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Study & Experimental Analysis of Pervious Concrete in Low Volume Roads

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Abstract – Pervious concrete is a special high porosity concrete used for flatwork applications that allows water from precipitation and other source to pass through there by reducing the runoff from a site and recharging ground water levels. Durability and Water Absorption are important properties of Pervious Concrete. It is a special type of concrete having a high void content of about 30% due to use of special admixture silica fumes (powder form), 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. This paper represents the experimental methodology and experimental results related to durability and water absorption. This investigation should be carried out at the end of 14 days for water absorption and 28 days for durability. Different concrete mix proportion such as 1:3, 1:4 and 1:5 with size of gravel such as 20 mm passing and 12 mm retained should be used to check both these properties of pervious concrete. Test results indicates that pervious concrete made by 1:3 concrete mix proportion has more durability and less water absorption and pervious concrete made by 1:5 mix proportion has more water absorption and less durability that's why durability and water absorption are inversely proportional to each other.

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INTRODUCTION

Pervious Concrete is a special type of concrete in which fine aggregates are not used and only coarse aggregate are used. Pervious Concrete is a homogeneous mixture of cement, coarse aggregate, silica fumes and water. Cubes of size of 150x150x150 are used for an experimental investigation of Water Absorption and Durability of Pervious Concrete. Concrete Durability is one of the most important considerations in the design of new structures and when assessing the condition of existing structures. The main purpose of durability is about minimizing the rate of decay. Durability of Concrete is related to the design process, specification of materials, workmanship, environmental effects, accidents and repairs. In Water Absorption Test cubes are cured in curing pond for 28 days and weighing it & % water absorption is to be determined. In Durability Test cubes are first cured in curing pond for 28 days and then after tested against compressive strength. The hydraulic conductivity test for percolation of water through the voids of concrete is measured. The Durability of Concrete is the resistance of concrete to weathering action, chemical attack, abrasion and other degradation processes.

EXPERIMENTAL MATERIALS

Pervious Concrete is a mixture of Cement, Coarse Aggregate, silica fumes (powder form) and Water. No Fine Aggregates are used for making pervious concrete. Admixtures are used to achieve adequate strength and durability of pervious concrete. Pervious Concrete has been casted with different concrete mix proportion such as 1:3, 1:4 and 1:5 with 20mm passing and 12 mm retained with OPC 53 Grade and Silica fumes (powder form).

NEED FOR PERVIOUS CONCRETE

In rural 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. 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 rivers, 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 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. 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.

LITERATURE REVIEW

Mr. M. Harshavarthana Balaji (2013) Pervious concrete is a zero-slump, open graded material consisting of hydraulic cement, coarse aggregate, admixtures and water. Because pervious concrete contains little or no fine aggregates such as sand, it is sometimes referred to as “no-fines” concrete. It is a special type of concrete having a high void content of about 30%, is becoming popular now a days due to its potential to reduce the runoff to the drainage systems which can provide a water flow rate around 0.34 cm/second.

Pervious concrete has a large open pore structure hence less heat storage and faster. Pervious concrete also find its effective application in low loading intensity parking pavements, footpaths, walkways and highways.

Mr. Darshan S. Shah (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 pavements 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. Pervious concrete pavement is unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground. This pavement technology creates more efficient land use by eliminating the need for retention ponds, swell, and other costly storm water management devices.

Mr. V.R Patil (2011) discussed pervious concrete as it, 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. This brings the phenomenon of hot island in city.

Mr. Manoj Chopra (2007) discussed pervious concrete system and its corresponding strength are as important as its permeability characteristics. The strength of the system not only relies on the compressive strength of the pervious concrete but also on the strength of the soil beneath it for support. Previous studies indicate that pervious concrete has lower compressive strength capabilities than conventional concrete and will only support light traffic loadings. This project conducted experimental studies on the compressive strength on pervious concrete as it relates to water-cement ratio, aggregate-cement ratio, aggregate size, and compaction. Since voids are supposed to reduce the strength of concrete, the goal is to find a balance between water, aggregate, and cement in order to increase strength and permeability, two characteristics which tend to counteract one another. Also important is appropriate traffic loads and volumes so that the pervious concrete is able to maintain its structural integrity.

