



# DESIGNING AND MODELING OF PERVIOUS CONCRET PAVEMENT

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**Abstract:** Pervious Concrete is a special type of concrete, which consist of cement, coarse aggregates, water and if required admixtures and other cementitious materials. As there are no fine aggregates used in the concrete mix, the void content is more which allows the water to flow through its body. So, the Pervious Concrete is also called as Permeable Concrete and Porous Concrete.

There is lot of research work is going in the field of Pervious Concrete. The compressive strength of Pervious Concrete is less when compared to the conventional concrete due to its porosity and voids. Hence, the usage of Pervious Concrete is limited even though it has lot of advantages. If the compressive strength and flexural strength of Pervious Concrete is increased, then it can be used for a greater number of applications. For now, the usage of Pervious Concrete is mostly limited to light traffic roads only. If the properties are improved, then it can also be used for medium and heavy traffic rigid pavements also. Along with that, the Pervious Concrete eliminates surface runoff of storm water, facilitates the ground water recharge, and makes the effective usage of available land.

The Pervious Concrete can be an important part of context-sensitive construction and low-impact development used to improve water quality by capturing the “first flush” of surface runoff, reducing temperature rise in receiving waters, increasing base flow, and reducing flooding potential by creating short term storage detention of rainfall. In order to fully utilize these benefits, the hydrological behavior of the pervious concrete system must be assessed. The hydrological performance is usually a key parameter in decisions to use this material as a best management practice for storm water management.

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.

***Index Terms - Concrete, cement, Pervious Concrete structure, storm water***

## 1. INTRODUCTION

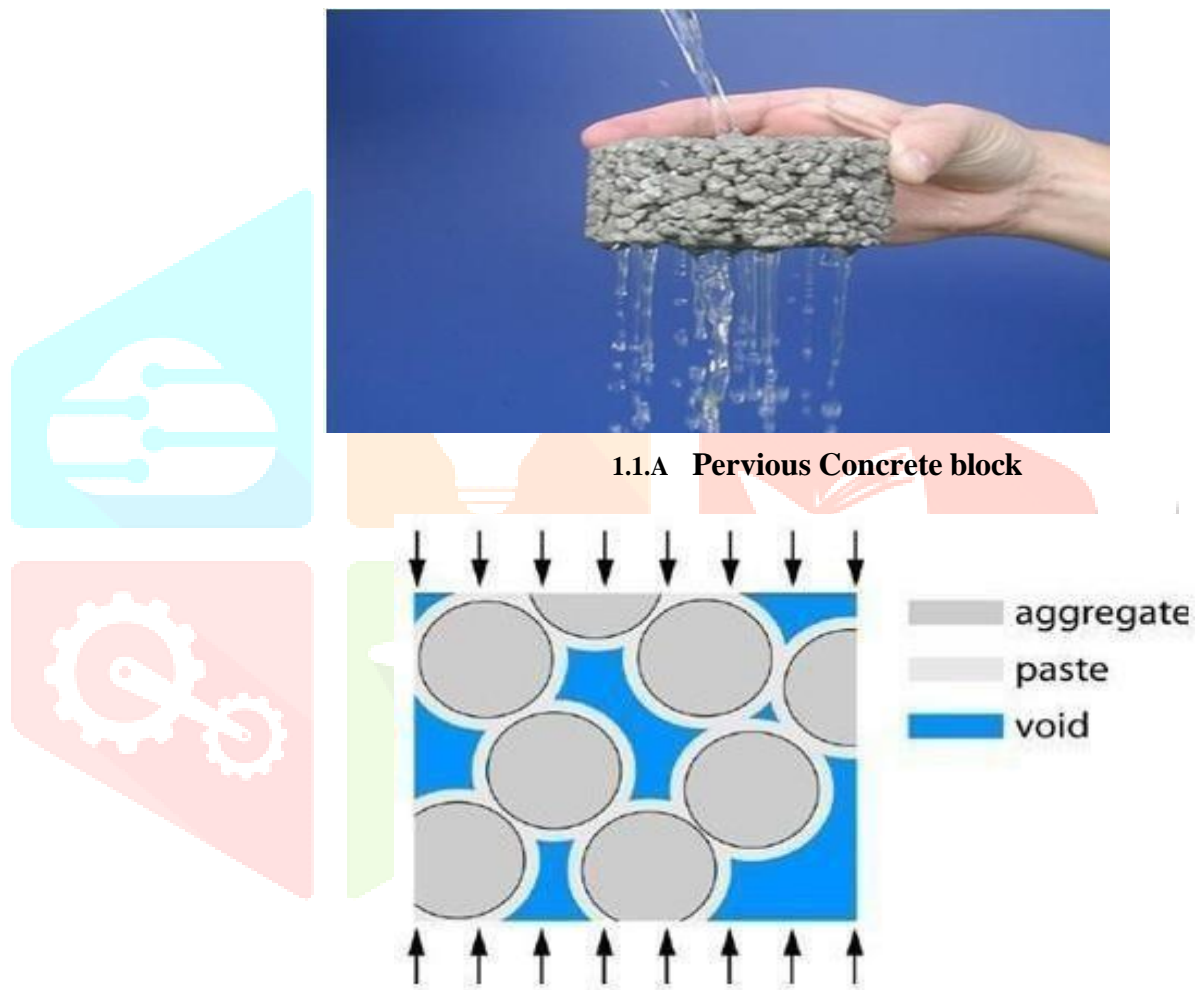
### 1.1 GENERAL ABOUT PERVIOUS CONCRETE

Pervious Concrete, which is also known as the 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 is a mixture of gravel or granite stone, cement, water, with or without admixtures. When Previous Concrete is used for paving, the open cell structures allow storm water to filter through the pavement and into the underlying soils. In other words, Previous Concrete helps in protecting the surface of the pavement and its environment. As stated above, Previous 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. Pervious Concrete can allow the passage of [11.33-18.97] liters of water per minute through its open cells for each square foot (0.0929m<sup>2</sup>) of surface area which is far greater than most rain occurrences.

