# 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 flatwork applications that allows water from precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. It is also called as porous concrete, permeable concrete, no fines concrete and porous pavement. Pervious concrete is made using large aggregates with little to no fine aggregates. The concrete paste then coats the aggregates and allows water to pass through the concrete slab. This type of concrete having a high void content of about 30%, is becoming popular nowadays due to its potential to reduce the runoff to the drainage systems which can provide a water flow rate around 0.34 cm/second. It is an important application for sustainable construction and is one of many low impact development techniques used by builders to protect water quality . Pervious concrete also find its effective application in low loading intensity parking pavements, footpaths, walkways and highways. The pervious concrete is considered as an Environmental Protection Agency (EPA) for providing pollution control, storm management and suitable development. It is a composite material produced by mixing cement, inert matrix of sand and gravel or crushed stone. This concrete has a light colour and open-cell structure because of which they do not absorb heat from the sun; they also do not radiate the heat back into the atmosphere, which reduces heating in the environment. Pervious concrete has low installation costs. In addition, it filters the storm water thus reducing the number of pollutants entering the rivers and ponds. Pervious concrete also improves the growth of trees. In the present study the behaviour of pervious concrete has been studied experimentally. The water-cement ratio was kept at different ratios 0.35, 0.40, 0.45. Different properties of pervious concrete e.g. workability, compressive strength, split tensile strength, flexural strength test at 7, 14 & 28 days have been studied experimentally. The mix proportions with aggregates size (4.75 mm to 10 mm) gives higher strength when compared to mixes with aggregates size (10 mm to 20 mm) and (4.75 mm to 20 mm) respectively.**

***Keywords*: pervious concrete, Mix proportion, Permeability, porosity.**

## 1. INTRODUCTION

### 1.1 GENERAL:

Construction technology has seen a rapid change over time. Many typical structures can be constructed within a month of duration using advanced construction techniques. Through it is proven that no construction can be done economically without using concrete.The word “concrete” originates from the Latin verb “concretes” which means to grow together.Concrete is a construction material that consists of cement, aggregate, and water. Concrete solidifies and hardens after mixture and placement due to a chemical process known as hydration. The water reacts with cement, which bonds the other components together and eventually creating a stone material. It is used to make pavement, architectural structure, foundation, overpasses, parking structure etc.., those concrete are rigid material with high compressive strength and weak in tensile strength. Reinforcing bars are used to improve the tensile strength. Fresh concrete is a freshly mixed material; which can be moulded into any shape, the relative quantities of cement, aggregate and water mixed together control the properties of concrete in the wet state as well as in the hardened state. The strength of concrete mainly depends on water cement ratio. If the water cement ratio increases then too much the bleeding of concrete takes place and the strength of concrete also reduced.

Generally the high performance concrete usually contains ordinary Portland cement. The use of different types of sub-products into the cement based materials has become a common practice in concrete industry. Pervious concrete is an innovative material which is a mixture of coarse aggregate, cement, water and little to no sand containing a network of holes or voids, to allow air or water to move through . This allows water to drain naturally through it and allow replenishment of groundwater when conventional concrete does not. This innovative material sometimes called as No Fines Concrete also. Absence of sand or fine aggregate permit the properly placed pervious concrete to have about 15 to 30% of void space, the pores can range from 0.08 to 0.32 inches (2 to 8mm), which permit water to pass through without causing any damage to the matrix of the porous concrete .In the recent past due to climatic imbalance land is drying up causing a serious problem. Rather than building them with conventional concrete or asphalt, more and more communities, municipalities, and businesses are switching to pervious concrete or porous pavement, a material that offers the inherent durability and low life-cycle costs of a typical concrete pavement while retaining storm water runoff and replenishing local watershed systems.

### 1.2OBJECTIVES:

In this report, the effects of varying the components of pervious concrete on itscompressive strength are investigated. The goal is to achieve a maximum compressive strength without inhibiting the permeability characteristics of the pervious concrete. This will be accomplished through extensive experiments on test cylinders created for this purpose. Experiments include specific gravity tests, permeability tests, and compression tests.Loadings on pervious concrete are also an area of concern. Existing pervious concrete pavements are studied.

