International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** V **Month of publication:** May 2019

DOI: https://doi.org/10.22214/ijraset.2019.5100

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue V, May 2019- Available at www.ijraset.com

Permeable Pavement by using Waste Plastic Bottles

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Abstract: The purpose of this papers to summarize literature on permeable pavements, highlight current trend in research and industry, and to recommend future areas of research and development .Permeable paving is a range of sustainable material sand techniques for permeable pavements with a base and sub base that allow the movement of storm water through the surface. In addition to reducing run off, this effectively trap suspended solids and filters pollutants from the water. The goal is to control storm water at the source, reduce run off, 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. Porous pavement is unique and effective mean to meet growing environmental demands. By capturing rain water and allowing it to seep into the ground this pavement technology creates or efficiently and use by eliminating the need for retention ponds, swell, and other costly stormier management devices. In addition the pavement block which are made by waste plastic. Plastic waste which is increasing day by day becomes eyesore and in turn pollutes the environment, especially in high mountain villages where no garbage collection system exists. A large amount of plastic is being brought into the tourist trekking regions are discarded or burned which leads to the contamination of environment and air .Hence, these waste plastics are to be effectively utilised. High density polyethylene (HDPE) and polyethylene (PE) bags are cleaned and added with sand and aggregate at various percentages to obtain high strength bricks that possess thermal and sound insulation properties to control pollution.

I. PERMEABLE PAVEMENT

A. Introduction

Permeable pavements have gained very rapid use across North American in the past ten years. Examples of permeable pavement types are provided in Figure 1. For new designs and retrofit projects, permeable pavements transform conventional, non-permeable pavement into a storm water management asset. Almost all permeable pavements use an open-graded aggregate base or subbase to store and infiltrate water into the soil subgrade. The asphalt, concrete and interlocking concrete pavement industries, as well as a number of other manufacturers of permeable surfaces, provide a variety of pavement surface options. Regardless of the surface, permeable pavement systems include three design approaches. First, they are primarily used to promote complete or full infiltration of rainfall into the soil subgrade. Second, where soil subgrades have low infiltration rates, partial infiltration into the soil subgrade occurs and the remaining water exits via underdrains. Third, for designs that require no infiltration, permeable pavement systems are enveloped with a geomembrane that prevents detained water from entering the soil subgrade and the stored water exits via underdrains. These three design approaches are illustrated.

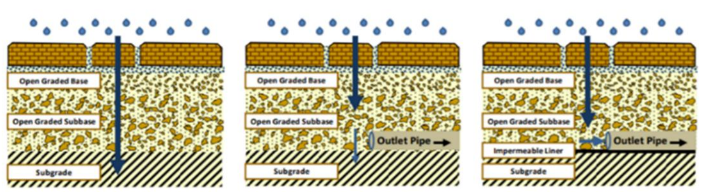

Figure 2a. Full Infiltration **Figure 2b. Partial Infiltration** **Figure 2c. No Infiltration**

Figure 1. Examples of Permeable Pavement Types

B. Definition And Background

Permeable pavements must allow water to infiltrate; therefore, they show a high porosity structure with open and interconnected spaces where water and air can pass through. Infiltration must be fast enough to avoid the possibility of significant ponding for most rainfall events. Although they are often referred as porous pavements in literature, it is important to notice that all pavements present some level of porosity; thus, it is more accurate to use the terms permeable or pervious meaning that it is capable of being permeated by liquid or gas. Various kinds of surfaces may be used for those pavements: concrete blocks, in placed pervious concrete, pervious asphalt, concrete grids, aggregates, grass, plastic grids, granular materials and loose decks. The ones that provide

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vehicular support are concrete blocks used on permeable interlocking concrete pavement, in place pervious concrete and pervious asphalt. The pavement base/sub-base is similar to the conventional one. The main difference is the aggregate void rate, which must be such that it allows the base to perform as a water reservoir. The high void content results on less strength; for that reason, permeable pavements are normally applied on areas with low volume traffic and with limited heavy vehicle loading.

