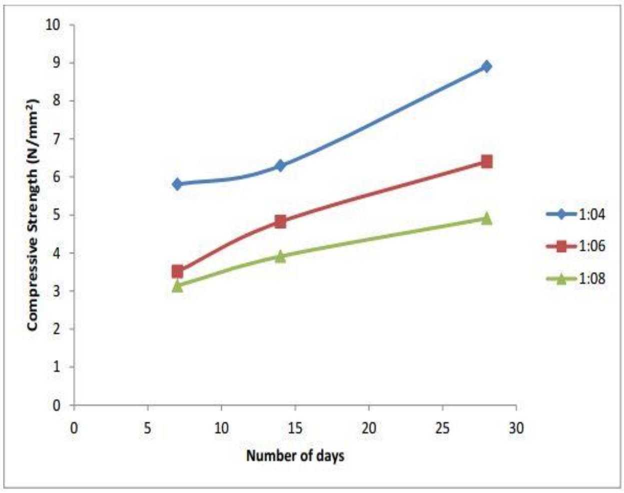
Compressive Strength of cement and aggregate proportions with replacement by 10%
Zeolite




Samples prepared by replacing cement with 10% silica fume

| Age | Water/cement ratio | Cement/Aggregate ratio | Calculated value($N/^{mm2}$) |
|---|---|---|---|
| 7days | 0.4 | 1:4 | 5.8 |
| | | 1:6 | 3.51 |
| | | 1:8 | 3.14 |
| 14 days | 0.4 | 1:4 | 6.29 |
| | | 1:6 | 4.82 |
| | | 1:8 | 3.91 |
| 28 days | 0.4 | 1:4 | 8.9 |
| | | 1:6 | 6.4 |
| | | 1:8 | 4.91 |

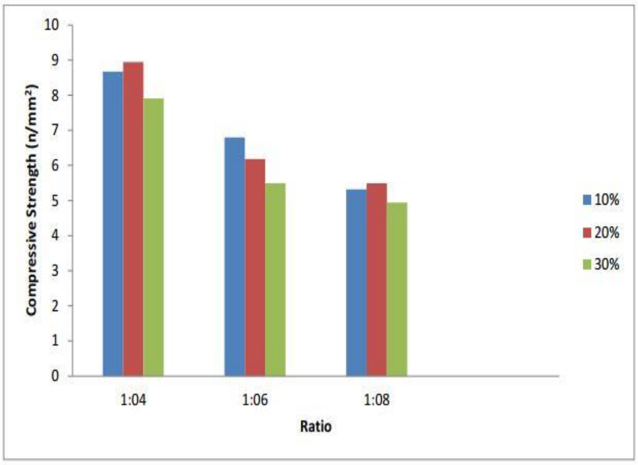
Compressive Strength of cement and aggregate proportions with replacement by 10%
Silica Fume




Samples prepared by replacing cement with 10%, 20%, and 30% fly ash

| Age | Water/cement ratio | Cement/Aggregate ratio | Fly ash % | Calculated value($N/mm^2$) |
|---|---|---|---|---|
| 28 days | 0.4 | 1:4 | 10% | 8.67 |
| | | | 20% | 8.94 |
| | | | 30% | 7.91 |
| | | 1:6 | 10% | 6.8 |
| | | | 20% | 6.18 |
| | | | 30% | 5.49 |
| | | | 10% | 5.32 |
| 28 days | 0.4 | 1:8 | 20% | 5.49 |
| | | | 30% | 4.94 |

Graph for the replacement of cement with 10%, 20%, and 30% fly ash for 28 days




## CONCLUSION

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 (gardens).

The ideal pervious concrete mix is expected to provide the maximum compressive strength, and the optimal infiltration rate. The ratios 1:4 and 1:6 are quiet resourceful and are abundantly used for construction works, due to their high performance regarding any problems.

Pervious concrete is a smart sustainable option with very high potential. Pervious concrete is an ideal solution to control storm water, re-charging of ground water, flood control at downstream and sustainable land management. Knowledge on pervious concrete is very well received by the Specifies / Architects / Engineers.

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