**1.3The benefits from its use are its potential to:**

•Reduce the quantity of runoff water
• Improve water quality
• Enhance pavement skid resistance, especiallyduring storm events by rapidly draining rain water
• Reduce traffic-induced noise levels

## 2.LITERATURE REVIEW

### 2.1 GENERAL

A detail review of literature has been carried out and the works done by various researches in the field of various concrete are presented in this chapter**.**To create a pervious concrete structure with optimum permeability and compressive strength, the amount of water, amount of cement, type and size of aggregate, and compaction must all be considered. A multitude of experiments have been previously conducted throughout the past few decades by a variety of researchers comparing some or all of these elements.

### 2.2 LITERATURE SURVEY

**Ravindrarajah Sri R. and Yukari A., (2010**)They have studied the environmentally friendly pervious concrete for sustainable construction. This paper reports an experimental investigation into the, physical and engineering properties of pervious concrete having varying amount of low calcium fly ash as the cement replacement material. Various properties of pervious concrete were studied such as porosity, unit weight, and compressive strength, weight loss on drying, free drying shrinkage and water permeability under constant head. It seems that porosity has significant effect on compressive strength and permeability of pervious concrete. Replacement of 50% cement by fly ash had no significant effect on water permeability but it was noted that there is a marginal strength effect of pervious concrete. Three previous concrete mixtures were prepared by replacing 0,20 and 50% of fly ash and its properties were studied. Based on the data, it is obtained that there is a co-relation between strength and porosity and between permeability and porosity. It also found that pervious concrete maintain a porosity range of 15- 30%. Also it is assuming that replacement of 50% of cement has no significant effect on water permeability. So it is possible to prepare environment friendly pervious concrete with significantly reduced amount of Portland cement with fly ash. ShackelB .,(2006)

**Yang J. and Jiang G.(2003)** have evaluated the experimental study on properties of pavement material. In the present study porous material were introduced for roadway application. By introduction of smaller sized aggregate, super plasticizer and silica fume can enhance the strength of the pervious concrete. It is concluded that the material can achieve maximum compressive strength of 50 MPa and the flexural strength 6 MPa. Controlling the pressing force to keep the unit weight of 1900-2100 kg/m3 can ensure good wear penetration. Patil S.S and Khurd V.G (2016) have investigated the stress and deflection response analysis of a concrete pavement resting on elastic foundation (spring foundation) subjected to static circular wheel loads at interior, edge and corner part of concrete pavement by using Westergaard‟s closed form solution and compare the results with A3D-FE modelling in ANSYS. The study reveals that Finite Element Method can be applicable and reliable tool for concrete pavement analysis.

**Ibrahim H.A and Razak H.A (2016)** have studied the addition of palm oil clinker on properties of pervious concrete. In this study, Palm oil clinker is taken as the coarse aggregate in the fabrication of pervious concrete. Raw materials like Portland cement Type I,10 mm size coarse aggregate and fixed water-cement ratio of 0.3 are used. Here, natural aggregate are replaced by Palm oil clinker ranging from 0-100%. The test results indicated that substitution with POC decreases the strength of the material but porosity and permeability increases. The compressive strength of the material lies between 3.43- 9.52 MPa. It is noted that loss in strength was about 65% is observed full replacement. However, replacement of Palm oil clinker at 25% shows better performance among all. As such, it has been identified as the best mix for optimum performance of the POCPC.

**Yeih W et al. (2015)** have studied the engineering properties of pervious concrete made with air-cooling electric arc furnace slag as aggregates. It is observed from the experiment that porous concrete prepared from EAFS aggregates have better mechanical strength and water permeability than that made with natural river gravels. Apart from this porous concrete made with EAFS aggregates had a lower weight loss than that made with natural river gravels for the soundness tests. It is found that EAFS based pervious concrete has a higher water permeability and higher compressive strength than that made with gravels. The compressive strength is higher than 21 MPa and water permeability is 0.01 cm/s.

**Gesoglu M. et al. (2014)** investigating the properties of pervious concretes containing waste tire rubber. Three types of rubber were used in the production of rubberized plain pervious concrete mixtures which obtained by partially replacing the aggregate with rubber. Here, water-cement (w/c) ratio, moist curing period, and rubber contents by total aggregate volume were considered as experimental parameters. The results compared with non-rubberized pervious concrete (control) mixture. Finally it is concluded that the use of rubber significantly improve the engineering properties and permeability.

