Implementation of Permeable Pavements to Avoid Accidents

J Ritesh[1], B.Lokeswar Reddy[2], K.Bharadwaj[3], Y. Sreeragavedra[4]
[1,2]*Assistant Professor,Department Of CIVIL Engineering, GATES INSTITUTE OF TECHNOLOGY::GOOTY Ananthapurum (dist)*
[3]*PG Scholar,Department Of CIVIL Engineering, GATES INSTITUTE OF TECHNOLOGY::GOOTY Ananthapurum (dist)*

***Abstract*-Pervious concrete is one of the best emerging technologies especially used for the surface runoff and to keep the pavement dry for riding conditions. The key concept is the presence of inter connecting voids through which water escapes out leaving the surface dry in contrast to the conventional rigid pavements where we use a mixture of cement ,fine aggregate and coarse aggregate which makes a water tight impervious concrete surface. The absence of the fine aggregate creates a lot of space for the water to infiltrate to the bottom layers from where it will be drained out .By many experiments the infiltration rate comes out to the value of approximately 312 inches / hour.**

The greatest application areas of these pervious concrete are the airport pavements (recently), footpaths and parkings lots. Pervious concrete is formed by a mixture of cement and coarse aggregate with minimum or no fines or zero fine aggregates.

Lots of experimental analysis have been done on this new emerging concept to draw conclusions like use of different water quantities to find infiltration rates ,replacement of cement with slag,TiO2,fly ash etc to find the strength parameters like compressive strengths ,split tensile strengths ,permeability etc, infiltration rate will be increased with provision of beneficial slope in the pavement like 5 % and so on .

INTRODUCTION

PAVEMENTS

Pavement is the actual travel surface especially made durable and serviceable to withstand the traffic load acting upon it. Pavement grants friction for the vehicles thus providing comfort to the drivers and transfers the traffic load from the upper surface to the natural soil.

In the earlier times before the vehicular traffic became most regular, cobblestone paths were much familiar for animal carts and on foot traffic load. This brought up the necessity of providing a hard surface for these wheeled vehicles to move on.

Actually Romans are the pioneers for the roads. During the period of Roman civilization many roads were built of stone blocks of considerable thickness. The Appian way was built in 312 B.C. extending over 580 km.

Pavements are primarily to be used by vehicles and pedestrians. Storm water drainage and environmental conditions are a major concern in the designing of a pavement. Depending on the vertical alignment and the environmental condition of the site, the pavement may be constructed over an embankment, cut or almost at the ground level itself. It is also desirable to construct the pavement well above the maximum level of the ground water or the highest water table, to keep the subgrade soil relatively dry even during mason season.

Generally the pavement structure (from bottom to top) typically consists of the following layers:

Prepared soil subgrade

Granular sub-base course, which serves as drainage layer

Base course

Surface course

All hard road pavements usually fall into two broad categories namely:

Flexible Pavement & Rigid Pavement.

Normally in flexible pavements, the sub-base is made of G.S.B and base course is provided with Wet Mix Macadam and surface course is divided into two parts 1) Dense Bitumen Macadam and 2) Bitumen course.

As well as in rigid pavement, the sub-base course is made of Dry Lean Concrete or Lean Cement Concrete and top layer is provided with Cement Concrete pavement slab

FLEXIBLE PAVEMENT

Flexible pavement on the whole has low or negligible flexible in their structural action.

Flexible pavements are usually asphalt, is laid with no reinforcement or with a specialized fabric reinforcement that permits limited flow or repositioning of the road bed underground changes.

The black top pavement including water and gravel bound macadam fall in this category.

The vertical compressive stress is maximum on the pavement surface directly under the wheel load and is equal to contact pressure under the wheels. Due to the ability to distribute the stress to large area in the shape of truncated cone, the stresses get decreased in the lower layer.

As such the flexible pavement may be constructed in a number of layers and the top layer has to be strongest as the highest compressive stresses.

To be sustained by this layer, in addition to wear and tear, the lower layer have to take up only lesser magnitude of stress as there is no direct wearing action due to traffic loads, therefore interior material with lower cost can be used in the lower layers.

