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Water Absorbing Roads (WAR): A New Construction Technique for Roads in India

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Abstract - *Roads are lifeline of our country as it is the best suitable method for all type of vehicles and most used by common people. The development of any country largely depends on the efficiency of its transportation system, because the transportation of a chain of activities related to economic development. Human wants are satisfied by the production of good and its distribution. It provides access to airport, dock & harbors railways stations which are other modes of transport. It provides door to door services which is not possible by other modes of transport. Total road length = 5,532,482 km in India including village road. The road are ordinary type i.e. concrete road, WBM road or bituminous road. If we replace these road by water absorbing road (WAR) we can save large quantity of water. Ordinary road constructed in cities majorly face the problem of flooding of road and because it's top layer is impervious. In urban 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 and becomes stormwater. 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.*

***Key Words*: Water Absorbing Roads (WAR), Bituminous Roads, Impervious Surface, Stormwater, etc.**

1. INTRODUCTION

1.1 Water absorbing roads: Porous pavement, or permeable pavement, is an engineered hardscaping surface that allows water to flow through it. This differs from traditional types of pavement, which are impermeable and convert most rainfall to runoff. There are three basic types of porous pavement, which are generally suitable as an alternative to the traditional impermeable surface:

1. Pervious Concrete.
2. Porous Asphalt.
3. Permeable Pavers.

Pervious concrete: Pervious concrete is similar to conventional concrete but manufactured without most or all of the sand in order to create voids allowing water to flow through the concrete and drain through the subgrade for filtration, ground water recharge and reduction in overall storm water runoff, says Dan Huffman, vice president of national resources for the National Ready Mixed Concrete Association (NRMCA). Pervious concrete has been in limited use in Europe for over 100 years but took hold in the United States about 30 years ago, Huffman adds.

Porous asphalt: Porous asphalt pavements with stone reservoirs are a multifunctional, low impact development technology that integrate ecological and environmental goals for a site with land development goals, reducing the net environmental impact for a project. Not only do they provide a strong pavement surface for parking, walkways, trails, and roadways, they are designed to manage and treat storm water runoff. With proper design and installation, porous asphalt pavements can provide a cost-effective solution for storm water management in an environmentally friendly way.

Permeable Pavers: Pavers are solid concrete blocks that fit together to form a pattern with small aggregate-filled spaces in between the pavers that allow storm water to infiltrate. These spaces typically account for 5 to 15 percent of the surface area. Various types of pavers are:

(a) Permeable interlocking concrete pavers (PICP).

(b) Permeable interlocking clay brick pavers (PICBP).

(c) Concrete grid pavers (CGP).

Fig-1: Types of Permeable Pavers.

1.2 PROBLEM STATEMENT

The road or the pavements are the essentials for the country's growth as they provides door to door service of goods and materials. The methods of construction of roads are mutated from one century to another. In the traditional road construction, we have faced so many problems like surface water flooding, poor water quality, high maintenance cost, reduced ground water levels, increased risk of contamination. For over 300 years now, Mumbai has been receiving heavy rains and also witnessing high tides. The amount of rain that the city receives has remained the same. So, what has changed? Why does it now submerge the city after every spell? Rapid urbanisation, which turned Mumbai into a concrete jungle, is one of the key reasons.

1.3 OBJECTIVES

There are numerous objectives associated with the use of WAR:

Volume Reduction & Flood Control: Because water flows through porous pavement, the volume of runoff generated during a storm event is significantly decreased or eliminated altogether. This reduction in volume results in flood control and reduces the need for traditional stormwater infrastructure (piping, catch basins, stormwater ponds, curbing, etc.).

Water Quality: Pollutants are captured during infiltration, reducing pollutant load to local waterways. Infiltrated runoff recharges groundwater supplies, improves flow in streams, and reduces the need for landscaping irrigation.

Road Safety and Durability: Porous pavement increases skid resistance and traction on wet surfaces while also reducing the spray from passing vehicles and decreasing noise. Since water infiltrates rather than pools, black ice does not form and less road salting is needed. Pavement lifespan also increases.