**Hossain T et al. (2012)** have studied the pervious concrete using brick chips as coarse aggregate-An experimental study. The properties of pervious concrete such as strength, permeability and void ratio were investigated. Different sizes of aggregate were used here. Stone aggregates were also used here for comparison purposes. Relationships among various parameters i.e. strength, void ratio, aggregate size, permeability for two different pervious concrete are also presented here. It can be seen that pervious concrete made of brick chips performs well in respect of permeability. However; the strength of this concrete is lower than that of the stone aggregate concrete. Brick aggregate can effectively be used as a coarse aggregate in pervious concrete. From experiment it was found that strength of brick aggregate pervious concrete is less than that of stone aggregate concrete for same aggregate size. However, permeability of brick aggregate pervious concrete is higher than stone aggregate pervious concrete. Thus brick aggregate can be used in pervious concrete in places where load is comparatively less and more permeability is required. Mixture of different size of brick aggregate may produce higher strength concrete therefore; will increase its suitability and scope of applications.

**DarshanS.Shah et al.(2014)** studied the hardened properties of pervious concrete. Compressive strength, split Tensile Strength and flexural Strength are included in hardened properties of pervious concrete. To investigate the result of compressive strength, cubes of size 150 mm x 150 mm x 150 mm are prepared and for flexural strength, beams of size 500 mm x 100 mm x 100 mm are prepared and investigation should be carried out at a regular interval of 7,14 and 28 days . Mix design were prepared in the ratio such as 1:6, 1:8 and 1:10 with different size of gravel such as 18.75 mm and 9.375 mm should be used to check both these hardened properties of pervious concrete . Test results indicates that smaller size of gravel (9.375 mm gravel) has more Compressive Strength (12.71 N/mm2 ) and Flexural Strength (1.91 N/mm2 ) with 1:6 concrete mix proportion and for OPC 53 Grade Cement .

**Alaica A.L et al. (2010)** have carried out his experiment on optimizing strength and permeability of pervious concrete. This paper mainly focused on evaluating the performance of different pervious concrete mixture is an endeavor to achieve an optimized mix with adequate tensile strength and porosity. Apart from this, a relationship was investigated between permeability and porosity of different mixture. The mix design variables investigated in this study included aggregate to cementing materials ratio (A/C), aggregate gradation, cementing material blend, ternary blend of silica fume/slag and metakaolin/slag were examined. Single and hybrid fiber systems were also evaluated. These included wollastonite natural fibers and polypropylene macro-fibers. From the above, the following results are comes out. An optimized pervious concrete mix was achieved using aggregate size of 10-13mm, cement to aggregate to ratio of 1:4 and a ternary cementing blend of silica fume and slag. Testing of tensile strength revealed that the addition of wollastonite and polypropylene fibers improved the strength of the paste.

## 3.MATERIAL AND DESIGN METHODOLOGY

### 3.1 GENERAL

The present chapter deals with the presentation of results obtained from various tests conducted on material used for the concrete. In order to achieve the objectives of present study, an experimental program was planned to investigate polyvinyl chloride on compression strength and split tensile strength of concrete. The various steps involved in our thesis are as follows,

1. Need for safety
2. Literature review
3. Identification of materials
4. Collection of materials
5. Testing of materials
6. Mix design preparation.
7. Specimen casting
8. Results and conclusion

### 3.2 MATERIALS

The properties of materials used for making concrete mix are determined in laboratory as per relevant codes of practice. Different materials used in present study were cement, coarse aggregates, and fine aggregates, in addition to crushed PVC pipes. The aim of studying of various properties of material is used to check the appearance with codal requirements and to enable an engineer to design a concrete mix for a particular strength.

#### 3.2.1 Ordinary Portland cement

Ordinary Portland cement is the most important type of cement and is a fine powder produced by grinding Portland cement clinker. The OPC is classified into three grades, namely 33 grade, 43 grade, 53 grade depending upon the strength of 28 days. It has been possible to upgrade the qualities of cement by using high quality limestone, modern equipment's, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cement offers many advantage for making stronger concrete.Ordinary Portland cement (OPC) of 53 Grade (Ambuja cement) was used throughout the course of the investigation. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture. The various tests conducted on cement are initial and final setting time, specific gravity, fineness and compressive strength.

#### 3.2.2 Aggregates

Aggregates constitute the bulk of a concrete mixture and give dimensional stability to concrete. To increase the density of resulting mix, the aggregates are frequently used in two or more sizes. The most important function of the fine aggregate is to assist in producing workability and uniformity in mixture. The fine aggregate is to assist the cement paste to hold the coarse aggregate particles in suspension. This action promotes plasticity in the mixture and prevents the possible segregation of paste and coarse aggregate, particularly when it is necessary to transport the concrete some distance from the mixing plant to placement. The aggregates provide about 75percentage of the body of the concrete and hence its influence is extremely important. They should therefore meet certain requirements if the concrete is to be workable, strong, durable and economical. The aggregate must be proper shape, clean, hard, strong, and well graded.