C. Key Permeable Pavement Design Features

A successful permeable pavement considers structural and hydrologic design. Structural design considers the pavement strength required to accommodate the vehicle loadings without the pavement failing. Hydrologic design considers the capacity required to infiltrate, store and release water in a manner that contributes positively to storm water management. Some key design, construction and maintenance considerations are as follows:

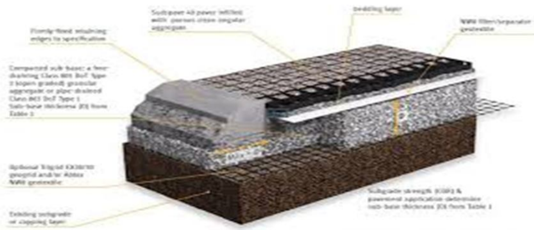

Figure 2. Section of permeable pavement

1) *Site Drainage:* Consider the overall site drainage and evaluate rainfall onto the pavement and water that may drain onto the permeable pavement from surrounding areas. This could include adjacent pavements, grassed areas, building roofs, etc.
2) *Contaminant Loading:* Consider potential contaminants such as winter sand (for traction), biomass (tree leaves and needles, grass clippings, etc.) and sediment. Contaminants may reduce the long term permeability of the pavement system and likely require maintenance such as vacuum sweeping.
3) Groundwater Depth: The top of the subgrade under a permeable pavement should be no less than 0.6 m from the seasonal high groundwater level.
4) *Subgrade Type and Strength:* The type of subgrade and its compaction/consolidation govern if water can be adequately infiltrated into the ground. Permeability values in the order of 12 mm/hr permit full infiltration designs that accommodate rainstorm depths in most areas of North America. Lower permeability subgrade in high rainfall event areas may require supplemental underdrains. Permeable pavements constructed over fine-grained soils (silts and clays) generally require thicker pavements than those constructed over coarse-grained soils (sands and gravels).
5) *Infiltration Rates:* Initially, infiltration is over 50-75in/hr.

Reduce by around 50% in the first 5 years.

Over a 20-year period, PICP's are designed to achieve and maintain a consistent 3in/hr.

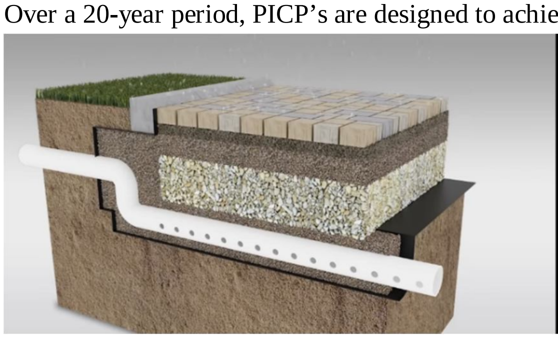

Figure 3 Cross section of permeable pavement with infiltration pipe

6) *Pavement Surface:* Consider the type of surface most appropriate for the traffic and infiltration capacity conditions. For example, porous asphalt or pervious concrete may be more appropriate for some slope conditions whereas permeable interlocking concrete and grid pavements may be more suitable for situations where vehicles are turning. While some projects have steeper slopes, most permeable pavements should have slopes less than 5 percent.
7) *Aggregate Base and Subbase:* Permeable pavements typically utilize open graded aggregates to provide structural and hydraulic capacity for the pavement. The aggregates should be hard, durable and have a low percentage of material passing the