Heat Island Effect Mitigation: Heat islands are developed areas that are hotter than surrounding rural areas. Traditional paving materials, which become hotter than vegetated surfaces, contribute to the heat island effect. In applications of porous pavement, the amount of heat released at night is reduced due to the limited transfer of heat to the subsurface layers.

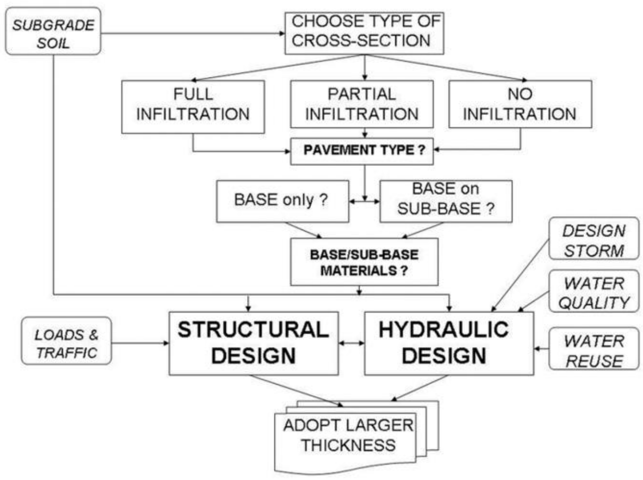
2. PREVIOUS RESEARCH

Karthik H. Obla (2010) Pervious Concrete: An Overview.
Pervious concrete is a special high porosity concrete used for flatwork applications that allows water from precipitation and other sources to pass through, thereby reducing the runoff from a site and recharging ground water levels. Its void content ranges from 18 to 35% with compressive strengths of 400 to 4000 psi (28 to 281 kg/cm2). The infiltration rate of pervious concrete will fall into the range of 2 to 18 gallons per minute per square foot (80 to 720 liters per minute per square meter). Typically, pervious concrete has little or no fine aggregate and has just enough cementitious paste to coat the coarse aggregate particles while preserving the interconnectivity of the voids.

Reshma K. J. , Keerthi K. ,Vidhyashree H. P. , Shabnam K. R. , Deekshitha and Kiran Raj Shetty: Challenges in Implementation of Porous Asphalt Concrete in Barmanna Layout, Nelamangala Bangalore Rural District.
Bangalore which is also known as the Silicon City of India has faced a heavy rain fall of 1666mm in October, 2017 breaking the earlier record of 1606mm in 2005. Roads were inundated, all the vehicles were submerged and even found floating. The increased rain fall has led to 50% of accidents and potholes (Times of India, Oct 16 th 2017). Frequent road reconstruction has resulted in heavy traffic, potholes on the rods and accidents as a result of poor road conditions. This project mainly focused on Nelamangala to implement porous asphalt pavements. A survey was conducted in Barmanna Layout and identified that poor roads conditions was the most important problem. The data was collected through survey and identified that about 57% of the respondent were in the opinion that poor road condition has increased the accidents and number of potholes. For the identified problems porous asphalt pavement can be a solution which helps in overcoming these problems and cost analysis of asphalt pavement was done. It was concluded that porous asphalt pavement can reduce accidents, potholes and heavy traffic.

Lucas Niehuns Antunes, Enedir Ghisi and Liseane Padilha Thives (Nov. 2018): Permeable Pavements Life Cycle Assessment: A Literature Review.
The number of studies involving life cycle assessment has increased significantly in recent years. The life cycle assessment has been applied to assess the environmental performance of water infrastructures, including the environmental impacts associated with construction, maintenance and disposal, mainly evaluating the amount of greenhouse gas emissions, as well as the consumption of energy and natural resources. The objective of this paper is to present an overview of permeable pavements and show studies of life cycle assessment that compare the environmental performance of permeable pavements with traditional drainage systems.

3. DESIGN PROCEDURE CONTENT



4. MATERIALS

4.1 Geotextiles

Non-woven geotextiles (filter fabrics) are typically used to prevent fines in the subgrade from migrating up into the stone recharge bed from the subbase.

