The Study of Porous Asphalt Pavement with Emphasis in Road Construction Design

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Abstract*: The purpose of this paper is to study the durability, maintenance requirements, hydrologic benefits, and environmental considerations of a full-depth porous asphalt (PA) pavement, installed on a low-volume roadway. This paper includes the design, construction, and performance of porous asphalt. Porous asphalt pavements are designed for dual duty: they provide pavements for parking and roads and also serve as storm water storage and infiltration systems. They are in demand because they offer site planners and public works officials the opportunity to manage storm water in an environmentally friendly way. With the proper design and installation, porous asphalt structures can offer cost-effective, attractive parking lots with a long life span while also providing storm water management systems that promote infiltration improve water quality.*

Key Words: *Porous asphalt pavement, storm water runoff, Design and installation, Drain out system.*

Introduction: The performance of porous asphalt pavements is similar to that of other asphalt pavements. And, like other asphalt pavements, they can be designed for many situations. Common applications of Porous Asphalt Pavements are parking lots, side-walks, pathways, shoulders, drains, noise barriers, friction course for highway pavements, permeable sub base under the conventional flexible or rigid pavements and low volume roads. In addition, porous asphalt can also be used as an application for tennis courts, patios, slope stabilization, swimming pool decks, green house floors, zoo areas etc.,

The Economic Benefits includes:- reduction in storm water runoff, including reduction of temperature, total water volume, and flow rate, increase in groundwater infiltration and recharge, provides local flood control, improves the quality of local surface waterways, reduces soil erosion, reduces the need for traditional storm water infrastructure, which may reduce the overall project cost, increases traction when wet, reduces splash-up in trafficked areas, extends the life of paved area in cold climates due to less cracking and buckling from the freeze-thaw cycle, reduces the need for salt and sand use during the winter, due to little or no black ice, requires less snow-ploughing, reduces groundwater pollution, creates green space (grass groundcover, shade from tree canopies, etc.), offers evaporative cooling.

Literature Review: Porous asphalt pavements are an alternative technology that differs from traditional asphalt pavement designs in that the structure permits fluids to pass freely through it, reducing or controlling the amount of run-off from the surrounding area. By allowing precipitation and run-off to flow through the structure, this pavement type functions as an additional storm water management technique accounting for ground water recharge. The overall benefits of porous asphalt pavements may include both environmental and safety benefits including improved storm water management, improved skid resistance, reduction of spray to drivers and pedestrians, as well as a potential for noise reduction.

Objectives of paper:

- To study of porous pavement.
- Planning and designing of porous pavement.
- Develop a permeable pavement.
- Provide proper drain out system.
- Environmental consideration of porous asphalt.

Research Methodology:

1. Study of Pervious Pavement-

Depending on the type of surface pavement, permeable pavement can be referred to as: porous asphalt, pervious concrete, or interlocking concrete pavers. Permeable pavement has several permeable layers and has the ability to store storm water until it infiltrates through the sub grade soil or is collected by an under drain. Because permeable pavements have the ability to reduce runoff volume, they are usually used as a low impact development (LID) design for storm water best management practice (BMP).

Porous Asphalt-The thickness of surface permeable asphalt may vary depending on the application. For instance, the National Asphalt Pavement Association

(NAPA) (2008) recommended minimum thickness of 2.5, 4, and 6 inch compacted porous asphalt surface when used for a parking lot (little or no trucks), residential traffic (some trucks), and heavy traffic (heavy trucks), respectively.

Fig:1 Porous Section.

2. Making of Pervious Wearing Course-

Bitumen: It is a semi solid hydrocarbon produced by removing the lighter fractions (such as liquid petroleum gas, petrol and diesel) from heavy crude oil during the refining process. Immediately the hot bitumen 60/70 or 80/100 grade (160 degree slices) is added.

Aggregate: 7 lab test on aggregate to check quality for use in road work.

Bitumen Binder-PG 70-28: Polymer Modified Bitumen- Polymer modified bitumen (PMB) is one of the specially designed and engineered bitumen grades that is used in making pavement, roads for heavy duty traffic and home roofing solutions to withstand extreme weather conditions. PMB is normal bitumen with added polymer, which gives it extra strength, high cohesiveness and resistance to fatigue, stripping and deformations, making it a favorable material for infrastructure.

3. Mix Design-

- Minimum asphalt content 5.5% - 6.5% by weight
- No recycled material
- Mix Gradation; 100% passing ¾", 75% retained on ½"
- Coarse Aggregate Angularity >55%
- Bitumen binder: - PG 70-28
- Coarse Aggregate Absorption < 2%
- Air Voids; 17 - 19%
- Mix Storage; 90 minutes' maximum
- Mix to be placed with a track paver only
- 10-ton steel wheeled non-vibratory rollers only (1 or 2 passes) for compaction.
- No vehicular traffic on finished surface for > 24hrs, prevent contamination of surface.