**Coarse Aggregates:**

The aggregates which is retained over IS sieve 4.75mm is termed as coarse aggregate. The coarse aggregates may be of following types Crushed graves or stone obtained by crushing of gravel or hard stone .Uncrushed gravel or stone resulting from the natural disintegration of rocks .Partially crushed gravel obtained as product of blending of above two types .The normal maximum size is gradually 10-20 mm; however particle sizes up to 40mm or more have been used in self compacting concrete. Regarding the characteristics of different types of aggregate, crushed aggregates tend to improve the strength because of interlocking of angular particles, while rounded aggregates improved the flow because of lower internal friction .Locally available coarse aggregate having the maximum size of 20mm was used in this work. The aggregates were washed to remove dust and dirt and were dried to surface dry condition. The aggregates were tested as per IS: 383-1970. Specific gravity and other properties of coarse aggregates are given in table 3.1, 3.2. The sieve analysis of coarse aggregates was done.

**A .Specific Gravity**

Specific gravity is used in design calculation of concrete mixes. With the specific gravity of each constituent known, its weight can be converted into solid volume and hence a theoretical yield of concrete per unit volume can be calculated. Specific gravity of aggregate is also required to be considered when we deal with light weight and heavy weight concrete.

**Table 3.1** Specific Gravity of coarse aggregates

| **S .No** | **Description** | **Trial –I (Kg)** | **Trial – 2 (Kg)** |
|---|---|---|---|
| 1. | Weight of empty pycnometer ($W_1$) | 0.656 | 0.654 |
| 2. | Weight of pycnometer + coarse aggregate ($W_2$) | 1.262 | 1.252 |
| 3. | Weight of pycnometer + coarse aggregate + water ($W_3$) | 1.872 | 1.865 |
| 4. | Weight of pycnometer + water ($W_4$) | 1.487 | 1.485 |

Specific gravity = $(W_2-W_1)/ (W_4-W_1)-(W_3-W_2)$
Specific gravity = 2.76

**B .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/$m^3$

**Table 3.2** Properties of coarse Aggregates

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

**C .Fineness Modulus (Sieve analysis)**

The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation. The test consists of the simple operation of dividing aggregates into fractions, each consisting of particles of the same size. The sieve analysis on coarse aggregate was carried out as per IS2386 (Part I) -1963 and results are presented in table 3.3.

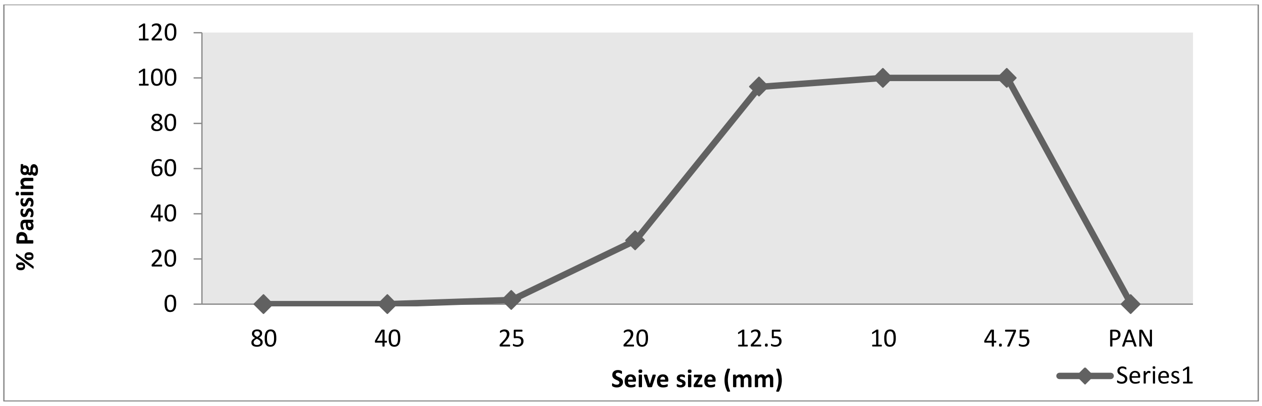



fig3.1 Fineness Modulus Graph for Coarse

**D .Crushing strength on aggregate:**

Dimension of mould = 15.10cm

Height of mould = $(\pi x(15.1)^2)/(4x13) = 2328.02cm^3$

Table 3.4: Crushing strength on aggregate

| S. No | Total weight of aggregate ($W_1$)g | IS sieve 2.36mm passing materials ($W_2$)g | Aggregate crushing value ($W_2/W_1$)x100g |
|---|---|---|---|
| 1. | 2500 | 400 | 16.00 |
| 2. | 2500 | 350 | 14.00 |