1.1 RIGID PAVEMENTS

The characteristics of the rigid pavement are associated with rigidity or flexural strength or slab action. So the load is distribution over a wide area of subgrade soil. Rigid pavement is laid in slabs with steel reinforcement.

The rigid pavements are made of cement concrete either plain, reinforcement or prestressed concrete. The CC pavement slabs made of plain cement concrete generally expected to sustain up to 45 kg/cm^2 of flexural stress

Critical condition of stress in the rigid pavement is the maximum flexural stress occurring in the slab due to wheel load and the temperature changes.

Rigid pavement is designed and analyzed by using the elastic theory. Rigid pavement lasts much longer i.e. 30+ years. Rigid pavement has the ability to bridge small imperfections in the subgrade.

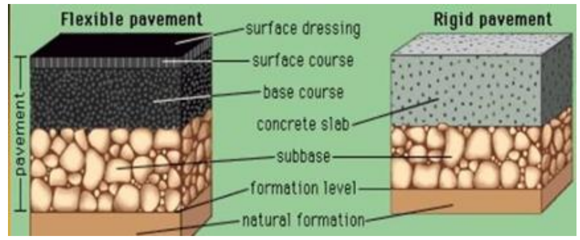


Figure-1 components parts of pavements

1.4 IMPERMEABLE PAVEMENT

Impermeable pavements are quite apposite to permeable pavements, instead of allowing water to seep through its surface is actually quite water repellant, with the aim of being completely waterproof. Is most common application is in urban, heavily populated areas and high traffic. The idea is that instead of water seeping through pavement surface, it will instead be redirected into a nearby storm drain.

1.5 PERMEABLE PAVEMENT

Figure 2 DIFFERENCE BETWEEN PERVIOUS AND IMPERVIOUS SURFACES

As the names implies, pervious pavement is any type of pavement surface that allows water to seep and pass through its surface. This allows the pavement to greatly reduce run-off, and reduce water build up on its surface. Pervious pavement is a great choice for areas that may be in close proximity with water, such as cool surfaces or boat launching ramps. Pervious pavements also helps to reduce the risk of hydro planning, and helps prevent the build of ice in cold weather.

1.8 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 (Mary, 2010). By definition, pervious concrete is a mixture of gravel or granite stone, cement, water, no sand (fine aggregate) with or without admixtures. When pervious 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, pervious concrete helps in protecting the surface of the pavement and its environment.

As stated above, pervious concrete has the same basic constituents as conventional concrete 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 3-5 gallons (0.014 - 0.023m3) of water per minute through its open cells for each square foot (0.0929m2) of surface area which is far greater than most rain occurrences. Apart from being used to eliminate or reduce the need for expensive retention ponds, developers and other private companies are also using it to

free up valuable real estate for development, while still providing a paved park.

BINDING MATERIAL + COARSEAGGREGATE + PORTABLE WATER= PERVIOUS CONCRETE

Pervious concrete is also a unique and effective means to address important environmental issues and sustainable growth. When it rains, pervious concrete automatically acts as a drainage system, thereby putting water back where it belongs. Pervious concrete is rough textured, and has a honeycombed surface, with moderate amount of surface raveling which occurs on heavily travelled roadways.

Carefully controlled amount of water and cementatious materials are used to create a paste. The paste then forms a thick coating around aggregate particles, to prevent the flowing off of the paste during mixing and placing. Using enough paste to coat the particles maintain a system of interconnected voids which allow water and air to pass through. The lack of sand in pervious concrete results in a very harsh mix that negatively affects mixing, delivery and placement. Also, due to the high void content, pervious concrete is light in weight (about 1600 to 1900kg/m3). Pervious concrete void structure provides pollutant captures which also add significant structural strength as well. It also results in a very high permeable concrete that drains quickly

Apparently, when compared to conventional concrete, pervious concrete has a lower compressive strength, greater permeability, and a lower unit weight. However, pervious concrete has a greater advantage in many regards. Nevertheless, it has its own limitations which must be put in 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.