Pervious Concrete is a special concrete used to intentionally allow water to pass through the surface of a pavement and allow storm water to eventually absorb back into the surrounding soils or evaporate. This keeps runoff water from downstream urban flooding and erosion. It also breaks the cycle of water treatment plants needing to treat storm water where municipalities have combined sewer and storm water systems. Pervious Concrete pavements are “Best Management Practices” (BMP’s) to collect, clean and cool storm water. This usually eliminates the need for detention/retention ponds, thus reducing construction expenses, safety issues, and maintenance.

The single-diameter aggregates from a framework for Pervious Concrete and the aggregates are bound together with cement paste. (Photo 1.1.A) The voids maintained throughout the structure due to the single-diameter aggregates being held together with the thin cement paste allow air or water to penetrate through the Pervious Concrete.



**1.1.B Schematic diagram of Pervious Concrete structure**

Because the cement paste that binds the structure together is thin, this reduces the strength of pavement. For this reason, Pervious Concrete would not be appropriate for highway use, as it would need to accommodate for high volume of heavy vehicle traffic each day. It could however be implemented on the highway shoulders, which do not carry the repetitive loads of vehicle traffic each day. Also, because Pervious Concrete has numerous voids exposed to the surface, it is prone to clog with debris, which could hinder water from infiltrating through the structure. This can be prevented with proper maintenance techniques. These properties are important for the proper functionality of this material. Higher compressive strength is a plus but not a determining factor for quality.

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 water percolates back in ground where it belongs. Pervious Concrete is rough textured, and has a honeycombed surface, with moderate amount of surface raveling which occurs on heavily travelled roadways. While casting carefully controlled amount of water and cementations materials are used to create a paste. The paste then

forms a thick coating around aggregate particles, to prevent the flowing off the paste during mixing and placing. Using enough paste to coat the particles to maintain a system of interconnected voids which allow water and air to pass through. The lack of sand in Previous Concrete results in a very harsh mix that negatively affects mixing, delivery, and placement due to the high void content, Previous Concrete is light in weight. ( $1600\text{kg/m}^3$  -  $2000\text{kg/m}^3$ ). Pervious Concrete can be used in a wide range of applications, although its primary use is in pavements which are in residential roads, alleys and driveways, low volume pavements, low water crossings, sidewalks and pathways, parking areas, tennis courts, slope tennis stabilization, sub-base for conventional concrete pavements etc.

Pervious Concrete system has advantages over impervious concrete in that it is effective in managing run-off from paved surfaces, prevent contamination in run-off water, and recharge aquifer, repelling saltwater intrusion, control pollution in water seepage to ground water recharge concrete and asphalt, reduces the need for air conditioning. Pervious Concrete allows for increased site optimization because in most cases, it use should totally limit the need for detention and retention ponds, swales and other more traditional storm water management devices that are otherwise required for compliances with the Federal storm water air temperature will be reduced, requiring less power to cool the building. In addition, costly storm water structures such as piping, inlets and ponds will be eliminated. Construction scheduling will also be improved as the stone recharge bed will be installed at the beginning of construction, enhancing erosion control measures, and preventing rain delays due to harsh site conditions. Apparently, when compared to conventional concrete, Pervious Concrete has a lower compressive strength, greater permeability, and a lower unit weight (approximately 70% of conventional concrete). However, Pervious Concrete has a greater advantage in many regards. Nevertheless, it has its own limitations which must be put into effective consideration when planning its use. Structurally when higher permeability and low strength are required the effect of variation in aggregate size on strength and permeability for the same aggregate cement ratio need to be investigated.

## 1.2 WHY DO WE NEED PERVIOUS CONCRETE

A large amount of rainwater ends up falling on impervious surface such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil. This creates an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion and pollution of river, lakes, and coastal water as rainwater rushing across pavement surfaces picks up everything from oil and grease spills to de-icing salts and chemical fertilizers.

A simple solution to avoid these problems is to stop constructing impervious surface that block natural water infiltration into the soil. Rather than building them with conventional concrete or Asphalt, we should be switching to Pervious Concrete or porous pavement, a material that offers the inherent durability of low life cycle cost of a typical concrete pavement while retaining storm water runoff and replenishing local water shade system. Instead of preventing infiltration of water into the soil, Pervious Concrete pavement assists the process by capturing rainwater in a network of voids and allowing it to percolate into the underlying soil. In many cases, Pervious Concrete roadways and parking lots can double as water retention structures, reducing or eliminating the need for traditional storm water management system such as retention ponds, sewer tie-ins.

Pervious Concrete also naturally filters water from rainfall or storm and can reduce pollutant loads entering streams, ponds, and river. So, in this way it helps in ground water recharge.

It also reduces the bad impact of urbanization on trees. A Pervious Concrete ground surface allows the transfer of water and air to root system allowing trees to flourish. For a given rainfall intensity, the amount of runoff from a Pervious Concrete pavement system is controlled by the soil infiltration rate and the water storage capacity available in the Pervious Concrete and aggregate subbase under the Pervious Concrete. Generally, for a given set of materials, the strength and infiltration rate of Pervious Concrete are a function of concrete density. Greater the density, higher is the strength and lower the infiltration rate.

## 1.3 OBJECTIVES OF PERVIOUS CONCRETE

The objectives include finding optimal Pervious Concrete mix designs for wearing course sections in pavement applications. Information needed for the wearing course sections must address the issue of noise and skid resistance, assuming adequate strength and durability are developed. The constructability issues are also very critical. It is of paramount importance for the research to determine techniques for construction that utilize existing pavement equipment. At present the construction of Pervious Concrete sections is quite labour intensive. The use of Pervious Concrete as a wearing course entails construction of a concrete overlay in rehabilitation efforts. In new construction, two-lift construction is a possibility.