4. Develop Permeable Sub base Course with Drain out System

1. Porous Asphalt: It consists of asphalt binder, stone aggregate (passing from ¾" and retained on ½").

Porous asphalt pavements are typically built over an uncompacted subgrade to maximize infiltration through the soil. The last layer consists of one or more layers of porous asphalt mixes with interconnected voids that allow water to flow through the pavement into the stone reservoir. These porous asphalt layers consist of asphalt binder, aggregates, sands, and recycled materials and are much like a dense graded hot mix asphalt mixture. By limiting the amount of fines, the porous mixture allows for more air voids. (Typically between 16% and 22% is recommended.)

2. Chocker Coarse/Filter Coarse: ½" crushed aggregate which is clean, smaller, single sized.

To stabilize the surface for paving, a thin (about 1-inch-thick) layer of clean, smaller, single-size crushed stones is often placed on top; this is called the stabilizing course or choker course. The choker courses fills in the larger void space at the surface of the coarse aggregate layer and provides a more stable working surface for construction. In recent years, a use of a finely graded choker course over a coarse aggregate recharge bed, has been replaced with the use of a finer overall section.

Fig.2. Chocker Coarse

3. Rail Road Ballast: 2"-2 ½" size crushed stones. It requires little compaction has 40% voids. Also this is main subbase coarse which is sustain all loads.

Fig.3.Rail Road Ballast

4. Stone Reservoir: 2”-3’’ crushed aggregate (uniformly graded clean crushed stones with 40%
voids). The next layer is a stone reservoir consisting of uniformly graded, clean crushed stone with 40% voids serving as a structural layer and temporarily storing water as it infiltrates into the soil below.

Fig.4. Stone Reservoir

5. Geotextile Sheet: -Knighted and non-woven sheets. Above the compacted subgrade is a geotextile fabric, which prevents the migration of fines from the subgrade into the stone recharge bed while still allowing for water to pass through. A non-woven geotextile fabric can also be used to separate the reservoir bed with subgrade soil. To prevent fines from entering the subbase, geotextile filter fabric is typically placed between the subgrade layer and stone reservoir. Geotextiles are permeable fabrics which when used in association with soil, have the ability to separate, filter, reinforce, protect, or drain.

5 Project Model –

The project model consists the size of glass box is 2’x1’x 2’2’’(LxBxH) which includes the all of materials that are used. The bottom surface is uncompacted subgrade which is soil including in glass box at height 4 inches. The slope is provided as 1:10. and non-woven geotextile sheet is provided over a slope. After that uncompacted subgrade above surface consists the stone reservoir that is river stones which are in sizes 2 to 3 inches in between at height 10 inches. After that above surface contains rail road ballast in sizes 2 to 2.5 inches in between at height 4 inches. Next surface contains chocker coarse or filter coarse in sizes 0.5 inches at height 2 inches. Then next layer consists the porous asphalt pavement containing thickness 4 inches. In between all layers the geotextile knitted sheet is provided. The bottom part consists the gutter at the centre of model which is in 12’’x 4’’x 4’’ as per our model and above that gutter the mesh is provided including knitted geotextile sheet in size.

Fig.5. Working Model.

Case Study

To find out water infiltration rate and water consumption capacity we are taking the readings entering water into the model at specific time interval of 10 minutes. So following are the readings,

Sr. No.	Time Period	Water Inserted in Lit	Amount of water absorbed in Lit
1.	10 Minutes	15 Liter	12.6
2	20 Minutes	15 Liter	14.7
3.	30 Minutes	15 Liter	14.8
4.	40 Minutes	15 Liter	14.8
5.	50 Minutes	15 Liter	14.8
6.	60 Minutes	15 Liter	14.8
7.	70 Minutes	15 Liter	14.9
8.	80 Minutes	15 Liter	14.9
9.	90 Minutes	15 Liter	14.9
10.	100 Minutes	15 Liter	14.9
Total Water Recover =80%			

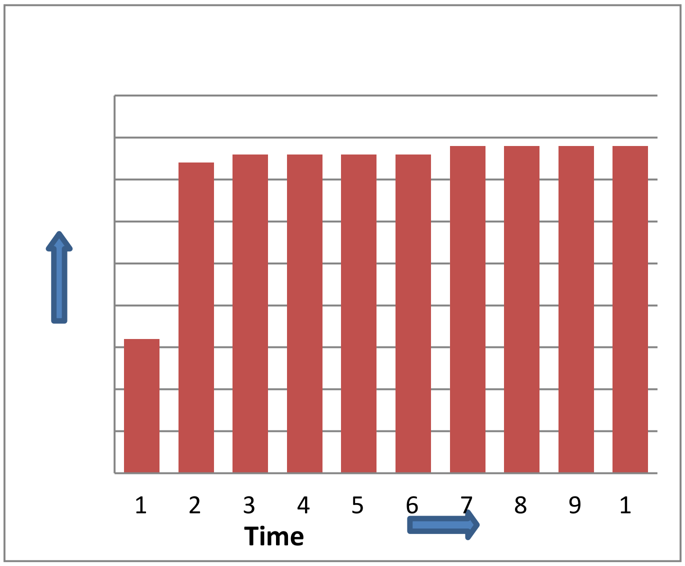

Chart 1: Time vs. Amount of water collected in Liter.

$$correlation\ coefficient = \frac{Total\ average\ of\ water\ absorbed}{Amount\ of\ water\ inserted}$$

$$= \frac{14.61}{15} = 0.97$$

Result from Model:

The average of collected water is 14.61 liters. Thereupon it is concluded that the high linear correlation of the values of Porous Asphalt means the project is precise and accurate.

