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Feasibility Study for Permeable Pavements to control flash flood in Guwahati City

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ABSTRACT - Guwahati is affected by flash flood during monsoon period in many residential areas. Permeable pavement can reduce the flood problem somehow and will be useful for the reuse of rain water during dry seasons.

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. Increase of subsurface water level is one way to harvest storm water. Porous pavement is unique and effective means to meet growing environmental demands. By collecting storm water and allowing it to soak into the ground, this pavement technology creates more efficient land use by eliminating the need for preservation of ponds, swell, and other costly storm water management devices.

***Key words**: permeable pavement system, sustainable urban development system, recycling pavement system, porous pavement, ground water recharge, flood control in urban area*

1. INTRODUCTION

The average rainfall in Guwahati city is 1698 mm. Impermeable 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 accommodate maximum traffic usage, which only occurs occasionally, so most of the area remains unused during majority of the time. The large 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 which are not lead to quality water for storage.

Pervious paving allows runoff to infiltrate into the underlying basecourse where it is temporarily stored and slowly released either into the subgrade or underdrain. This provides storm water attenuation of the peak flows, volume reduction through infiltration and wetting/drying of the filtration media and water quality treatment due to settling, filtration, adsorption and microbiological action in the bedding sand and basecourse. This provides both storm water quantity and quality treatment, particularly important for maintaining stream health in the urban environment with increasing impervious areas.

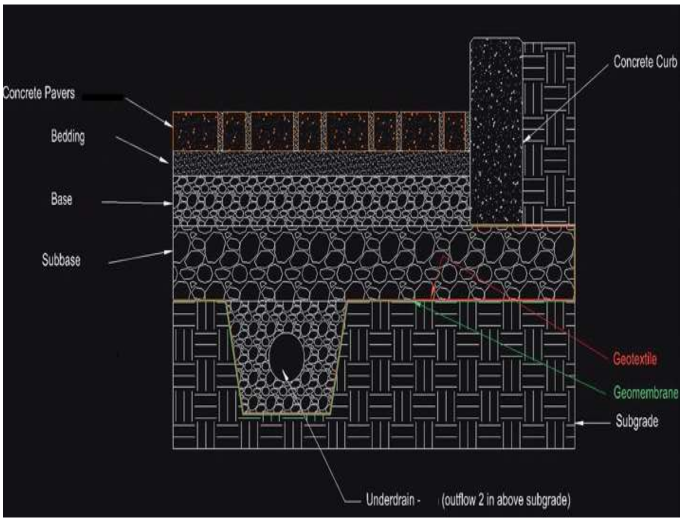

Fig:1 Typical Layers in Pervious Paving

2. LITERATURE REVIEW

Wilson et al., (2003) said that PPS should be constructed with an impermeable membrane, and the treated storm water should subsequently be discharged into a suitable drainage system. Porous pavements have been developed to reduce the runoff rates and growing volumes of storm water collected in urbanised areas. They should meet storm water demands while providing a hard surface, which can be utilised in urban areas (Schluter and Jefferies, 2004 and Scholz, 2006). Block paving stones made of specially designed porous concrete (i.e. polymer-modified porous concrete) exhibit better fatigue behaviour than those without polymers said Pindado et al., (1999). The lifespan of porous asphalt, porous pavement or permeable surfaces, in general, depends predominantly on the size of the air voids in the media. The more possibilities for oxidation, the less durability can be achieved (Choubane et al., 1998). Caoi et al. (1998) provided a method to determine the amount of infiltration liquid, and the storage capacity of a permeable base relative to the time of retention and degree of saturation associated with the characteristics of the base.

3. THE PAROUS PAVEMENT

Permeable pavement has been developed to reduce the runoff water in the urban areas. While providing them a solid surface, the demands of storm water should be met, which can be used in urban areas, porous asphalt or macadam pavement looks like conventional asphalt but is relatively porous. It has open graded asphalt and concrete on the open-grade total base above the well-flowing soil. Porosity is provided by the emission of fine aggregate.