4.2 Stone recharge bed and choker course

Aggregate for the stone recharge bed needs to be clean, uniformly graded, crushed stone, with minimum voids of 40 percent. To make sure the aggregate does not have excessive fines that could clog the bed, an additional grading requirement of 0 to 2 percent passing the No. 100 sieve is recommended.

4.3 Optional choker course

In many cases when using an AASHTO No. 3 stone for the recharge bed, an AASHTO No. 57 stone has worked well as a choker course. The choker course should be placed no more than one inch thick and be sufficient to fill the voids of the recharge bed stone in order to provide a smooth paving surface. A number of contractors have reported that they have found no advantage to using a choker course and have successfully constructed pavements without this course. Therefore, the choker course may be considered optional.

4.4 Porous asphalt surface

Open-graded asphalt pavement mixes are used to surface porous asphalt parking lots. These mixes are also used for surfaces on highways in many states.

In most cases, the mixes are made with polymer-modified asphalt and in some cases fibers. The polymer-modified asphalt helps to reduce draindown and improve the high-temperature performance of the mix (resistance to scuffing). Fibers are another way to reduce draindown. In draindown, which sometimes occurs during construction, liquid asphalt cement migrates to the bottom of the load of asphalt pavement material. Modern construction methods and materials prevent this from happening.

Open-graded mixes may be designed using the Superpave or Marshall methods with requirements for higher air voids to assure permeability. While modified asphalts should be used for most applications, these are not always necessary, or practical.

4.5 Pervious Concrete Surface

Pervious concrete uses the same materials as conventional concrete, with the exceptions that the fine aggregate typically is eliminated entirely, and the size distribution (grading) of the coarse aggregate is kept narrow, allowing for relatively little particle packing. This provides the useful hardened properties, but also results in a mix that requires different considerations in mixing, placing, compaction, and curing. Proportioning pervious concrete mixtures is different compared to procedures used for conventional concrete and the mixture proportions are somewhat less forgiving than conventional concrete mixtures—tight controls on batching of all of the ingredients are necessary to provide the desired results.

When developing pervious concrete mixtures, the goal is to obtain a target or design void content that will allow for the percolation of water. The void content of a pervious concrete mixture will depend on the characteristics of the ingredients, how they are proportioned and how the mixture is consolidated. Pervious concrete is typically designed for a void content in the range of 15% to 30%. Generally as the void content decreases, the strength increases and permeability decreases. For pervious concrete mixtures it is even more important to verify through trial batches that the mixture achieves the characteristics assumed or targeted when developing mixture proportions. Frequently one finds that even though the design void content is 20%, when the pervious concrete mixture is proportioned, the experimentally measured void content is considerably different. This depends on the workability of the mixture and amount of consolidation.

4.6 Permeable Pavers

Permeable interlocking concrete pavement, also referred to as PICP, consists solid concrete paving units with joints that create openings in the pavement surface when assembled into a pattern. (The USEPA has a fact sheet on PICP.) The joints are filled with permeable aggregates that allow water to freely enter the surface. The permeable surface allows flow rates as high as 1,000 in. /hr. (2,540 cm/hr). The paving units are placed on a bedding layer of permeable aggregates which rests over a base and subbase of open-graded aggregates. The concrete pavers, bedding and base layers are typically restrained by a concrete curb in vehicular applications. Permeable interlocking concrete pavers (PICP) and clay brick pavers (PICBP) as well as concrete grid pavers (CGP) are similar in installation and function but are made from different materials.