1. Pervious Concrete has little or no fine aggregate.
2. It has just enough cementitious paste to coat the coarse aggregate particles while preserving the

interconnectivity of the voids.

3. Pervious Concrete is traditionally used in parking areas, areas with light traffic, pedestrian walkways, and greenhouses and contributes to sustainable construction.
4. It consists of 15% to 35% voids, allowing for quick drainage.
5. The infiltration rate of pervious concrete will fall into the range of 80 to 720 lits/min/sq.m.
6. To help restore ground water supply.
7. Reduce pollution of costal water.
8. To pave parking.
9. To recharge ground water table.
10. Reduces runoff water.
11. Reduces risk of flooding and topsoil wash away.

#### 1.4 AIM OF PROJECT

The name of our project is “**Designing and Modeling of Pervious Concrete Pavement.**” The trend of today is to make impervious concrete pavement and thus not allowing water to percolate in the ground. These will not only increase the runoff from the road but also reduce virgin land area from where water will recharge the surface. For most of the cities, ground water requirement has declined up to 30m and more observed. In order to tackle the growing problem of ground water level declined, it is necessary to take up for water conservation and artificial recharge to ground water on priority. If impervious concrete pavement constructed, sufficient slope should be given to reach up to the storm drainage line. This will increase amount of concrete/ aggregate in constructing impervious road and forced to increase the capacity of storm water drainage network. To minimize this problem best method is “act locally” i.e. wherever water drops it will reach in that locality only. For these different techniques are available. One of the methods is to construct Pervious Concrete Pavement.

In our Amravati city ground water level has declined to a greater depth. Scenario of today’s Amravati is that construction of impervious pavement in every locality, so instead of constructing whole locality with impervious pavement at least walkways, parking lots, etc., or where there is a low traffic area should be constructed with Pervious Concrete pavements, so that it will help in increasing ground water level of Amravati city.

Basically, the aim of our project is to make awareness in people for constructing Pervious Concrete pavement, so that it can be greatly helpful for us and upcoming new generation.

#### 1.5 FUTURISTIC SCOPE

- 1.5.1 Pervious Concrete is a special type of concrete with a high porosity used for concrete flatwork applications that allows water precipitation and other sources to pass directly through, thereby reducing the runoff from a site and allowing groundwater recharge. In India, the issue of urbanization of cities left many metro cities in floods.
- 1.5.2 For example, floods faced in Mumbai are perfect example of how much Pervious Concrete can be utilized. In Mumbai, due to additional growth of areas, one of the areas where a river which used to take water out of city and pour it in sea was blocked. After these, the outcomes were loud and clear. Mumbai faced its worst flood ever which not only handicapped the city but also killed many.



**1.5.A Waterlogged concrete pavement road**

- 1.5.3 As the scope of urban cities will increases, Pervious Concrete can provide a solution to this rapid growth of cities. The Pervious Concrete pavement can absorb the noise of vehicles, which creates quiet and comfortable environment.
- 1.5.4 The Pervious Concrete pavement materials have holes that can cumulate heat. Such pavement can adjust the temperature and humidity of the Earth's surface and eliminates the phenomenon of hot

island in cities.

- 1.5.5 In urban areas larger amount of rainwater ends up falling on impervious surfaces such as parking lots, driveways, sidewalks, and streets rather than soaking into the soil. In future this will create an imbalance in the natural ecosystem and leads to a host of problems including erosion, floods, ground water level depletion and pollution of rivers, as rainwater rushing across pavement surfaces picks up everything from oil and grease spills to de-icing salts and chemical fertilizers.
- 1.5.6 A simple solution to avoid these problems is to stop constructing impervious surfaces that block natural water infiltration into the soil. Rather than building them with conventional concrete, we should be 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.
- 1.5.7 Instead of preventing infiltration of water into the soil, Pervious pavement assists the process by capturing rainwater in a network of voids and allowing it to percolate into the underlying soil.



### 1.5. B Project concrete block (porosity)

- 1.5.8 Theoretically the sound absorption properties of a rigid frame porous medium are mainly influenced by void texture and thus the main focus of modelling is to determine the generalized void texture.
- 1.5.9 Since porous sound absorbing materials, such as polyurethane, fabrics, formed metal, etc. The main concern of the present study is the absorption characteristics of porous concrete in case the vertical incidence acoustic wave has occurred.
- 1.5.10 Many other type of noise including the rolling noise of vehicles or impact noise with high sound pressure considering random incidence acoustic waves, also need to be considered when designing porous concrete used as an acoustic wall.
- 1.5.11 However, this issue is beyond the scope of present work, nevertheless, it should be subject of future work for developing more versatile acoustic absorption models for porous concrete.
- 1.5.12 There are many factors that give rise to water scarcity. One of such factors is the urbanization of areas and decreases in the natural pervious soil area that result in reduced magnitude of the ground water recharge.
- 1.5.13 As India is facing the problem of water, In future there will be too much shortage of water in world. Groundwater tables and river levels are receding in many parts of the world due to human water use.
- 1.5.14 In India, farmers are now using nearly 80% of the country's available water, largely from groundwater wells. We will have to buy water for drinking purposes. With the help of pervious pavement, we can store rainwater and it can be very helpful in future.
- 1.5.15 The increasing number of paved roads consequently decreases the area of pervious soil, due to which the ground water table is affected. One-third of the developing world will face severe water shortages in the twenty-first century even though large amounts of water will continue to annually flood out to sea from water-scarce regions.