Internal drainage cell type modular interlocking concrete block pre-cast or cast in-situ are forged or concrete or plastic gauze, with open cells. Mud mixed with grass seeds or porous aggregate usually fills the cells. Modular interlocking concrete blocks with external open drainage cells are also available on the market. Open cells are formed when the blocks are assembled in an interlocking manner and are filled with clean gravel.

Block paving stones made of specially designed porous concrete (i.e. polymer-modified porous concrete) exhibit better fatigue behaviour than those without polymers. Yet it has been shown that these improvements decrease for low values of stress levels, and sometimes appear to be negligible in the case of traffic loads on main and highway roads.

These concrete products can function as pollution sinks, because of their particle retention capacity during filtration. The high porosity of the special concrete leads to good infiltration and air exchange rates. Filtered out pollutants can sometimes be removed by cleaning of the pavement.

Porous asphalt and porous concrete pavement systems are usually prone to clogging within three years after installation. Due to clogging of voids, these systems can experience loss of porosity. The main reasons for clogging are:

- Before being washed off, the traffic carry the sediment into the porous pavement;
- Waterborne sediment, which goes on pavement and clogged pores before washing; And
- By the breaking actions of vehicles at the same spot, which results in collapsing pores of the permeable pavement.

If totally clogged, the systems must be reconstructed. Regular replacement renders these types of systems unfeasible and expensive.

Therefore, porous pavement maintenance is to prevent the surface of the pavement and / or the underlying intrusion bed being surrounded by fine sediments. For the whole year to keep the system clean and increase its age, the pavement surface should be replicated with a professional cleaning unit. All inlet structures should also be cleaned on a biennial basis within intrusion beds or in order to remove them.

4. ABOUT STUDY AREA: -

Guwahati located at co-ordinate of 26.1445° N, 91.7362° E Situated between the southern bank of the Brahmaputra river and the foothills of the Shillong plateau, with LGB International Airport to the west, and the town of Narengi to the east, Guwahati formerly Pragyotishpura (Sanskrit word meaning city of eastern light), was the capital of Ancient state of Kamarupa. A metropolis, Guwahati is the largest city of Assam in India and ancient urban area in North East India. The average annual temperature is 22.2 °C, with extremes ranging from 40.6 °C recorded on 24 April 2014 to 2.0 °C recorded in January 1964 and yearly average rainfall is recorded as 2,054. The total area covers by the city is 328 Km2.

5. DESIGN

The lifespan of porous asphalt, porous pavement or permeable surfaces, in general, depends predominantly on the size of the air voids in the media. The more possibilities for oxidation, the less durability can be achieved.

In the selected area (Anil Nagar, Zoo Road, Lachit Nagar) the traffic survey was done and the following result is getting from the survey.

Location	Calculated CMSA		Adopted values of CMSA for pavement design	
	For 10 years	For 15 years	For 10 years	For 15 years
Anil Nagar	5.06	8.72	6	10
Lachit Nagar	0.65	1.15	1	2
Zoo Road	2.74	4.76	3	5

Recommended Pavement Composition for road from IRC:37-2012 (Plate 4- 6% CBR)

Sl. No	Location	New Construction/ Widening				
		Bituminous concrete (BC)	Dense Bituminous Macadam (DBM)	Granular Base (WMM)	Granular sub Base (GSB)	Total thickness (mm)
1	Anil Nagar	40	65	250	260	615
2	Lachit Nagar	20	50	225	175	470
3	Zoo Road	25	50	250	210	535

Since the existing pavement is a compacted surface so it may consider as GSB and the bituminous layers all together consider as permeable asphalt. Therefore, from the above composition we may recommended that permeable pavement composition as below –

Sl. No	Location	New Construction/ Widening		
		Permeable Asphalt concrete (mm)	Granular Base (mm)	Total thickness (mm)
1	Anil Nagar	105	250	355
2	Lachit Nagar	70	225	295
3	Zoo Road	75	250	325

Recommendations for Permeable Interlocking Concrete Pavement: -Now as per the requirement we are considering here pavement with porous properties in the pavement. Here we consider the following composition from table 4 of BS 7533-2.