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75 µm sieve size. Select durable, crushed aggregate materials to maximize structural capacity and porosity for water storage. For heavier traffic conditions, a cement- or asphalt-stabilized open-graded aggregate may be more suitable. Dense-graded aggregates for road bases are generally not used because of low water storage capacity and fines that can weaken them when saturated. To prevent migration of smaller base aggregate material into the larger subbase aggregate, aggregate gradations should satisfy the following criteria: D50 Subbase/D50 Base < 25 D15 Subbase/D85 Base < 5 For example, the ratio of the D50 Subbase (subbase aggregate size at which 50 percent of the material is larger than this size and 50 percent is smaller) to D50 Base (base aggregate size at which 50 percent of the material is larger than this size and 50 percent is smaller) must be less than 25. There are situations where filtering is the primary goal and not storage and infiltration. In such situations, aggregate bases with a smaller portion of aggregates are used with no greater than 2 percent passing the 75 µm sieve. Such denser-graded aggregates trade porosity for higher density and structural capacity. The hydrologic design should account for their reduced porosity and water storage capacity. Some state highway agency specifications describe such materials as drainage layers for use under conventional impervious pavements.

8) *Subgrade Slope:* Infiltration designs should minimize subgrade slope to promote water infiltration. Sites with subgrade slopes over 3 percent often require buffers, weirs, check dams, etc. to control water flow within the pavement.
9) *Pavement Overflow:* During high intensity/depth storm events, the pavement design should incorporate features such as curb cut outs, grading to supplementary drainage outlets such as catch basins, storm water ponds, etc. to prevent the pavement system from flooding.
10) *Underdrains:* For partial or no infiltration designs determine the type, location and need for underdrains. Specify outlet details and clean out provisions.

Figure 4 Model of Permeable Pavement

II. PAVEMENT BLOCK BY USING WASTE PLASTIC BOTTLES

A. *Introduction*

Paver block paving is versatile, aesthetically attractive, functional, and cost effective and requires little or no maintenance if correctly manufactured and laid. Most concrete block paving constructed in India also has performed satisfactorily but two main areas of concern are occasional failure due to excessive surface wear, and variability in the strength of block. Natural resources are depleting worldwide at the same time the generated wastes from the industry and residential area are increasing substantially. The sustainable development for construction involves the use of Non-conventional and innovative materials, and recycling of waste materials in order to compensate the lack of natural resources and to find alternative ways conserving the environment.

Plastic waste used in this work was brought from the surrounding areas. Currently about 56 lakh tonnes of plastic waste dumped in India in a year. The dumped waste pollutes the surrounding environment. As the result it affects both human beings and animals in direct and indirect ways. Hence it necessary to dispose the plastic waste properly as per the regulations provided by our government. The replacement of plastic waste for cement provides potential environmental as well as economic benefits. With the view to investigate the behaviour of quarry rock dust, recycled plastic, production of plastic paver block from the solid waste a critical review of literature was taken up. Al1 to reuse the solid waste quarry dust fly-ash and PET with an aim not to lose the strength far from original Paver blocks. From the observations of test results, PET can be reused with 50% of quarry dust and 20% of fly-ash in Plastic Paver block. The physical and mechanical properties of materials used in Plastic Paver block were investigated. For the test 6 cubes cube were cast for measuring Compressive strength. Used recycled plastic aggregate in various proportions in concrete mix and check there stability.

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B. Materials

1) *Course Aggregate:* Locally available coarse aggregates were used in this work. Aggregates passing through 10mm sieve and retained on 6.3mm sieve were sieved and tested as per Indian standard specification IS: 383-1970
2) *Waste Plastic:* We are using plastic bottles as waste plastic which is flexible bond between aggregate and waste plastic. Polyethylene Terephthalate (plastic bottles) sometimes absorbs odours and flavours from food and drinks that are stored in them. Items made from this plastic are commonly recycled.


Figure5 Waste plastic bottles crush

3) *Fly ash:* It is by-product from burning pulverized coal in electric power generating plants. Fly ash chemically reacts with by-products calcium hydroxide released by chemical reaction between waste plastic and aggregate that improve many desirable properties. Fly ash working as void filling material and crack repairing agent.

