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EXPERIMENTAL ANALYSIS ON PERMEABLE PAVEMENT

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Abstract

The purpose of this project is to summarize literature on permeable pavements, highlight current problem arises in Nagpur that is water logging on bituminous and concrete pavement on the date 6/7/18, and to recommend future need of permeable pavement. permeable paving is a choice of sustainable materials and techniques for permeable pavements with a base and sub base that allow the movement of storm water through the surface. In addition to reducing runoff, this efficiently traps suspended solids and filters pollutants from the water. The goal is to control storm water at the source, reduce runoff, reduce cost and improve water quality by filtering pollutants in the substrata layers and increase subsurface water level, thus one way to harvest storm water, improve skid resistance and reduce traffic noise. Permeable 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. Typically, permeable concrete has modest or no fine aggregate and has just enough cementitious paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids. Permeable concrete is traditionally used in parking areas, areas with light traffic, pedestrian walkways, and greenhouses and contributes to sustainable construction.

Keywords: permeable pavement, sustainable material, skid resistance, substrata layer, preserving, retention pond, trap.

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1. Introduction

The purpose of this project is to summarize literature on permeable pavements, highlight current problem arises in Nagpur that is water logging on bituminous and concrete pavement on the date 6/7/18, and to recommend future need of permeable pavement. Permeable paving is a choice of sustainable materials and techniques for permeable pavements with a base and sub base that allow the movement of storm water through the surface. In addition to decreasing runoff, this efficiently traps suspended solids and filters pollutants from the water. The goal is to control storm reducing the strain on our environment is essential to the overall health and wellbeing of our society. **Permeable concrete,** can be defined as an open graded or "no-fines "concrete that allows rain water to percolate through to the underlying sub-base Pervious concrete can replace traditional impervious pavement for most pedestrian and vehicular applications except high-volume/high-speed roadways. Pervious concrete can be designed to handle heavy loads, but surface abrasion from constant traffic will cause the pavement to deteriorate more quickly than conventional concrete. Pervious concrete has proved successfully in pedestrian walkways, sidewalks, driveways, parking lots, and low-volume roadways. The environmental advantages from pervious concrete allow it to be incorporated into municipal green infrastructure and low impact development programs. In addition to providing storm water volume and quality management, the light colour of concrete is cooler than conventional asphalt and helps to reduce urban temperatures and improve air quality. Unlike the smoothed surface of conventional concrete, the surface consistency of pervious concrete is slightly rougher, providing more traction to vehicles and pedestrians.

Impervious surfaces have mostly used in the decline of watershed integrity in urban and urbanizing areas. These surfaces are mostly used to serve vehicle travel, but a maximum portion of these surfaces, particularly driveways, parking lots and road shoulders, experience only minimal traffic loading. Parking lots are of sized to provide accommodation to maximum traffic usage, which only occurs occasionally, so most of the area remains unused during majority of the time. The most impervious surfaces lead to higher peak stream flows which cause bank erosion, increased sediment transportation, reduction in infiltration which reduces groundwater recharge and lowers stream base flow. Runoff from impervious surfaces also increases pollutant quantity in surface flow.

Permeable pavement is a best solution for problem of increased storm water runoff and decreased stream water quality. Permeable pavements are an emerging technology constructed for low volume roads and parking lots as an option storm water management technique or best management practice. Permeable pavements are option for paving surfaces that capture and temporarily store the storm water by filtering runoff through voids in the pavement surface into an underlying stone reservoir. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially infiltrate into the soil. This system is not so widely used in India

Permeable Pavement Systems are designed to attain water quality and quantity benefits by allowing movement of storm water through the pavement surface and into a base/sub base reservoir. The water passes through the voids in the pavement materials and provides the structural support as conventional pavement. That's why permeable pavements can be served as an alternative to conventional road and parking lots. These pavements have ability to reduce urban runoff and trap pollutants. Also, it provides the opportunities to reduce the impacts of urbanization on receiving water systems by providing at source treatment and management of storm water. Permeable pavement systems have been shown to improve the storm water quality by reducing the pollutant concentrations and pollutant loading of suspended solids, heavy metals, hydrocarbons and some nutrients.