Pervious concrete pavement in rural areas is a unique and effective means to achieve important environmental issues and support green, sustainable growth. By capturing storm water and allowing it to seep into the ground, porous concrete is instrumental in recharging groundwater, reducing storm water runoff.

1.9 RAINFALL

Rain is liquid water in the form of droplets that have condensed from atmospheric water vapor and then precipitated. Rain is a major component of the water cycle and is responsible for depositing most of the fresh water on the earth. It provides suitable conditions for many types of ecosystems, as well as water for hydroelectric power plants and crop irrigation.

As per the Meteorological Data (2000-2017) the rainfall in Andhra Pradesh is as:

Coastal Andhra Pradesh - 1094 mm,
Telengana - 961 mm,
Rayalaseema - 680 mm.

1.10 DRAINAGE

Drains are the common drainage components of the road which intercept the surface water running off the carriageway, shoulders and side slopes flanking the road.

The process of surface drainage involves the collection and then disposing of the surface water. The water from the pavement surface is immediately removed by providing chamber or cross slope to the pavement. The camber or cross slope are designed according to the intensity of rainfall and type of pavement.

Depending upon the formation level of road, drains are provided as in figure-1.10.

Figure 3 Location of Drains

1.11 Description of the study area:

The purpose of this work is to provide moisture free surface that provides easy flow of vehicular traffic.

In this work we used cementious materials and coarse aggregates only. We know that fine aggregate fills all the voids, that create impermeable strata. So we negotiates the whole content of fine aggregates. This results in preparing of permeable strata that have high voids ratio.

1.12 Scope:

This experimental work was carried out by using the materials which are available in Gooty. This work can further be carried out to test for compression and permeability.

1.13 Objectives:

To study the properties of pervious concrete made by the elimination of total content of fine aggregates. To propose optimum proportion of cement and coarse aggregates at which maximum strength attains in compression as well as compression

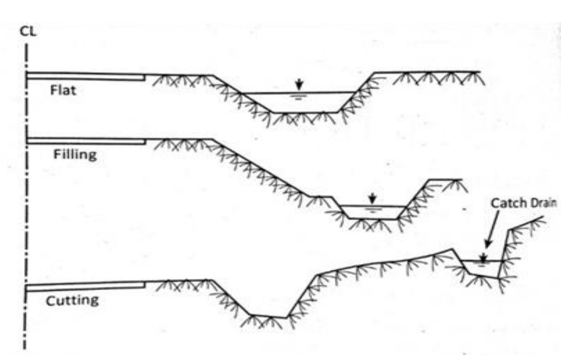
3.1 MATERIALS

CEMENT

The most commonly available Portland cement of 53-grade was used for the investigation. Cement was bought from the same source throughout the research work. While storing cement, all possible contact with moisture was avoided.

Table 3.1 CHEMICAL COMPOSITION OF OPC

Oxide Composition	% by mass
SiO_2	20.99
Al_2O_3	6.19
Fe_2O_3	3.86
CaO	65.96
Mgo	0.22
Na_2O_3	0.17
K_2O	0.60
LOI	1.73



COARSE AGGREGATE

Hard broken granite stones were used as a coarse aggregate in concrete. Size of the coarse aggregate used in the investigation was 20 mm and 10 mm.

WATER

Locally available water is used for this study. Water free from salts, Organic Matter are used throughout the study

3.2 TESTING OF MATERIALS

COARSE AGGREGATE:

Table 3.2 EXPERIMENTAL VALUES OF COARSE AGGREGATE

S.no	Type of Experiment	Result
1	Aggregate Impact Value	35.59%
2	Aggregate Crushing Strength value	24.20%
3	LOS Angeles Abrasion Value	34.04%

3.3 MATERIAL TEST RESULTS:

Various tests mentioned above on materials were conducted to know their properties and results are shown below

3.4 METHODS OF TESTS FOR STRENGTH OF CONCRETE IS 516:1959

3.4.1 MAKING AND CURING OF TEST SPECIMENS IN THE LABORATORY:

This clause specifies the procedure for making and curing compression test specimens of concrete in the laboratory where accurate control of the quantities of materials and test conditions are possible and where the maximum nominal size of aggregate does not exceed 38 mm. The IS method is especially applicable to the making of preliminary compression and Flexural tests to ascertain the suitability of the available materials or to determine suitable mix proportions.