The Y-values were close to each other and this means that the project is accurate. This is because as more time went on, the Y-values also increased.

To get the value of amount of water collected, we choose our college parking area. For this we measure the area of parking land which is as below.

Name of case study area-

Front side parking area of Ashokrao Mane Polytecnic, College of Engineering Vathar Tarf Vadgaon.

Area =l x b= 21.64 x 29.56
= 639.67 i.e. 640 sq.m.

Calculations of runoff water- Rational Formula=c x i x A

= Runoff factor x Rainfall intensity x area

(c = constant, rainfall intensity in mm/hr., area in sq. m)

= 0.3 x 32 x 640.05
= 6,144.48 Liter per hour For one day we can collect the amount of water =24 hours' x 6144.48

=1, 47,467.52 lit per day

Benefits-

1. Water Storage- By using our project, we can conclude that we can collect the amount of water 1,47,467.52 liters per day. Which can be used for gardening purposes or sanitary purposes. As per discussion with college gardener we can state that we will fulfil the need of water required for gardening.

2. Reduce Noise- Noise generated from vehicles operating on the pavement arises from different sources and one of them is related to tire passes over the pavement. On this case study area, we can park 120 two wheelers at a time and due to smooth surface provided, it reduces the noise which creates on this area

3. Recharging of groundwater supplies- Due to infiltration occurred due to porous surface, the rate of water infiltration increases through this land. The water infiltrates to soil at the rate of 0.97, it will be increase the ground water table.

4. Rain water harvesting- From this technique we can improve rainwater harvesting system. It collects and store the rainwater into the tank and will be used for many purposes like for domestic use or for groundwater recharge.

5. Allows for better use of land- The land consists this type of construction it will be the better use of that area because of the purpose of water collection all over this case study area.

6. Reduces runoff- The runoff from this surface is often directed to storm water collection systems and thus is not absorbed into the nearby soil. So maximum percentage of an water collections by using porous road. Avoiding problems of floods as well as chock up open drainage systems. Totally rainwater percolates this road surface.
This system is provided as section wise, so collected water is easily filtered and reuse.

Future scope:

As per application area-

Parking lots –The main goal of maintaining porous asphalt pavement, which is commonly used in parking lots, is to prevent the surface of the pavement and the underlying infiltration bed from being clogged with fine sediments. With proper routine maintenance, the porous asphalt can last effectively for 20+ years. As this way these pavements, used mostly for parking lots, allow water to drain through the pavement surface into a stone recharge bed and infiltrate into the soils below the pavement.

Highway Shoulders- A more experimental and environmentally beneficial approach is the full depth permeable pavement shoulder designed. Under this design the entire amount or majority of runoff water from the highway or road surface will be retain with in the shoulder, there won't be a need for additional treatment. While permeable pavements are effective for storm water runoff volume control in parking lots and low speed residential roads, their uses have not been adequately tested for heavy vehicle loads and moderate speed.

Footpaths-Permeable road surface is a method of paving vehicle and pedestrian pathways that allows for infiltration of fluids. In pavement design the base is the top portion of the roadway that pedestrians or vehicles come into contact with. The media used for the base of permeable paving may be porous to allow for fluids to flow through it or nonporous media that are spaced so that fluid may flow in between the crack may be used.

As per design-

1. Hydraulic design
2. Structural design
3. Climate change
4. Strom water pollution
5. Energy impact
6. Noise impact

Conclusion:

- This paper concludes that the high linear correlation of the values of porous asphalts means the project is precise & accurate.

- Porous pavement is a sound choice on economics alone. A porous asphalt pavement surface costs approximately the same as conventional asphalt. Because porous pavement is designed to "fit into" the topography of a site, there is generally less earthwork. The underlying stone bed is usually more expensive than a conventional compacted sub-base, but this cost difference is offset by eliminating the detention basin and other components of storm water management systems. On projects where unit costs have been compared, the porous pavement has been the less expensive option. Porous pavements are therefore attractive on both environmental and economic grounds.

- Design, maintenance and water quality control aspects relevant to the practitioner were out lined for permeable and porous pavement system. The detailed design and specific maintenance requirements for PPS do not allow for the specification of general guidelines. Research is therefore likely to be empirical and of applied nature in the future. The most important target pollutants were hydrocarbons, heavy metals and nutrients. The advantages and disadvantages of different PPS were discussed with the help of case studies concerning different water quality aspect.

- Recent innovations were highlighted and explained and their potential for further research work was outlined. The development of a combined geothermal heating and cooling, water treatment and recycling pavements system is promising, and is therefore encouraged. Further work on the assessment of the self-sustainability and sustainability of PPS is also encouraged.

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