2. ADVANTAGES:

Nowadays, pervious pavements are used in different places due to the following benefits

2.1 Environmental Benefits

- Reduces storm water & snowmelt runoff
- Recognized by the EPA as a BMP
- Reduces heat island effect

2.2 Economic Benefits

- Reduces the need for large detention ponds
- More place can be developed at a lower cost
- Allows the use of smaller capability storm sewers

2.3 Structural benefits

- Surface texture provides enhanced traction.
- Void structure provides increased safety for drivers.
- Pervious concrete is a tough and durable material.

3.Application of Pervious Concrete

- Parking LotPavements.
- Sub base for conventional concrete pavements.
- Light Traffic Streets.
- Road Shoulders.
- Edge Drains.
- Driveways, Sidewalks.
- Patios, Tennis Courts.
- Low water crossings.
- Slope stabilization.
- Low-volume traffic.

4. MATERIALS AND ANALYSIS

Pervious concrete also known as no fines, permeable, or improved porosity concrete, usually consists of normal Portland cement, uniform-sized coarse aggregate, and water. This combination forms an agglomeration of coarse aggregate surrounded by a thin coat of hardened cement paste at their points of contract. This arrangement produces interconnected voids between the coarse aggregate, which allow water to permeate at a much higher rate than conventional concrete. Pervious concrete is considered a highly porous concrete. Such porous concrete can be classified into two types one where the porosity is present in the aggregate component of the mixtures (pervious concrete). Pervious concrete has slight or no fine aggregate in the mixture.

4.1. Cement

Portland Pozzolona (PPC) cement of 53 Grade is used throughout this work.

The following are the advantages of PPC:

1. Resistance to Alkali-Aggregate Reaction.

2. Reduce heat and cracking in mass concrete.

3. Reduce the global warming.

The following are the tests to be performed on cement:

Name of the Test

1.Sp. Gravity of Cement

2. Consistency

3. Initial Setting Time

4. Final Setting Time

5. Fineness Test

5. Soundness

4.2 Fine Aggregate

River sand is used throughout this work. While pervious concrete is considered as a "no fine" concrete, a small percentage of fine particles can be added to increase the compressive strength of the pervious concrete mix.

The following are the tests to be performed on fine aggregate:

Name of the Test

1.Sp. Gravity of Cement

2. Water Absorption

4.3 Coarse Aggregate

Normal Coarse Aggregates of Angular shape is used. Coarse Aggregates is kept to a narrow Gradation. Graded aggregates of 10 mm and 20mm are used. Coarse aggregate of Angular shape is used throughout this work.

The following are the tests to be performed on coarse aggregate:

Name of the Test

1.Sp. Gravity of Cement

2. Water Absorption

3. Crushing Value

4. Flakiness Index

5. METHODOLOGY

The Methodology used in this study is depicted below:

1. Collection of Material (Cement, Fine & Coarse aggregate and Water)

2. Preliminary test on Material

3. Mix Design with and without fine Aggregate

4. Fresh Concrete test visual check of cohesiveness of Mix and Plastic density

5. Check Hardened Concrete Test (Compressive Strength, Flexural Strength and Void ratio)

The Methodology used in this study is depicted below:

• Testing on materials: The materials required for making concrete cubes are tested first to determine their properties such as specific gravity, fineness test etc.

• Tests on fresh concrete: The concrete made for required proportions is first tested before making cubes. The ratio of materials by weight for pervious concrete is 1:4, 1:5, 1:7 for water cement ratio is 0.35.

