IAPA Research Paper

Porous Pavement: Benefits & Applications

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Introduction

Roads have become a critical part of many aspects of life. People rely on roads to see their families and new adventures, allow them to transport themselves to and from work, give us access to many social benefits such as doctors, post offices, etc., and much more. Roads also open additional opportunities for economic and social development. The economy depends on roads as they link producers to markets, jobs to people, students to school, and so on. These roads must be built to design such wear and tear and be able to keep up with the ever-increasing demand. They are designed to withstanding minimum to heavy loads of traffic at a time as well as weathering and cracking due to particles absorbed into the roadway material, freezing, then expanding. One of the biggest factors to consider when designing a road is water. When rainfall occurs, water can infiltrate into the ground, however, if the material is unable to retain the rainfall, then runoff can occur. Runoff is excess flow of water due to stormwater (rainwater). As a result of runoff, the Earth's surface (roadways, sidewalks, etc.) can accumulate stormwater due to impervious areas that cannot absorb it into the ground, thus making it difficult for people and the environment.

Background

Introducing Porous Cement:

Porous pavement is a water-permeable paved surface or area made up of a specific, permeable material mix which mitigates the runoff by allowing the precipitation to pass into the ground's surface due to the high porosity. Porous pavement surfaces could be asphalt, concrete or interlock pavers. With porosity and permeability being significantly high enough, hydrology, rooting habitats, and other environmental aspects are impacted due to infiltration (*Porous Pavements*). Since the water enters the grounds surface, runoff is reduced therefore also reducing water pollution and keeping the roadways safer.

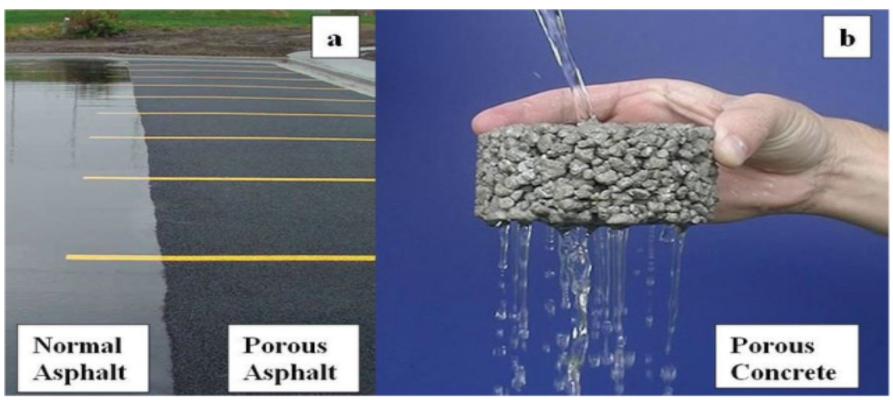

Figure 1: Normal and Porous Asphalt (NAPA, 2012); b) Porous Concrete (Hall, 2012)

History:

According to the records, pervious concrete was first implemented in Europe in the 1800s as pavement surfacing; however, it gained a lot more momentum overseas after the Second

World War due to the shortage of cement. In the United States, it has only been implemented in the past fifty years with the goal of reducing floods, raising water tables, and replenishing aquifers (*Permeable pavement*). Since then, permeable concrete has significantly evolved in the past 15 years and has grown in popularity across the United States due to its numerous benefits and versatility of uses.

What are the benefits of Porous Pavement?

Permeable pavement is a realistic and sustainable option, especially opposed to conventional methods and mixes. Some of the benefits include but are not limited to less runoff, environmental reasons, longevity, and it's cost efficiency. The primary incentive for using permeable pavement is to add a hydrological benefit to a roadway or site design. They allow a more natural water passage into the ground, reduces run off, and lessens flooding disasters. When roadways are flooded, many accidents can occur which could result in death, injury, or heavy traffic. Through keeping water off the surface of the road, not only are the roads safer, but they are also less likely to get water related damages as quickly. Stormwater ordinances have begun requiring better stormwater management systems on site. Permeable pavements are a reliable and cost-efficient option as it allows infiltration into the soil. They diminish the need for traditional stormwater management systems such as detention basins. (USEPA 2009, 21- 25). These requirements have been defined to help areas such as urban ones that lack natural land cover. The lack of natural land cover has caused various issues: flooding and transporting pollutants, but as mentioned before, pervious pavement helps lessen the effects of these issues.

Porous pavement has been attributed to reducing the spread of pollutants not only by reducing runoff which often contains oil, hard metals, etc., but also through physically, chemically, or biologically capturing the pollutants. Normally, rainfall soaks into the soil and vegetation and naturally gets filtered, but in urban areas, this process is not as easy. Instead of permeable surfaces such as grass and dirt, rooftops, and roads release contaminants (bacteria, trash, heavy metals, etc.) which is one the most significant sources of water pollution (EPA, 2008).