**Calculation:**

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

**E .Water absorption test:**

All aggregate particles contain small pores that vary in size and number from particle to particle. Oven-dry aggregate particles exposed to water absorb water into the pores. The rate September 1, 2003 CONCRETE MANUAL 5-694.123 and extent of absorption into the particles depends on the size of the pores and the amount of water available for absorption. For test purposes, the material is considered to have absorbed its maximum quantity of water when it has remained submerged in water at approximately 21ºC (70ºF) for 48 hours. The absorption factor of a test sample of material is determined by dividing the difference in mass (weight) between the saturated surface dry material and the oven-dry material by the oven-dry mass (weight).

Table No.3.5: water absorption test

| S .No | 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 $=W_3/W_1$x100g |
|---|---|---|---|---|
| 1. | 200 | 210 | 10 | 5% |
| 2. | 200 | 210 | 10 | 5% |

**Calculation:**

To find $W_3 = W_2-W_1$ = 210-200 = 10g

% of water absorption;$=W_3/W_1$x100g = 5%

**F .Loss angle abrasion test on coarse aggregate**

Table No.3.6 Abrasion test

**g)**

| 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<br>(5000-4785)/5000)x100= 4.3% |

**Impact test on coarse aggregate**

Table 3.7 Impact test on coarse aggregate

| S .No | 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 2.36mm sieve test($W_2$)g | 80 | 84 |
| 3. | Weight of aggregate retained 2.36mm 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

**3.2.3Water**

Generally, water that is suitable for drinking is satisfactory for use in concrete. Water from lakes and streams that contain marine life also usually is suitable.. Water from such sources should be avoided since the quality of the water could change due to low water or by intermittent tab water is used for casting. The portable water is generally considered satisfactory for mixing and curing of concrete in material testing laboratory. This was free from any detrimental contamination and was good potable quality.

**4. Mix Design**

Although pervious concrete contains the same basic ingredients as the conventional concrete, the proportions of the ingredients can vary. One major difference is the requirement of increased void content within the pervious concrete. The amount of void space is directly correlated to the permeability of the pavement .The need for void space within the mix design correlates with using little to no fine aggregates .The porous concrete mix designs adopted for this study were based on materials that were readily available in the metropolitan area.

The mix consisted of 200 lbs. of #8 Stone (Millville), little to no fine aggregates, cement type I-/II, and macro/micro fibers. The mix also included admixtures including a Viscosity Modifying Admixture (VMA), an air entraining agent, and a High-Range Water Reducer (HRWR). These admixtures are used to potentially improve the bond between the cement and the coarse aggregate, and to improve workability as well as flexural properties of the pervious concrete. A retarder was also included since the low water content of porous concrete pavement mixes causes them to dry quickly. The sand content was varied for all mixes. Trial batches were prepared and tested for acceptable unit weights and percent voids.

**Mix Design Calculations Mix Proportion For M30 Grade of Pervious Concrete:stipulation For Proportioning Grade for proportioning: M30**

- Type of cement: OPC 43 grade confirming to IS 8112
- Maximum nominal size aggregate: 20 mm
- Minimum cement content: 320 kg/m3
- Maximum water cement ratio: 0.35
- Workability: 100 mm (slump)
- Exposure condition: Severe
- Method of concrete placing: ?
- Degree of supervision: Good
- Type of aggregate: Crushed angular aggregate
- Maximum cement content: 450 kg/m3 Test Data For Materials
- Cement used: OPC 43 grade conforming to IS 8112
- Specific gravity of cement: 3.15
- Specific gravity of coarse aggregate: 2.74
- Water absorption of coarse aggregate: 0.5%
- Free moisture of coarse aggregate: Nil

**Target Strength For Mix Proportion**

From table 1, of IS 10262 : 2009,
Standard deviation, s = 5 N/mm2
Therefore, target strength = 30 + 1.65 * 5 = 38.25 N/mm2

**Selection of Water Cement Ratio**

From Table 5, IS 456,
Maximum water cement ratio (see Note under 4.1) = 0.45
Based on experience, adopt water cement ratio = 0.35
0.35 < 0.45
Hence, ok.