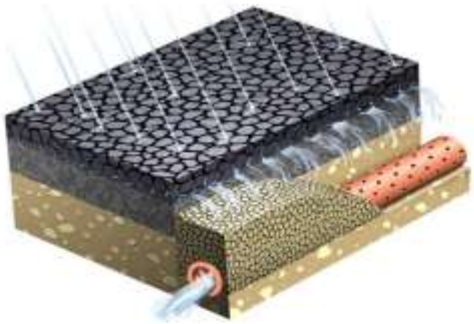
• Casting of concrete cubes: Concrete cubes are then made with the concrete using 15cm x 15cm x 15 cm cubes. Each layer of the concrete filled in the mould shall be compacted by not less than 35 strokes by tamping bar. The strokes shall be penetrated the underlying layer and the bottom layer shall be rodded through its depth. Where voids are left by the tamping bar the sides of the mould shall be tapped to close the voids.

• Curing of concrete cubes: The cube shall be removed from the moulds at the end of 24 hours and immersed in clean water at a temperature 24°C to 30°C till the 7, 14 and 28 days age of testing. The cubes shall be tested in the saturated and surface dry condition.

• Tests on hardened concrete i.e. on cubes: After the curing of concrete cubes have been done, the cubes are test for determining compressive strength on compression testing machine for 7 days strength, 14 days strength and 28 days strength, also porosity test and permeability test on concrete cube.

- Study of perforated drainage system and geotextile for permeable concrete.

- Design cross section of pervious concrete along with drainage system and geotextile material as shown in fig.



6. TEST FOR PERVIOUS CONCRETE

6.1. Fresh density and hardened density

Fresh density and hardened porosity are the most common acceptance tests for quality evaluation of PC. The fresh density of PC is determined based on ASTM 1688. In this procedure, fresh PC mixture is placed in the standard container with known weight and volume in two approximately equal lifts. Each lift is then compacted with 20 blows of the standard 5.5-lb Proctor Hammer with a 12-in drop. After the second lift is compacted, the top is finished flat using a strike-off plate and the weight of the container with fresh PC is recorded. The fresh density of PC is calculated as the ratio of the mass of fresh PC by the volume of the container. Hardened density is determined following ASTM C1754 that is typically performed on seven day-old specimens. In this procedure, hardened density is calculated by dividing the dry mass by the volume of the specimen. The dry weight of the specimens is first recorded (Md) and then the dimensions of the specimens are recorded to obtain the volume (V). Hardened density is calculated as the ratio of the dry mass to the volume of the specimen (Md/V). To characterize porosity, each specimen is submerged in water for at least 30 minutes, after which the submerged mass of each specimen is recorded (MW). The volume of the solids is obtained by dividing the difference between the dry and submergedweights by the density of water (ρw). Subsequently, porosity (ϕ)

$$\emptyset = 1 - \frac{(Md - Mw)}{\rho_{\omega} * V}$$

The size of the specimen may affect the hardened density and the ease of achieving the target density. Pervious concrete-like conventional PCC- is placed and compacted in two and three lifts.

6.2. Infiltration rate

An ASTM C1701 procedure exists for infiltration rate evaluation. The procedure for the determination of the infiltration rate. A watertight infiltration ring with a 12-in diameter is fixed on the surface of the PCP using plumber's putty. The time that takes for the known mass of water to infiltrate through the ring is measured. The test is repeated at multiple locations on the PCP surface. Infiltration test at each location is preceded by prewetting of the PCP with eight pounds of water. Each test should be performed within two minutes after the completion of the pre-wetting. The number of test locations is determined based on the area of the pavement

$$I = \frac{KM}{(D^2 * t)}$$

where, M is the mass of infiltrated water in lbs,

D is the inside diameter of infiltration ring inches,

t is the time required for the designated mass of water to infiltrate through PC in seconds,

K is the correction factor equal to 126,870 inches.