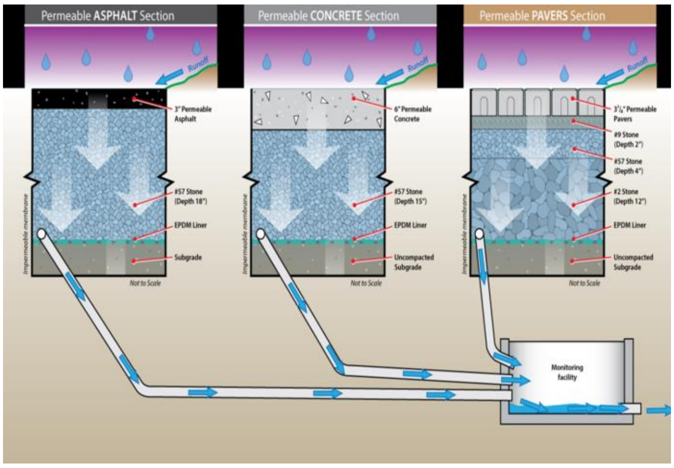


Fig-2 Water Absorbing Action through Different Types of Pavements.

5. Advantages and Limitations

5.1 Advantages

Durable
Once filled, permeable pavement is as durable as concrete or asphalt surfaces, and in many cases, even more durable. It can support heavy equipment such as wheel loaders, backhoes, fork lifts, dump trucks and 18-wheelers without a problem.

Sustainable
The permeable pavement grids are made from environmentally-friendly recycled materials, which reduces the amount of waste in the system and reduces the energy required to acquire new materials. At the end of their lifespan, they can easily be recycled, further reducing their carbon footprint.

Eliminates Costly Drainage Systems
With a conventional asphalt or concrete surface, the parking area must be crowned and have a system of storm drains and pipes to control water during rain or flooding events. This can significantly add to the construction costs of the parking area, and if the system is connected to a municipal waste water system, there may be extra costs and permits required to install the drainage system. Water absorbing roads allows any water that accumulates to drain through the surface and into the ground. This helps to prevent flooding and allows any aquifers in the area to replenish naturally.

Low Cost
Asphalt and concrete can be expensive to install and require a large amount of labour. Permeable pavement is less expensive per square foot, and is much less labour-intensive. The fill materials can be obtained from local sources, reducing transportation costs, and because the paving grids are made from lightweight plastic, the shipping costs are kept to a minimum.

5.2 Limitations

- Limited for use in heavy vehicles traffic areas.
- It requires specialized construction practices.
- Lack of standardize test methods.
- Clogging of voids thus affecting the purpose of pavement.
- Special attention possibly required with high groundwater.

6. Maintenance
The majority of pervious concrete pavements function well with little or no maintenance. However, after repeated water flows, debris and residue may lodge within the top 1” to 1 ¼” of the void structure. Maintenance of pervious concrete pavement consists primarily of removing this debris and residue from the void structure to rejuvenate some of its original permeability.

6.1 Routine Maintenance
All porous surfaces require some maintenance to preserve permeability and service life. A minimum amount of planning and regular maintenance is more effective than surface rehabilitation or replacement. Surfaces should be vacuumed at least 2 times per year. More may be necessary based on site conditions. Well maintained Regenerative Air Vacuum sweeping equipment is recommended. Operator experience and training on both equipment and porous surfaces is essential.

6.2 Rehabilitation, Repairs, and Replacement
Small areas of clogging can be rehabilitated using focused vacuum and water pressure. If in-situ rehabilitation is not successful the StormCrete unit can be removed for additional rehab techniques (soaking, air or water pressure applied from the underside of unit, light vibration / percussion, etc). In the event of wide-spread clogging, damage, or spill the unit can be removed and replaced in almost any weather, any time of the year.

6.3 Winter Maintenance
De-icers should be used sparingly during winter season. Due to their freely as it does on conventional impermeable pavements as readily as it does on conventional impermeable pavements during thaw-freeze cycles.

Fig-3. Winter Maintenance.

7. Conclusion
This research looked at various studies conducted on water absorbing roads and their current application. Also discussed about the detailed design of permeable pavement system, permeable interlocking concrete pavement in brief. Maintenance and water quality control aspects relevant to the practitioner were outlined for permeable pavement systems. These water absorbing roads are changing the way human development interacts with the natural environment.

Its application towards parking lots, highways and even airport runways are all improvements in terms of water quality, water quantity and safety.

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