C. Mix Design

1) Type 1

Mix ratio= 1:2

1 plastic, 2 aggregate

2) Type 2

Mix ratio= 1:3

1 plastic, 3 aggregate

3) Type 3

Mix ratio= 1:4

1 plastic, 4 aggregate

In additional replace 20% fly ash with weight of aggregate

(Fly is filling the void in the blocks and give better results)

D. Preparation of Paving Blocks

Plastic wastes are heated in a metal bucket at a temp of above 150˚. As a result of heating the plastic waste melt. The materials aggregate and other materials as described in previous chapter are added to it in right proportion at molten state of plastic and well mixed. The metal mould is cleaned through at using waste cloth. Now this mixture is transferred to the mould. It will be in hot condition and compact it well to reduce internal pores present in it. Then the blocks are allowed to dry for 24 hours so that they harden. After drying the paver block is removed from the moulds and ready for the use.


Figure 6 Melting waste plastic

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Figure 7 Hot mix poured in mould

Figure 8 Paving block after removing mould

III. TEST ON MATERIAL

A. *Specific Gravity Test*

Specific gravity test by Pycnometer the Pycnometer is used for determination of specific gravity of aggregate. The determination of specific gravity of aggregate will help in the calculation of void ratio, degree of saturation and other different aggregate properties.

Figure9 Specific gravity test by Pycnometer

Size of Aggregate	Specific Gravity
40mm	2.54
20mm	2.88
10mm	2.68

B. *Impact Test*

Toughness is the property of a material to resist impact. Due to traffic loads, the road stones are subjected to the pounding action or impact and there is possibility of stones breaking into smaller pieces. The road stones should therefore be tough enough to resist fracture under impact. A test designed to evaluate the toughness of stone i.e., the resistance of the stones to fracture under repeated impacts may be called an impact test for road stones

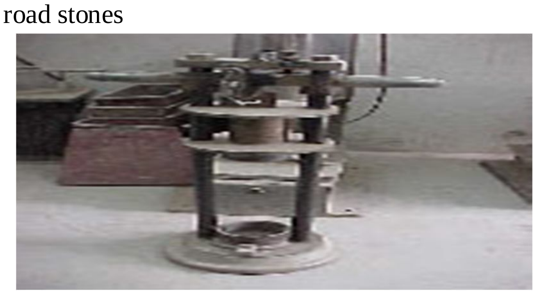

Figure10 Impact Test machine

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C. Sieve Analysis Test

A sieve analysis is a procedure to use to assess the particle size distribution of a granular material by allowing the material to pass through a series of sieves of progressively smaller mesh size and weighing the amount of material that is stopped by each sieve as fraction the whole mass.

Figure11 Sieve Analysis Test

D. Los Angeles Abrasion Test

Los Angeles Abrasion Test on aggregate is the measure of aggregate toughness and abrasion resistance such as crushing, degradation and disintegration. This test is carried out by AASHTO T 96 or ASTM C 131: Resistance to Degradation of small size coarse aggregate by abrasion and impact in the Los Angeles machine

Figure 12 Los Angeles Abrasion test

E. Compressive Test on Paving Block

Plastic Sand Ratio	Compressive Strength(N/mm^2)
1:2	4.78
1:3	7.45
1:4	5.12
1:3 Replace 20% fly ash by weight of aggregate	32.78

Fig. Compressive Test on Paving Block on UTM

F. Oven Test on Paving Blocks

Temperature (°c)	Remark
50	No change
100	No change
150	melted

IV. CONCLUSION

A. Permeable pavements can be a major contributor to the effective management of storm-water.

B. They provide the opportunity of transforming a traditional source of storm-water runoff into a best management practice for capturing, storing and infiltrating storm-water into the natural surroundings. Benefits achieved include reduced storm-water discharges as well as improvements to water quality including reduced suspended solids and reduction of chemical contaminants.

C. While they can be an effective tool, their design and construction should carefully consider structural and hydrological concerns to ensure that they provide cost-effective solutions over their design life.