6.3. Compressive Strength

Compressive strength testing was conducted in accordance with ASTM C39 (2010), Standard Test Method for Compressive Strength of Concrete Specimens. The concrete shall be mixed by hand, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after molding the desired number of test specimens. Test specimens cubical in shape shall be 15 × 15 × 15 cm. 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. The concrete shall be filled into the mould in layers approximately 5 cm deep. In placing eachscoopful of concrete, the scoop shall he moved around the top edge of the mould as the concrete slides from it, to ensure a symmetrical distribution of the concrete within the mould. Each layer shall be compacted either by hand or by vibration. The specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The load shall be applied without shock and increased continuously at a rate of

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approximately 140 kg/sq. cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

7. GEOTEXTILE MATERIAL

Geotextiles are made up of polypropylene, polyester, polyethylene, polyamide (nylon), polyvinylidene chloride, and fiberglass. Polypropylene and polyester are the most used. The physical properties of these materials can be varied using additives in the composition and by changing the processing methods used to form the molten material into filaments. Yarns are made from fibers which have been bundled and twisted together, a process also referred to as spinning. Yarns may be composed of very long fibers (filaments) or relatively short pieces cut from filaments.

Geotextile is made of synthetic fibers created into a sheet that are designed to allow water and gases to pass through them, while retain soil particles. Geotextile separates and consist the base from the underlying soil subgrade. It allows the base to drop water, and prevents the soil around it from working its way into the base.

Without geotextile, the soil will work its way into the base and deteriorate it. This is a slow process that takes place when the soil is saturated with water or during periods of thawing. Geotextile stops this process and increases the life of the base by many years. Geotextile is suggested for use over silt and clay soils. It is not essential in sandy soils.

8. DRAINAGE ELEMENTS

New or totally reconstructed pavements are outstanding opportunities for constructing drainable pavement systems since permeable bases can be provided. Drainable pavement systems eliminate infiltrated surface water which cannot be prevented from entering the pavement structure. Drainable pavement systems consist of the following elements:

8.1. Permeable bases

8.2. Separator layer

8.3. Edge drain system

Each of these elements must be properly designed so that there is no weak link in the drainage system.

A permeable base must provide both permeability and stability. Aggregate materials for permeable bases must be hard, durable, angular with good aggregate interlock. Aggregate gradation must be carefully selected to provide both permeability and stability. Permeable bases can be constructed using both stabilized and stabilized material Proper compaction is essential to seat the permeable base.

The separator layer between the permeable base and subgrade is equally important as the permeable base, aggregate separate layer or geotextile must be provided so that fines from the subgrade are not pumped up into the permeable base.

9. MAINTENANCE

Clogging is deposition of fines and vegetative matter on the pervious concrete surface or reduction in its voids thus reducing its infiltration rates. Clogging is an ongoingprocess, but it can be restricted by regularly maintaining permeable pavement and, of course, locating permeable pavements away from areas with soil disturbance. Following are type of maintenance

a) Routine maintenance

This routine maintenance should be perform as needed to keep the entire pervious concrete area clean. The following are the types of routine maintenance are

1. Blowing (leaf blower)

2. Truck sweeping

b) Periodic maintenance

Periodic maintenance is done as a temperature changes mainly in winter (per the season) to remove any antiskid materials.

Two main type of street sweepers:

1. Mechanical street sweeper

2. Vacuum street sweeper

c) Annual maintenance

Annual maintenance is a maintenance which is performed annually (ones in a year). The following are type of annual maintenance are:

1. Deep cleaning or unclogging

2. Use of chemical & pressure washing

10. CONCLUSION

This paper describes about the permeable pavements, needs and its present applications. This paper also looked at current problem of water logging which arises during the rainy season and effective solution for that problem which is permeable pavement. Also, shows studies conducted on permeable pavement systems. The water quality and life span aspects were outlined for permeable pavement systems. Future research and scope of this system is discussed in this paper briefly. The permeable pavement systems are changing the way of human development with natural environment. Its applications towards highways, road shoulders, parking lots and airport runways in India are all improvements in conditions of water quantity, water quality and safety

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