For PICP (Permeable interlocking concrete pavement)

Granular Sub base (GSB)- 150mm

Base course – 125mm

i.e. total permeable SUB-BASE= 150+125= 275mm minimum required

Laying Course (Course Sand) – 50mm (min. 30mm required)

Minimum paving block thickness – 80mm

Therefore, total thickness 400mm (minimum required)

6. Permeability test and cleaning of pavement:

The surface infiltration rate was first tested in its existing condition. Then an area of approximately 1m^2 was cleaned with the 'Eco-pave Cleaner', and then the infiltration rate retested.

The infiltration rate was tested using the ASTM Designation: C 1701/C 1701M-09; Standard Test Method for Infiltration Rate of In Place Pervious Concrete. The test procedure consists of an infiltration ring (300mm in diameter and 50mm high) being temporarily sealed to the surface of the pervious pavement. After prewetting the test location, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded.

The surface was cleaned by using the 'Eco-pave Cleaner', a water jet/suction device. After cleaning the Porous Gaps and Porous Blocks the joints are refilled with a 2/7mm chip (Porous Gaps) or a clean sand (Porous Blocks) and vibrated with a plate compactor.

7. Treatment and storage of absorbed water

The underground tank system is purpose-built to capture, treat, store and supply rainwater as an alternative to potable water for non-potable applications. This underground system offers great flexibility in its design with various configurations of its precast concrete barrels, and high-performance pump and filtration systems. Its ability to retain above ground land use while storing water underground makes the underground storage system a cost-effective solution for commercial, industrial and large-scale residential projects.

1. Absorbed water through permeable pavement is captured by the onsite drainage network.

2. It then passes through the pre-treatment filter, and into the storage tank.

3. Water from the filter enters the underground storage system via a calmed inlet device on the floor, directing water upwards and aerating the water column.

4. Particles that pass through the filter settle on the bottom in the sludge zone. Research has shown that this "living" environment is important in maintaining water quality.

5. Once full, the underground storage system overflows back to the drainage system via a skimming siphon; this ensures that any floating films or pollens are skimmed off the upper layer of the harvested water, improving oxygen transfer from the air zone.

6. Submersible pumps are located at the outlet end of the system. The pump intake is suspended 150 mm below the water surface by a float, to ensure only the best quality water is drawn from the operational storage zone for use.

7. The pump control system can be installed to draw on harvested water, or mains water supplies when storage levels are low, and can be connected to a building management system. The underground storage system can provide water for a range of applications, including irrigation, vehicle wash down, toilets, and cooling towers etc.

8. Conclusions

This paper is summarised for the rain water harvesting system using permeable pavement city like Guwahati where water scarcity in dry season from month November to March of every year. The other period water is available as highly rainfall area. Some more research and study will remain or required for such permeable pavement system for water harvesting. The related design, maintenance and water quality control aspects for the advisor were outlined for permeable and porous pavement systems. Detailed design, analysis and specific maintenance requirements for PPS do not allow specification of general guidelines. Therefore, future research is likely to be empirical and applicable nature.

Regarding perforated sidewalks, silica smoke and super plasticizers can be added to standard porous solid materials. It generally improves compression power of porous pavement to allow high load on the basis of application.

The short and long-term effects of pollutants living in PPS should be researched. Compared to traditional pavements, these relatively new systems require more assessment for the self-sustaining. Apart from this, the long-term effects of PPS on the environment are still unclear. Finally, since PPS is being set up as environment-friendly engineering techniques, engineers and planners need to develop simple computer-based decision-support tools.

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