## 2. LITERATURE REVIEW

### 2.1 GENERAL

Literature review of relevant literature published earlier, technical paper by various agencies is carried out. In this literature review attention is given about how new construction material like Pervious Concrete is used for pavement. The purpose of this literature review is getting an overview of new construction material like Pervious Concrete by using of different proportions and to know various research studies related to efficient and economic pavement construction, also the compressive strength. To achieve this purpose, study result is given by various authors are mentioned here in this literature review.

**2.1.1 “Use of Pervious concrete in construction of pavement for improving their performance.” Mr. V. R. Patil, Prof. A. K. Gupta, Prof. D. B. Desai.** Our cities are being covered with building and the air-proof concrete road more and more. In addition, the environment of city is far from natural. Because of the lack of water permeability and air permeability of the common concrete pavement, the rainwater is not filtered underground. Without constant supply of water to the soil, plants are difficult to grow normally. In addition, it is difficult for soil to exchange heat and moisture with air; therefore, the temperature and humidity of the Earth's surface in large cities cannot be adjusted. Pervious concrete is also widely used in Europe and Japan for roadway applications as a surface course to improve skid resistance and reduce traffic noise. However, the strength of the material is relatively low because of its porosity. The compressive strength of the material can only reach about 20 - 30MPa. The pervious concrete can only be applied to squares, footpaths, parking lots, and paths in parks.[1]

**2.1.2 “ Pervious Concrete: New Era For Rural Road Pavement”. Darshan Shah, Prof. Jayeshkumar Pitroda, Prof. J.J. Bhavsar 2013.**Pervious Concrete is a relatively new concept for rural road pavement, with increase into the problems in rural areas related to the low ground water level, agricultural problem. Pervious Concrete has introduced in rural road as a road pavement material. Pervious Concrete as a paving material has seen renewed interest due to its ability to allow water to flow through itself to recharge groundwater level and minimize storm water runoff. This introduction to Pervious Concrete Pavement reviews its applications and engineering properties, including environmental benefits, structural properties, and durability. In rural area cost consideration is the primary factor which must be kept in mind. So that in rural areas costly storm water management practices is not applicable.[2]

**2.1.3 “Ground water Recharging Through Pervious Concrete Pavement”. A. L. Guruji , A.V. Rana, [11 April 2015]** The trend of today is to make Impervious Concrete pavement and thus not allowing water to go in the ground. If Impervious Concrete pavement is constructed, the sufficient slope should be given to reach up to the storm-drainage line. This will increase amount of concrete/aggregate in constructing Impervious Road and forced to increase the capacity of storm water drainage network. For these different techniques are available. One of the methods is to construct Pervious Concrete pavement. In this paper attempt was to be made to prepare such kind of pavement for road, which recharge water directly into the subsurface. For preparing Pervious pavement, aggregates of different sizes, like 4.75mm to 20mm (coarse aggregate) were used. The proportion of aggregate and cement is 1:3 and tried to find best combination. The specimen prepared with coarse aggregate and cement is tested for compressive strength gives good result. Pervious Concrete not only reduce stormwater but also helps in rising ground water level by artificial recharging. There is an urgent need to think over the alternative for impervious pavement created for the sake of cleanness and durability. As the concrete is porous its strength gets reduce. In this paper there is attempt to optimize the available resources. Though the strength of concrete reduces due to Pervious property but can be used where there is a light load expected.[3]

**2.1.4 “Some Aspect on Pervious Concrete”. R. Selvaraj, M. Amirthavarshini, [January 2016]”.The** Pervious Concrete is produce by using materials like cement, aggregate, water and bonding agent. The quantity, proportions, and mixing techniques affect many properties of Pervious Concrete, in particular the voids structure and strength. Usually single sized coarse aggregate up to 20 mm sizes are normally adopted. Although the course aggregate size 6mm the 20mm are used, the most common being 10mm fairly uniform size is used.[4]

**2.1.5 “Pervious Concrete – Overview” Karthik H. Obla 26 july 2017”.**Pervious Concrete is a special high porosity concrete. Concrete mixtures are typically design for 20% void content as there is no significant percolation through the concrete at a void content lower than 15% . There are two factor which determine the design thickness of Pervious pavement, a Pervious Concrete pavement hydraulic properties and mechanically properties. ASTM C1701 is standard test method to calculate the infiltration rate of in place Pervious Concrete. To common preventable problems with Pervious Concrete are surface raveling and clogging. These paper gives the idea about Pervious Concrete projects that have been completed over the last 10years in USA and briefly describes about the successful Pervious Concrete in India.[5]

**2.1.6 “Design and Construction Of an Experimental Pervious Paved Parking Area to Harvest Reusable Rainwater” Elena Gomez-Ullate, Amaya V. Novo, Joseba R.Bayon Jorge R. Hernandez, R. J. and Daniel Castro-Fresno.2010”** Pervious Pavements are sustainable urban drainage system already known as rainwater infiltration techniques which reduce runoff formation and diffused pollution in cities. This research paper especially focused on the design and construction of an experimental parking area. The methodology of this research focused on the study of water storage and water quality within each Pervious pavement type. Aim of this research paper was to obtain good performance of Pervious pavement that offered simultaneously a positive urban service and help to harvest rainwater with a good quality.[6]

**2.1.7 “Deo Omkar, Neithalath Narayanan, “Compressive Strength Of Pervious Concretes Proportioned For Desired Porosities,” Construction and Building Materials vol. No. 25, 2011,p.p. 4181-4189.**In 2010, Omkar Deo, Neithlath Narayanan studied the properties of Pervious Concrete are strongly dependent on its pore structure features, porosity being and important one among them. Several Pervious Concrete mixtures with different pore structure features are proportioned and subjected to static compression test. The compressive stress-strain response of Pervious Concrete, a model to predict the stress-strain response and its relationship to several of the pore structure features are outlined. A statistical model was used to relate the compressive strength to the relevant pore structure features. It was observed that a proper understanding of the influence of the pore structure features on compressive response can lead to optimized material design for the desired properties.[7]

### 3.MATERIAL AND METHODOLOGY

#### 3.1 FLOW CHART OF PROJECT WORK

Collecting various materials which are required for casting like aggregates, cement, admixture.