Mr. V.M. Malhotra (1976) discussed pervious concrete as it relates to applications and properties. He provided details on such properties as consistency, proportions of materials, unit weight, compactibility, and curing in an attempt to maximize permeability in the pervious concrete. He also conducted multiple experiments on various test cylinders in an attempt to find a correlation between compressive strength and any of the material’s properties. He concluded that the compressive strength of pervious concrete was dependent on the water cement ratio and the aggregate cement ratio. The pervious concrete system and its corresponding strength are as important as its permeability characteristics. The strength of the system not only relies on the compressive strength of the pervious concrete but also on the strength of the soil beneath it for support. Previous studies indicate that pervious concrete has lower compressive strength capabilities than conventional concrete and will only support light traffic loadings. The authors of this work investigated prior studies on the compressive strength on pervious concrete as it relates to water-cement ratio, aggregate-cement ratio, aggregate size, and compaction and compare those results with results obtained in laboratory experiments conducted on samples of pervious concrete cylinders created for this purpose.

SECTIONAL PLAN

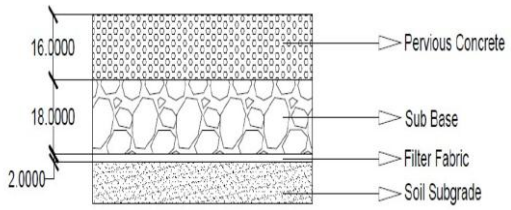

Fig.5.1 Cross Section of Pervious Concrete

TESTING AND RESULT OF CONVENTIONAL CONCRETE

Strength is the main property of concrete. Strength is defined as the ability of concrete to resist load. The hardened concrete should be therefore have sufficient strength to bear the load for which it is designed. The strength of hardened concrete mainly depends upon the water cement ratio, quality of water, quality of cement, degree of compaction and curing.

1. Compressive Strength:

The most important property of concrete is its high compressive strength. The compressive strength is measured in N/mm^2. Compressive Strength is influence by a number of factors, in addition to the water-cement ratio and degree of compaction, type of cement and its quality, texture of aggregates, curing method, and temperature and the time of hardening.

2. Compressive Strength Test of Concrete Cubes:

For cube test two types of specimens either cubes of 15cm X 15cm X 15cm or 10cm X 10cm x 10cm depending upon the size of aggregate are used. For most of the works cubical mould of size 15cm x 15cm x 15cm are commonly used.

This concrete is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. 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/cm2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete.

3. Percentage of voids (%) on pervious concrete:

The total void ratio (%) was calculated using 150 x 150 x 150 mm cube specimens, by taking the difference in weight between a oven dried and sample in water, and it is suggested by Park and Tia (Park, 2004). The relationship for total void ratio is as follows:

Vr = [(W2-W1)/W1] x 100

Where,

Vr = Total Void ratio (%)

W1 = weight specimen in water

W2 = oven dry weight of specimen

4. Measurement hydraulic conductivity (permeability)

As it has been stated that the pervious concrete has a large inter connected pore network, and hence the conventional method used for evaluating hydraulic conductivity of normal concrete is not applicable. Therefore to evaluate or to estimate the hydraulic conductivity of pervious concrete, a constant head permeability test apparatus has been used.

K = (qL/Ah)

Where,

k =coefficient of permeability in cm/sec.

L = length of the specimen cm.

h = constant head causing flow in cm.

A2 = cross sectional area of drain pipe

t = Time in seconds

CONCLUSION

The following conclusion comes through the study of the pervious concrete pavement in rural areas becomes more suitable to meet the rural area requirement such as to reduce the storm water runoff, to increase the ground water level, to eliminate the costly storm water management practices.

1. As per comparison 1:3 mix proportion at 7, 14, 28 days:

As per comparison for 7, 14, 28 days, M20 grade and 1:3 mix proportion the conventional concrete (M20) compressive strength are lesser than pervious concrete and pervious concrete compressive strength are lesser than pervious concrete with admixture.

2. As per comparison 1:4 mix proportion at 7, 14, 28 days:

At 7 days, M20 grade and 1:4 mix proportion the conventional concrete (M20) compressive strength are lesser than pervious concrete and pervious concrete compressive strength are lesser than pervious concrete with admixture.

At 14 days, M20 grade and 1:4 mix proportion the conventional concrete (M20) compressive strength are greater than pervious concrete and pervious concrete compressive strength are lesser than pervious concrete with admixture.

At 28 days, M20 grade and 1:4 mix proportion the conventional concrete (M20) compressive strength are lesser than pervious concrete and pervious concrete compressive strength are lesser than pervious concrete with admixture.

3. As per comparison 1:5 mix proportion at 7, 14, 28 days:

At 7 days, M20 grade and 1:5 mix proportion the conventional concrete (M20) compressive strength are greater than both pervious concrete and pervious concrete with admixture.

Similarly 14 and 28 days the conventional concrete (M20) compressive strength are greater than both concrete.

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