**Selection of Water Content**
From Table 2, from IS 10262, 2009,
Maximum water content for 20 mm aggregate
= 186 lit ( for 25 to 50 mm slump range)
Estimated water content for 100 mm slump
= 186+6/100*186 =197 lit.

**Calculations of Cement Content**
Water cement ratio = 0.35
Cement content=197/0.35=562.86kg/m3>450kg/m3
Hence, consider cement content =450kg/m3………(From IS 456, clause no.8.2.4.2)
From Table 5, of IS 456,
Minimum cement content for „severe" exposure condition = 320 kg/m3
450 kg/m3> 320 kg/m3,
Hence, ok.

**Proportion of volume of coarse aggregate content**
From table 3, of IS 10262: 2009, volume of coarse aggregate corresponding to 20mm size aggregate (zone) for water-cement ratio of 0.50 = 0.60
In the present case water-cement ratio is 0.35. Therefore, volume of coarse aggregate is required to be increased. As the water cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02.
Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.35 = 0.64
Therefore, volume of coarse aggregate = 0.64 * 0.9 = 0.58

**Mix Calculation**
a. Volume of concrete =1 m3
b. Volume of cement = Mass of cement /Specific gravity of water * 1/1000 = 450/3.15*1/1000
= 0.143 m3 Type equation here.
c. Volume of water = Mass of water / Specific gravity of water * 1/1000 =197/1 * 1/1000
= 0.197 m3
d. Volume of all in aggregate = (a-(b+c))
= (1-(0.143+0.197)) = 0.660 m3
e. Mass of coarse aggregate = d * Volume of coarse aggregate * Specific gravity of Coarse aggregate * 1000 = 0.660 * 0.58 * 2.74 * 1000 = 1048.87 kg = 1050 kg

**Mix Proportion**
Cement = 450 kg/m3
Water = 197 kg/m3
Coarse aggregate = 1050 kg
Water cement ratio = 0.35
Ratio = (C : S :A) = (1 : 0 : 2.33)

**Table 4.1 Mix proportions**

| Water cement ratio | cement | fine aggregates | Coarse aggregates | Water content |
|---|---|---|---|---|
| 0.45 | 437.78kg/m$^3$ | - | 1050kg/m$^3$ | 197 kg/m$^3$ |
| 0.40 | 450kg/m$^3$ | - | 1147.53kg/m$^3$ | 197 kg/m$^3$ |
| 0.35 | 450kg/m$^3$ | - | 1020kg/m$^3$ | 197 Kg/m$^3$ |

## 5. Test Methods

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

**a).Slump cone test**

Slum is a measurement of concrete's workability, or fluidity .It's an indirect measurement of concrete consistency or stiffness.
A slump test is a method used to determine the consistency of concrete. The consistency, or stiffness ,indicate how much water has been used in the mix .The stiffness of the concrete mix should be matched to the requirement for the finished quality.

**Type of Slump.**
1.Collapse slump
2.Shear slump
3.True slump

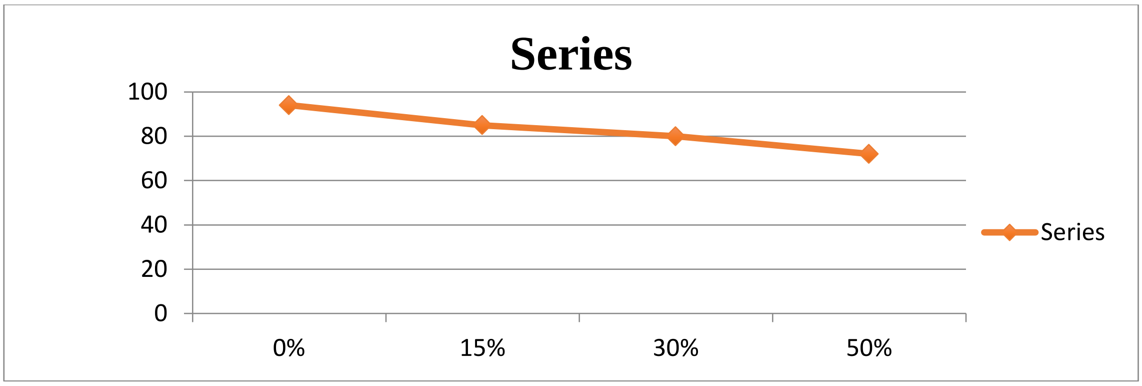



Fig 5.1Graph for Test on slump value

**b).Compaction test on concrete**

It is a test that is used to determine the compacting factor of the prepared concrete mix.