D. The utilization of waste plastic in production of paver block has productive way of disposal of plastic waste.

E. Economic of waste plastic paving block is better than cement concrete blocks. It’s totally eco-friendly

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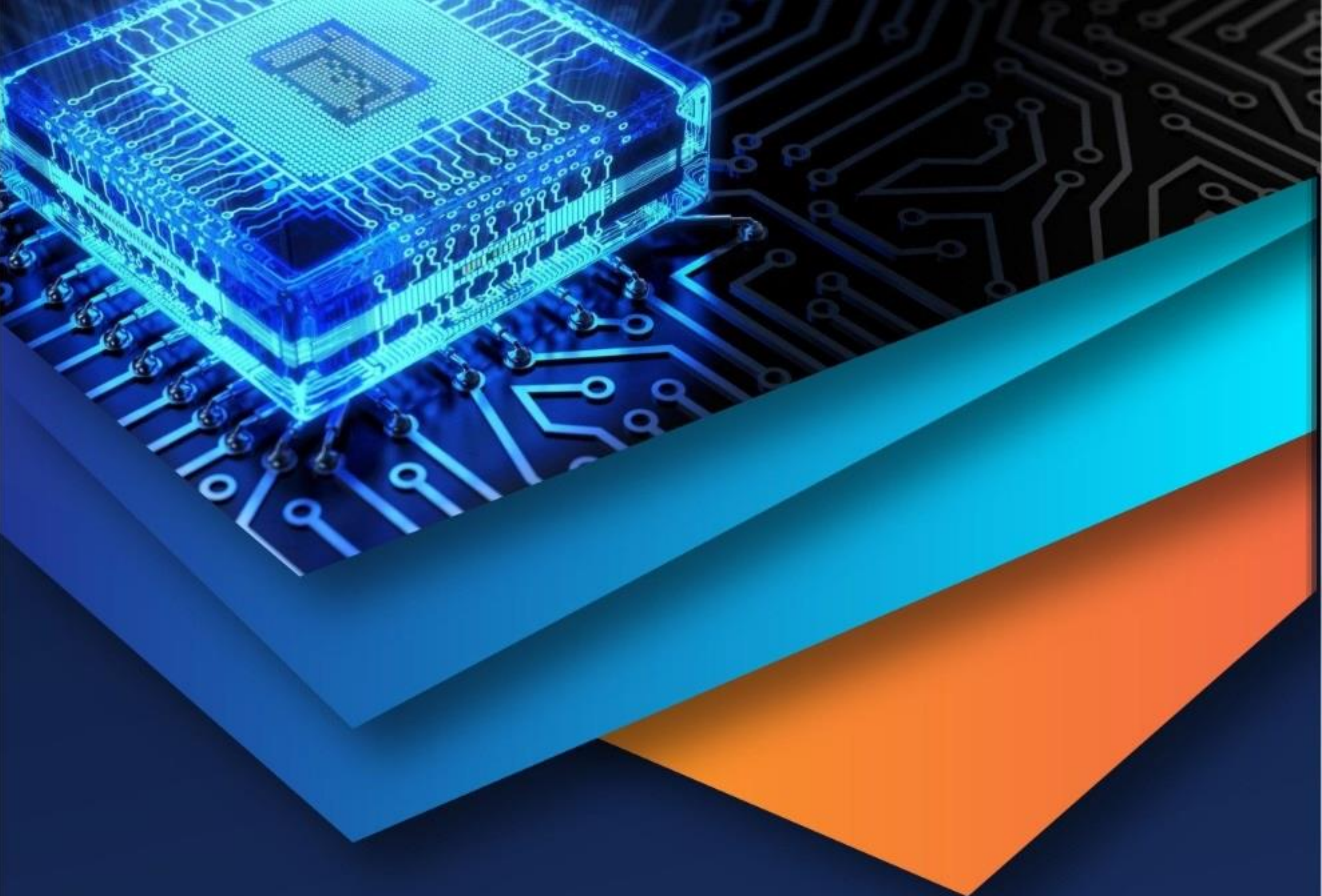

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