Casting of 18 Pervious Concrete cubes of (1:3) cement aggregate ratio to be tested at 7 and 28 days.



Casting of 2 slab Pervious Concrete as (1:3) cement aggregate ratio to be tested at 7 and 28 days.



Following test to be carried out:

Slum cone test.

Compressive strength test.

Permeability test.



Result and analysis of Pervious Concrete cubes.



Found effective, hence model making.



Results of the project

**Fig.1: Flowchart of work**

#### 3.2 MATERIAL USED IN PERVIOUS CONCRETE

##### 3.2.1 CEMENT

The product manufactured by burning and crushing to powder and well proportion mixture of calcareous and argillaceous material is called cement. Cement is the key ingredient of the versatile and modern construction material “concrete”.

Pozzolana Portland Cement was used for the project work. Pozzolana is a very old construction material which was in Roman times. It does not have any cementing or binding properties, but in finely ground form, it react with  $\text{Ca(OH)}_2$  to form, compound having cementing properties.

Pozzolana Portland Cement are manufactured by using Pozzolanic materials as one of the main ingredient. The percentage of Pozzolanic material used in the preparation should be between 10% to 30%. If the percentage is exceed, the strength of cement is reduced. Some of the Pozzolanic materials used are volcanic



ash, shales, and certain type of clays. But in our country Fly ash is the main constituents used in the preparation of cement. And moreover, this type of cement is used more than 80% for construction purposes.

### 3.2.1.A Cement

**Table 3.1 Typical Composition Of The Pozzolana Portland Cement**

Name of Compound	Chemical Composition	Abbreviation
Tricalcium Silicate	3CaO.SiO <sub>2</sub>	C3S
Dicalcium Silicate	2CaO.SiO <sub>2</sub>	C2S
Tricalcium Aluminate	3CaO.Al <sub>2</sub> O <sub>3</sub>	C3A
Tetracalcium Alumino Ferrite	4CaO.Al <sub>2</sub> O <sub>3</sub> .Fe <sub>2</sub> O <sub>3</sub>	C4AF

The pozzolana constituent must be within 10 to 25%. The mixing of pozzolana component should be very thorough. Pozzolana Portland Cement can be called a type of low heat cement as it produce low heat of hydration. It has more resistance to attack of aggressive water. It reduces leaching of calcium hydroxide when used in hydraulic structure. Of course, it can be used in all situations wherever OPC can be used.

The new IS code for PPC is 1489-1991 part1. The cement was tested as per IS code provision.

**Table 3.2 Observations of preliminary testing of cement**

Test	Fineness	Standard consistency	Initial setting time	Final setting time	Soundness
Standard value	<10	-	Not less than 30 min	Not greater than 600 min	<10
Result	2.22	33%	34min	566 min	4.47mm

#### ADVANTAGES OF POZZOLANA PORTLAND CEMENT

- (i) These cement gains compressive strength with age.
- (ii) It is highly resistance to sulphates.
- (iii) It gives better workability during preparation of concrete.
- (iv) It evolves low heat during setting.
- (iv) Ultimate strength is more than OPC.
- (v) It is resistance to expansion.
- (vi) It is cheap and affordable.
- (vii) Water tightness.

#### 4.EXPERIMENTAL STUDY

Pervious Concrete uses the same materials as conventional concrete, except that there is usually little or no fine aggregate. The quantity, proportions, and mixing techniques affect many properties of pervious concrete, in particular the void structure and strength. Usually, single sized coarse aggregate up to 20 mm size normally adopted. Larger size aggregates provide a rougher concrete finish while smaller size aggregates provide smoother surface that may be better suited for some application such as pedestrian pathways. Although the coarse aggregate size 6 mm to 20 mm are used, the most common being 10 mm uniform size is used. The aggregates may be rounded like gravel or angular like crushed stone.

Since the Pervious Concrete is highly permeable, the voids between aggregate particles cannot be entirely filled by cement paste. Use of smaller size aggregates can increase the number of aggregate particles per unit volume of concrete. As the aggregate particle increase the specific surface and thus increases the binding area. This results in the improved strength of pervious concrete. However, the major thrust for using Pervious Concrete stems from its capability to drain and potentially de-pollute enormous amounts of water in short time, thus reducing the runoff rates.



In our project we used Pozzolana Portland cement, and admixture Conplast SP430 for casting. To study the behavior of Pervious Concrete pavement, we adopted two different cement to aggregate ratio and different size of course aggregate for gap grading are as follows:

**Table 4.1 Cement /aggregate ratio for proportion 1:4.5**

Sr. No.	Percentage of Aggregate	Experimental Mix
1	60%	20mm
	40%	10 mm
2	100%	10mm
3	100%	6mm

**Table 4.2 Cement/aggregate ratio for proportion 1:3**

Sr. No.	Percentage of Aggregate	Experimental Mix
1	100%	20 mm
2	100%	10 mm
3	100%	6 mm

**4.1 Casting:** Quantity of material used for casting is given below For proportion 1:3

**Table 4.3 Quantity of materials (1:3)**

Sr. No.	Materials	Proportions (kg/m <sup>3</sup> )
1	Cement	395.4
2	Aggregate	1738.44
3	Water cement ratio	0.3
4	Admixture	20ml per 50kg

**Casting of cubes**

**Table 4.4 Quantity of materials (1:3)**

Sr. No.	Materials	Proportions (kg/m <sup>3</sup> )
1	Cement	543.18
2	Aggregate	1629.54
3	Water Cement ratio	0.3
4	Admixture	20ml per 50 kg

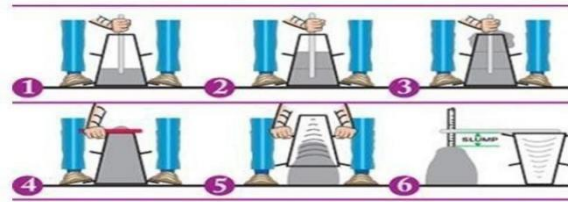
## 4.2 TESTING

### 4.2.1 Slump Cone Test

The concrete slump test measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due to the simplicity of apparatus used and simple procedure. The slump test is used to ensure uniformity for different loads of concrete under field conditions.