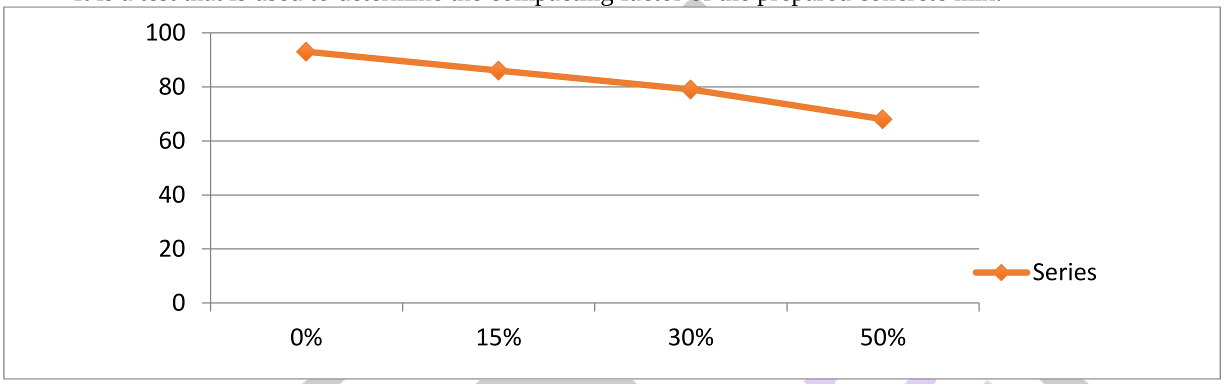



Fig 5.2 Graph for compaction test on concrete

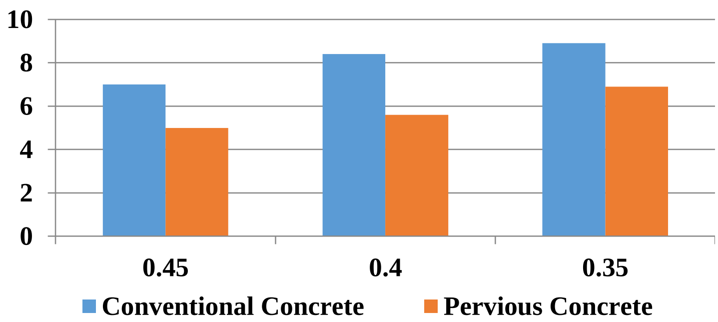
## 6.RESULTS AND DISCUSSION

The experimental program included the following:

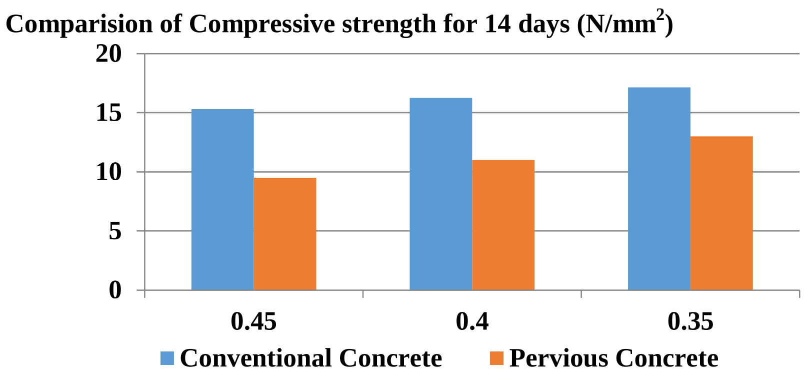
1. Testing of properties of materials used for making concrete.
2. Design mix (M30).
3. Casting and curing of specimens.
4. Test to determine the compressive strength.

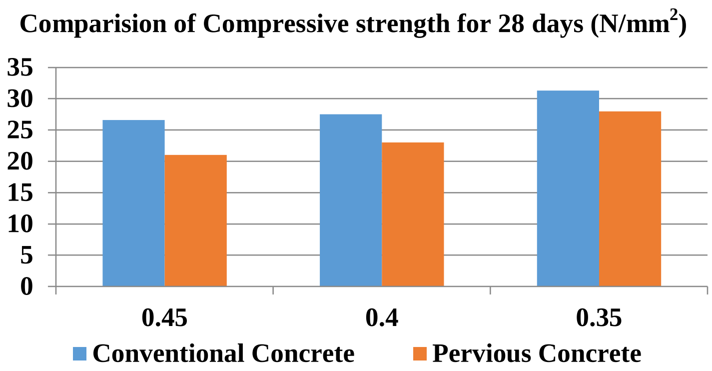
### 6.1COMPRESSIVE STRENGTH

Test specimen of size 150mm x 150mm x 150mm was prepared and tested using the compressive testing machine. 28-day compressive strength tests were performed in accordance with ASTM C39, Standard Test Method for Compressive Strength of Concrete Specimens.