PROPORTIONING:

The proportions of the materials, including water in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work. Where the proportions of the ingredients of the concrete as used in the site are to be specified by volume, they shall be calculated from the proportion by weight used in the test cubes and the unit weights of the materials.

WEIGHING:

The quantities if cement, each size of aggregate and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

MIXING OF CONCRETE:

Thorough mixing of the materials is essential for the production of uniform concrete. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency

COMPACTING BY HAND:

The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance. When compacting by hand the standard tamping bar shall be used and the strokes of the bar shall be distributed in a uniform manner all over the cross section of the mold.

The concrete shall be filled into the mold in layers in placing each scoopful of concrete, the scoop shall be moved around the top edge of the mold as the concrete slides from it, in order to ensure a symmetrical distribution of the concrete with in the mold. Each layer shall be compacted by hand. After the top layer has been compacted the surface of the concrete shall be finished level with the top of mold using a trowel, and covered with a glass or metal plate to prevent evaporation.

CURING:

The test specimen shall be stored in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27 +- 2 for 24 hours +- 1 hour from the time of addition of water to the dry ingredients. After this period the specimens shall be marked and removed from the molds and, unless required for test within 24 hours, immediately submerged in clean, fresh water or saturated like solution and kept there until taken out just prior to test. The water or solution in which the specimens are submerged shall be renewed every seven days and shall be maintained at a temperature of 27 +- 2. The specimens shall not be allowed to become dry at any time until they have been tested.

AGE AT TEST:

Tests shall be made at recognized ages of the test specimens, the most usual being 28 days. We have done for 7 days, 14 days and for 25 days.

NUMBER OF SPECIMENS TESTED:

For each mix 9 specimens were tested for compressive strength, at 7 days, 14 days and 28 days.

Fig 3.4.10 Specimens Casted

THEORY OF THE PROJECT

4.1 Overview:

Various tests have been done on coarse aggregate to know whether they are suitable in making Pervious concrete. As there are no standards for the mix design of Pervious concrete proportioning was taken as for normal concrete. From that weight of Corse aggregates obtained from mix Proportion, 50% are taken 20MM aggregates and 10MM aggregates. The variations of compressive strength with respect to No. of blows, and Permeability capacity of different mixes are discussed in the results section.

The experimental setup and procedures for conducting various tests on concrete are discussed below.

COMPRESSIVE STRENGTH TEST OF CONCRETE (IS: 516-1959)

From IS: 516-1959 – Methods of tests for strength of concrete.

Fig-4.1.1 Cubes testing in Compressive Testing Machine

4.1.2 PERMEABILITY TEST OF CONCRETE

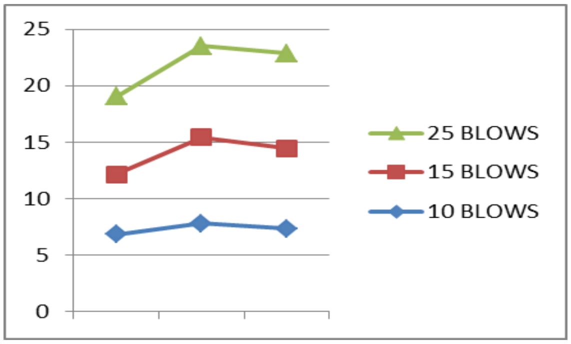
IS 3085(1965): Method of test for permeability of concrete