#### Procedure

The test is carried out using a metal mould in the shape of a conical frustum known as a slump cone or Abrams cone, that is open at both ends and has attached handles. The tool typically has an internal diameter of 100 millimeters (3.9 in) at the top and of 200 millimeters (7.9 in) at the bottom with a height of 300 millimeters (12.0 in). the cone is placed on a hard non-absorbent surface. This cone is filled with fresh concrete in three stages. Each time, each layer is tamped 25 times with a 2 ft (600 mm)-long bullet-nosed metal rod measuring 5/8 in (16 mm) in diameter. At the end of the third stage, the concrete is struck off flush with the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete cone. The concrete then slumps (subsides). The slump of the concrete is measured by measuring the distance from the top of the slumped concrete to the level of the top of the slump cone.



#### 4.2.1 (a) Diagrammatical representation of slump cone test procedure

The slumped concrete takes various shapes and according to the profile of slumped concrete, the slump is termed as true slump, shear slump or collapse slump. If a shear or collapse slump is achieved, a fresh sample should be taken and the test repeated. A collapse slump is an indication that the mix is too wet.

Only a true slump is of any use in the test. A collapse slump will generally mean that the mix is too wet or that it is a high workability mix, for which the slump test is not appropriate. Very dry mixes having slump 0 – 25 mm are typically used in road making, low workability mixes having slump 10 – 40 mm are typically used for foundations with light reinforcement, medium workability mixes with slump 50 – 90 mm, are typically used for normal reinforced concrete placed with vibration, high workability concrete with slump > 100 mm is typically used where reinforcing has tight spacing, and/or the concrete has to flow a great distance.



4.2.1 (b) Casting of slump cone

#### 4.2.2 Compressive Strength Test

Compressive strength of concrete cube test provides an idea about all the characteristics of concrete. By this single test one judge that whether Concreting has been done properly or not. Concrete compressive strength for general construction varies from 3 MPa to 28 MPa. Compressive strength of concrete depends on many factors such as water- cement ratio, cement strength, quality of concrete material, quality control during production of concrete etc. Various standard codes recommend concrete cylinder or concrete cube as the standard specimen for the test. these specimens are tested by compression testing machine after 7 days curing or 28 days curing. Load should be applied gradually at the rate of 140 kg/cm<sup>2</sup> per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

##### Sampling of Cubes for Test

- i) Clean the moulds and apply oil
- ii) Fill the concrete in the Moulds in layers approximately 5cm thick
- iii) Compact each layer with not less than 25 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet pointed at lower end)
- iv) Level the top surface and smoothen it with a trowel

##### Curing of Cubes

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the moulds and kept submerged in clear fresh water until taken out prior to test.

##### Procedure for Cube Test

- (I) Remove the specimen from water after specified curing time and wipe out excess water from the surface.
- (II) Take the dimension of the specimen to the nearest 0.2m.
- (III) Clean the bearing surface of the testing machine.
- (IV) Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
- (V) Align the specimen centrally on the base plate of the machine.
- (VI) Rotate the movable portion gently by hand so that it touches the top surface of the specimen.

(VII) Apply the load gradually without shock and continuously at the rate of 140 kg/cm<sup>2</sup> /minute till the specimen fails.

(VIII) Record the maximum load and note any unusual features in the type of failure.

### Compressive Strength of Concrete at Various Ages.

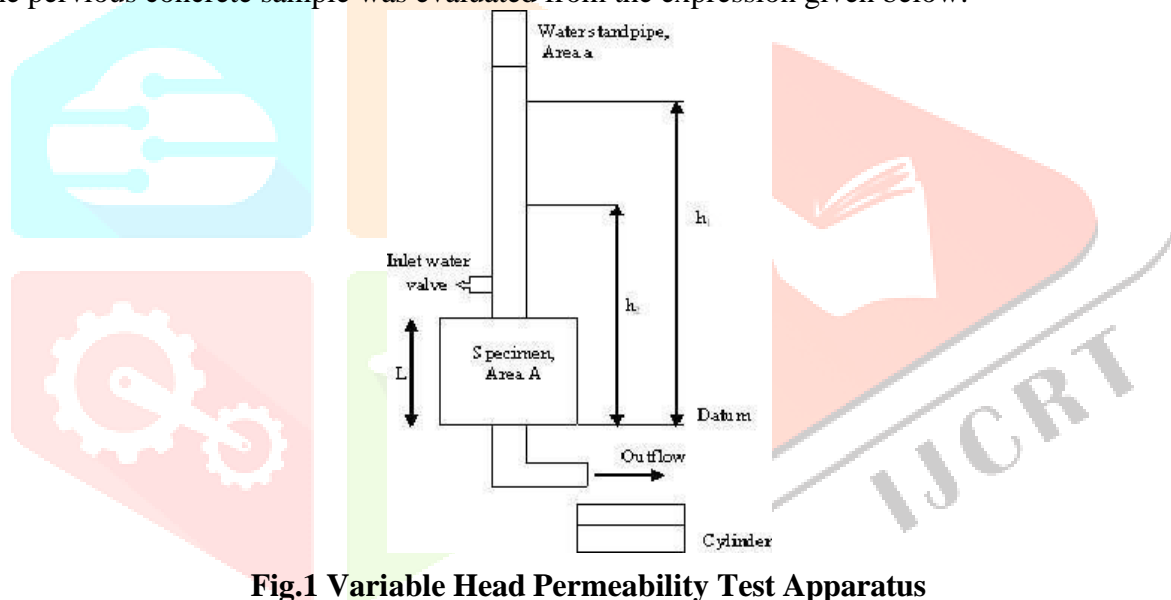
The strength of Pervious Concrete increases with age. Table shows the strength of concrete at different ages in comparison with the strength at 28 days after casting.