**Comparision of Compressive strength for 7 days (N/mm$^2$)**




**6.3 Freeze-Thaw Resistance**

Freeze-thaw resistance of pervious concrete in the field appears to depend on the saturation level of the voids in the concrete at the time of freezing. In the field, it appears that the rapid draining characteristics of pervious concrete prevent saturation from occurring. Anecdotal evidence also suggests that snow-covered pervious concrete clears quicker, possibly because its voids allow the snow to thaw more quickly than it would on conventional pavements. In fact, several pervious concrete placements in North Carolina and Tennessee have been in service for over 10 years. Note that the porosity of pervious concrete from the large voids is distinctly different from the microscopic air voids that provide protection to the paste in conventional concrete in a freeze-thaw environment. When the large open voids are saturated, complete freezing can cause severe damage in only a few cycles. Standardized testing by ASTM C 666 may not represent field conditions fairly, as the large open voids are kept saturated in the test, and because the rate of freezing and thawing is rapid. It has been shown that even after 80 cycles of slow freezing and thawing (one cycle/day), pervious concrete mixtures maintain more than 95% of their relative dynamic modulus, while the same mixtures showed less than 50% when tested at a more rapid rate (five to six cycles/day). It was noted that better performance also could be expected in the field because of the rapid draining characteristics of pervious concrete.Research indicates that entrained air in the paste dramatically improves freeze-thaw protection for pervious concrete. In addition to the use of air-entraining agents in the cement paste, placing the pervious concrete on a minimum of 6 inches (150 mm), and often up to 12 (300 mm) or even 18 inches (450 mm) of a drainable rock base, such as 1-inch (25-mm) crushed stone, is normally recommended in freeze-thaw environments where any substantial moisture will be encountered during freezing conditions.

**6.4 Sulfate Resistance**

Aggressive chemicals in soils or water, such as acids and sulfates, are a concern to conventional concrete and pervious concrete alike, and the mechanisms for attack are similar. However, the open structure of pervious concrete may make it more susceptible to attack over a larger area. Pervious concretes can be used in areas of high-sulfate soils and groundwaters if isolated from them. Placing the pervious concrete over a 6-inch (150-mm) layer of 1-inch (25-mm) maximum top size aggregate provides a pavement base, stormwater storage, and isolation for the pervious concrete. Unless these precautions are taken in aggressive environments, recommendations from ACI 201 on water-to-cement ratio and material types/proportions should be followed strictly.

**6.5 Abrasion Resistance**

Because of the rougher surface texture and open structure of pervious concrete, abrasion and raveling of aggregate particles can be a problem, particularly where snow plows are used to clear pavements. This is one reason why applications such as highways are generally not suitable for pervious concretes. However, anecdotal evidence indicates that pervious concrete pavements allow snow to melt faster, requiring less plowing. Most pervious concrete pavements will have a few loose aggregates on the surface in the early weeks after opening to traffic. These rocks were loosely bound to the surface initially, and popped out because of traffic loading. After the first few weeks, the rate of surface raveling is reduced considerably and the pavement surface becomes much more stable. Proper compaction and curing techniques reduce the occurrence of surface ravelling.

**7. CONCLUSION**

This study illustrates angularity number, which influence properties and behavior of pervious concrete with coarse aggregates. The ideal pervious concrete mix is expected to provide the maximum compressive strength, and the optimal infiltration rate. Especially for pervious concrete used on roadways, there is the need for it to be able to withstand various traffic loadings while providing adequate infiltration to reduce surface run offs. From the results of the analysis, the Control Mix is recommended. The control design mix showed a maximum compressive strength of $31 N/mm^2$ with a coefficient of permeability ranging between 57.8 and 299.5 in/hr. The standard Proctor Hammer compaction method appears to be the optimum procedure for preparing the pervious concrete. Under real applications the water would have sent the cement completely through the aggregate and into the sub base, leaving the aggregate with little cement for bonding. Although a wide range of compressive strengths were obtained, none of the mixtures provide strength equal to that of conventional concrete.

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