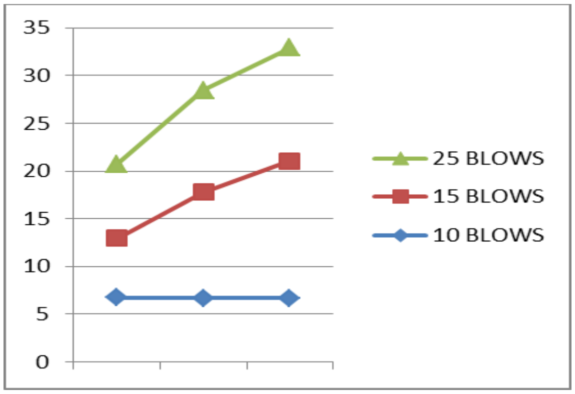
RESULTS AND DISCUSSIONS

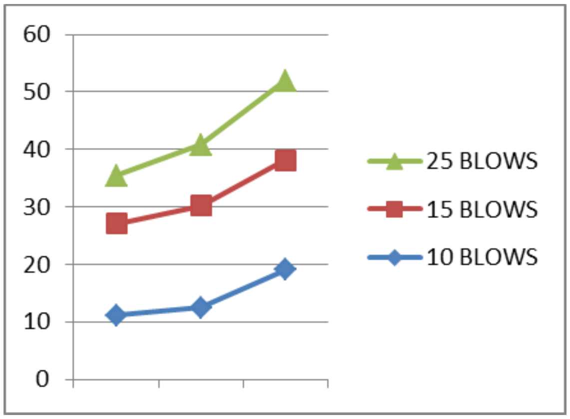
5.1 OVERVIEW OF RESULTS:

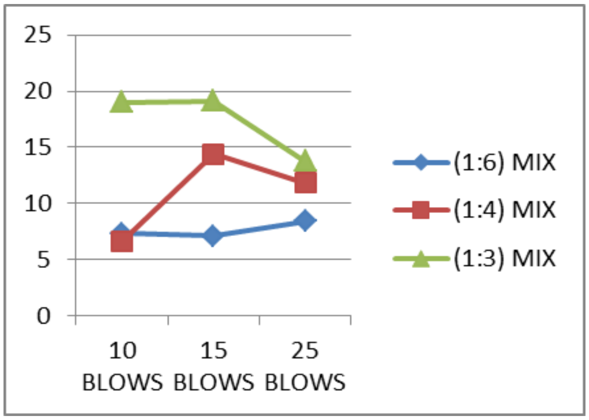
Three specimens of each mix were tested for their strengths to know the optimum proportion for which maximum strength will be attained. Results obtained are shown below.

5.2 RESULTS AND DISCUSSIONS:









- From the above results we can say the permeability of the concrete 1:3 mix taken can drain out the water with the rate of 0.014x10-3 cm/sec
- From the above results we can say the permeability of the concrete 1:4 mix taken can drain out the water with the rate of 0.013x10-3 cm/sec
- From the above results we can say the permeability of the concrete 1:6 mix taken can drain out the water with the rate of 0.0145x10-3 cm/sec
- On an average of the all the mixes we can say the permeability can be more for the 1:6 mix

CONCLUSIONS

- Based on the results of the experimental work the following conclusions can be made.
- Pervious concrete is not a workable concrete attains zero-slump.
- On an average of the all the permeability for mixes we can say the permeability can be more for the 1:6 mix
- On consideration of all the Compressive strengths the mix 1:6 having maximum strength i.e. 19.9N/mm2
- Concrete with less strength compared to ordinary concrete which can adopt in less traffic roads, foot paths, Parking lots and landscaping.
- On comparison for flexible and rigid pavements we choose rigid can choose a best example for economical.
- With the optimum case we can take the mix 1:4 as adapted mix with max permeability and strength with least number of blows.

- A permeable pavement has more friction compared to others.
- In the case of heavy rainfall areas this method of paving is more preferable.

LIST OF INDIAN STANDARD CODES

1. IS: 383 – 1970 Specifications for coarse and fine aggregates from natural sources for concrete.
2. IS: 456 – 2000 Code of practice for plain and reinforced concrete
3. IS: 516 – 1959 Method of test for strength of concrete.
4. IS: 2386(Part 1) -1963 Methods of test for aggregates for concrete: Part 1 Particle size and shape.
5. IS: 516-1959 Methods of tests for strength of concrete.
6. IS 3085(1965) Method of test for permeability of concrete.

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