**Table 4.5 strength of concrete**

Age	Strength per cent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

#### 4.2.3 Permeability Test

The permeability of pervious concrete was determined using a falling head Permeability set up Figure. Water was allowed to flow through the sample, through a Connected standpipe which provides the water head. Before starting the flow measurement, the samples were wrapped with polythene inside the cylinder. Then the test started by allowing water to flow through the sample until the water in the standpipe reached a given lower level. A constant time of 5seconds was taken for the water to fall from one head to another in the standpipe. The standpipe was refilled and the test was repeated when water reached a lower. The permeability of the pervious concrete sample was evaluated from the expression given below:



**Fig.1 Variable Head Permeability Test Apparatus**

$$\text{Formula: } K = \frac{2.303aL}{A(t_2 - t_1) \times \log\left(\frac{h_1}{h_2}\right)}$$

Where,

a = the sample cross section are

A = the cross section of the standpipe of diameter (d) = 0.95cm<sup>2</sup> L = the height of the pervious concrete

(t<sub>2</sub> - t<sub>1</sub>) = change in time for water to fall from one level to another (5secs.)

h<sub>1</sub> = upper water level h<sub>2</sub> = Lower water level

D = diameter of sample (10.5cm)

d = diameter of standpipe (1.1cm)

#### 4.2.3. A Permeability testing on 20mm size slab

#### 4.2.3. B Permeability testing on 10mm size slab

#### 4.2.3. C Permeability testing on 6mm size slab



#### 4.2.4 Flexural strength test

Direct measurement of tensile strength of concrete is difficult. Neither specimens nor testing apparatus have been designed which assure uniform distribution of the pull applied to the concrete. While number of investigation involve the direct measurement of tensile strength have been made ,beam tests are found to be dependable to measure flexural strength properly of concrete. The flexural strength is found in form of modulus of rupture. The system of loading used in finding out tension is central point loading and third point loading.

The standard size of specimen is 15x15x70cm. The mould should be metal preferably steel or cast iron and metal should be of sufficient thickness to prevent spreading or warping. The bed of testing machine should be provided with two steel rollers, 38mm in diameter. The load is applied axially and without subjecting specimen to any torsional stresses.

The test specimen stored in water at temperature of 24°C to 30°C for 48 hours before testing Test the specimen immediately on removal of from water whilst they still in wet condition. The axis of specimen carefully aligned with axis of loading device. The load is applied without shock and increasing continuously at the rate of 0.7kg/sq.cm./min. The load is increased until the specimen fails, and maximum load applied to specimen during test is recorded. The flexural strength of specimen is expressed in modulus of rupture as-

$$f_b = 3 \times p \times \frac{a}{b} \times d^2$$

Where,

b = width of specimen in cm.

d = depth of specimen in cm.

p = maximum load applied in kg to specimen

a= distance between the line of fracture and nearer support, measured on centerline of tension side of specimen.



#### 4.2.4 Flexural strength testing on slab

#### 4.2.5 Split tensile strength test

This test was developed in Brazil in 1943. This is also referred as, “Brazilian Test”. The test is carried out by placing the cylindrical specimen horizontally between the loading surfaces of a compression testing machine. The size of specimen is 150 mm in diameter and 300 mm in depth. The load is applied until specimen fail along vertical diameter.

The loading condition produces a high compressive stress immediately below the two generators to which is applied. But larger portion corresponding to depth is subjected to uniform tensile stress acting horizontally. It is estimated that compressive stress acting about D/6 depth and remaining depth is subjected to tension. In order to reduce the magnitude of compressive force near point of application of the load, narrow packing strips of suitable material such as plywood are placed, to distribute the load economically.

The main advantage of this test is same type of machine can be used performed both compression test as well as tensile test. This test gives more uniform results than another test. Strength determined in the splitting tensile strength test is believed to be closer to true tensile strength of concrete than modulus of rupture.

## 5. RESULTS AND DISCUSSION

### 5.1 Properties of cement tested at Concrete technology laboratory.

**Table 5.1.1 Cement test observation**

Sr. No.	Properties	Value
1	Fineness	2.22
2	Standard consistency	33%
3	Setting time a)Initial setting time b)Final setting time	34 min 566 min
4	Soundness	4.47 mm

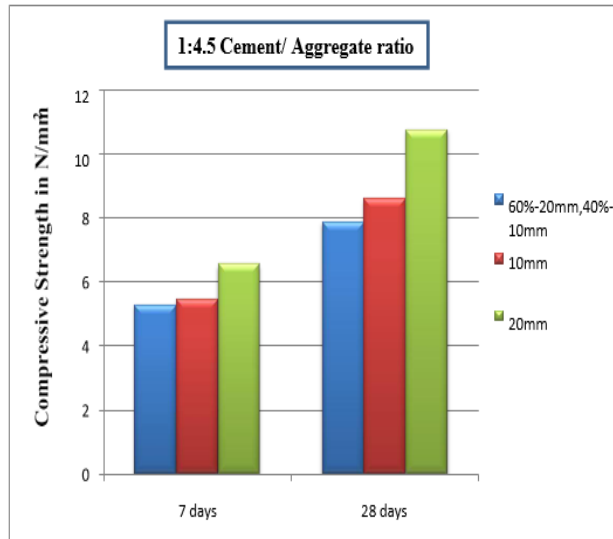
### 5.2 Compressive strength test results

**Table 5.2.1 Compressive strength for 7 Days (1:4.5)**

Sr. No	Cement/Aggregate ratio	% of aggregate	Size of aggregate in mm	Strength			
				7 Days			
				Sample 1	Sample 2	Sample 3	Avg N/mm <sup>2</sup>
1	1:4.5	40%	10	5.636	5.411	4.786	5.277
		60%	20				
		100%	10	5.421	5.896	5.092	5.469
		100%	20	6.941	7.034	5.726	6.567

**Table 5.2.2 Compressive strength for 28 Days (1:4.5)**

Sr. No	Cement/Aggregate ratio	% of aggregate	Size of aggregate in mm	Strength			
				28 Days			
				Sample1	Sample2	Sample3	Avg N/mm <sup>2</sup>
1	1:4.5	40%	10	8.052	8.228	7.364	7.880
		60%	20				
		100%	10	9.856	8.800	7.172	8.609
		100%	20	10.29	12.584	9.372	10.75



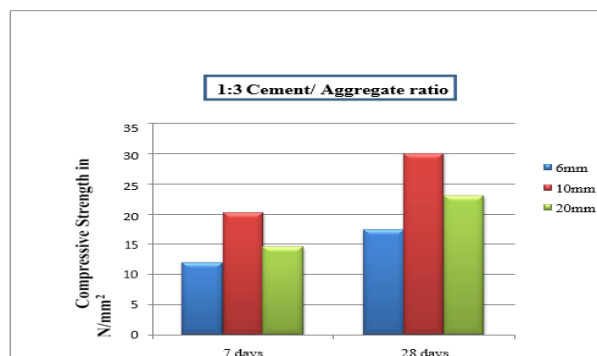
Graph 5.2.1 for 1:4.5 cement/aggregate ratio

Table 5.2.3 Compressive strength for 7 days (1:3)

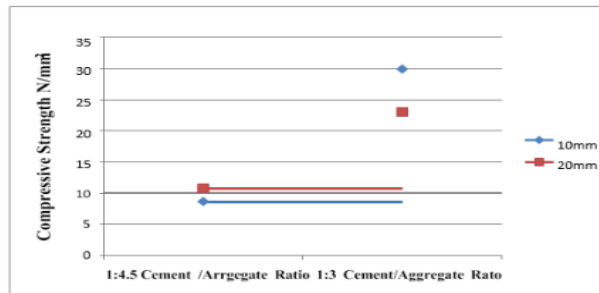
Sr. No	Cement/Aggregate ratio	% of aggregate	Size of aggregate in mm	Strength			
				7 Days			
				Sample1	Sample2	Sample3	Avg N/mm <sup>2</sup>
1	1:3	100%	6	13.662	11.206	10.918	11.931
		100%	10	19.999	18.438	22.207	20.214
		100%	20	14.209	15.977	13.475	14.546

Table 5.2.4 Compressive strength for 28 days (1:3)

Sr. No	Cement/Aggregate ratio	% of aggregate	Size of aggregate in mm	Strength			
				28 Days			
				Sample1	Sample2	Sample3	Avg N/mm <sup>2</sup>
1	1:3	100%	6	18.216	17.24	16.676	17.380
		100%	10	30.58	29.740	29.612	29.977
		100%	20	21.860	22.792	24.50	23.050



Graph 5.2.2 For 1:3 cement /aggregate ratio



Graph 5.2.3 Comparison of compressive strength for different ratio

### 5.3 Permeability Test Result

Table 6.4 Permeability test result for various layers of slab

Sr No.	Size of aggregate in slab	Input	Output	Time taken	Permeability in cm/sec
1	20mm	11 lit	10 lit 200 ml	34 sec	39.85
2	10mm	11 lit	9 lit 700 ml	68 sec	9.094
3	6mm	11 lit	9 lit 200 ml	102 sec	1.157

#### Calculation of Permeability

$$\text{Formula: } K = \frac{2.303aL}{A(t_2 - t_1) \times \log\left(\frac{h_1}{h_2}\right)}$$

Where,

a= Sample cross-section area,

L= Height of the pervious concrete

A= Cross-section of the stand pipe of diameter (d)

h<sub>1</sub>= Upper water level

h<sub>2</sub>= Lower water level

D= Diameter of sample

d= Diameter of Standpipe

(t<sub>2</sub> - t<sub>1</sub>)= Change in time for water to fall from one level to another.

### CONCLUSION

Pervious concrete reduces storm water runoff ultimately increases the capacity of rainwater harvesting system. It also helps to increase the ground water level, to eliminate the costly storm water management practices and compensate extraction of water either in village or city. From results it found that Pervious concrete prepared with all 20 mm size aggregate has maximum compressive strength for 1:4.5 Cement /Aggregate ratio, while Pervious concrete prepared with all 10 mm size aggregate has maximum compressive strength for 1:3 Cement/Aggregate ratio.

Pervious concrete prepared with combination of 10 mm and 20 mm size aggregate has more tensile strength for 1:4.5 Cement/Aggregate ratio and for 1:3 Cement/Aggregate Pervious concrete prepared with all 20 mm size aggregate has maximum tensile strength. Addition of CONPLAST SP 430 accelerates the strength of gain at early age and improves workability of concrete without increasing water demand. Using single size of aggregate for casting pervious concrete gives good permeability. Using single size of aggregate for casting pervious concrete gives good permeability. The permeability value of whole model is found to be 1.41 cm/hr. It is found that Pervious Concrete have less strength than conventional concrete. Hence, it is used for roads having low intensity of traffic. Void ratio and compressive strength of Pervious Concrete are inversely proportional to each other with increase in voids compressive strength decreases. Pervious Concrete pavements are a very cost-effective and environmentally friendly solution to support sustainable construction.

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