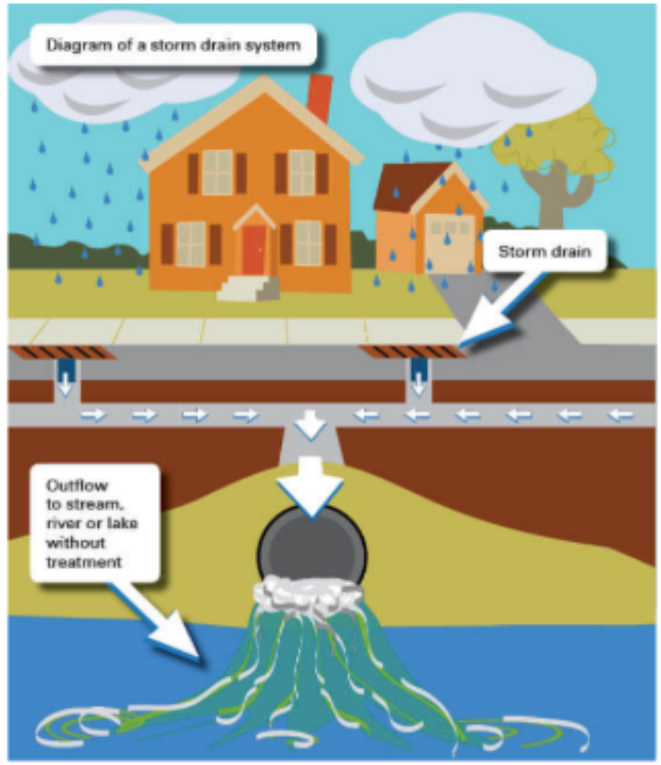

Figure 2: Pollutants entering waterways

More so, salting roads is a very common practice in colder climates since the salt helps melt the snow and ice off the roadways. The salt dissolves and melts with the ice and snow and penetrates the ground or waterways negatively impacting the groundwater, river, and any nearby bodies of water. Porous pavement can be utilized to reduce the application of salt. As mentioned before, porous pavement has holes and voids all along its surface. These voids are made to allow water to pass through, but when there is no water, air is kept inside the pavement and stores heat. The ice and snow are then melted away quicker. Roseen, Ballestero, Houle, Briggs, and Houle stated in their study that porous pavements supported a degree of infiltration volume which allowed it to remain well drained even during winter months. This trait let the melted snow and ice properly drain through and allowed the voids filled with air help heat the exposed surface (Roseen et al. 2012, 81-89). Depending on the nature and purpose of the porous pavement, pollutants can also be trapped in the soil or pavement, bacteria or other microbes can break down and utilize some pollutants, and plants can grow in-between some pavers and trap or store pollutants (USGS 2016).

In addition to benefiting the environment, pervious pavements have proven to be a very cost-efficient material and to yield a long-life expectancy. Due to the material's natural durability and resistance to water related weathering, porous pavement can handle rainwater management for decades without producing cracks and/or potholes and does not require nearly as much as repairs or reconstruction. With the robust and tough nature of the material, the life expectancy is 20 years. This has been proven through multiple porous pavement applications such as parking lots, walkways, and even high-volume highways. However, it is important to include the maintenance needed to keep porous pavement's surface and infiltration bed from getting clogged. The pavement surface needs to be vacuumed biannually with a commercial cleaning unit as well as any inlet structures within or draining to the beds should also be cleaned out on a biannual basis. Furthermore, abrasives

Figure 3: Porous Pavement Commercial Cleaning Unit

such as sand or cinders and sealants should never be applied to the surface (*Porous Pavement Operation and Maintenance Protocol*). Porous pavement also eases the demand for storm sewers which alleviates local government's impact fees and costs associated with storm sewers. More so, porous pavement diminishes the need of other storm water management options such as retention ponds, curbs, gutters, and more. There will also be lower installation costs as there is no underground piping, storms drains, or grading needed. Table 1 summarizes design requirements for sidewalks and the associated costs (Chen, X. C., Wang, H., & Najm, N. (n.d.).

	Structure design	Drainage system	Construction cost
Pervious Concrete Shoulder (Highway Traffic)	Thickness: 10" Reservoir layer:12"	Two collection slotted pipes were placed to document runoff volume and water quality analyses	1.5 times conventional paving method due to skilled labor to install the concrete layer
Permeable Asphalt (Light Traffic)	Thickness: 3"	N/A	$110 / sq. yard; full 8" including choker stone, Storage stone not included
Pervious Asphalt (Minimal Traffic)	N/A	Combination of traditional curbs channel to receiving storm sewer and pervious asphalt	Cost of designing and installing slightly higher than traditional pavement due to innovative engineering
Permeable Concrete for Sidewalk	Length: 1500' Width: 5 1/2'	N/A	$20/ sq. yard (bid price lower than expected), $10000 additional engineering cost
Permeable Concrete for Bicycle Lanes Sidewalk	Bike lane 5' wide; Sidewalk 6' wide	Gutter slope and overflow basin to remove standing water into storm water facility	Pervious concrete lane: $140 / sq. yard, Pervious Concrete Sidewalk: $92.25 /sy

Table 1: Summary of Porous Pavement Design Requirements and Costs

What are the different options for Porous Pavement?

Permeable concrete and permeable asphalt are typically the main options for permeable pavement. Permeable concrete is made through mixing concrete with minimal fine aggregates which naturally leaves a void content of about 20%. While the void content allows the water to follow through the concrete, it also greatly reduces the structural integrity of the concrete, so it is recommended that fibers or additional admixtures be added (Hein 2016). Shrinkage is also a possibility due to the void content being so high., so that will need to be factored into the design which will probably therefore raise the price (Hein 2016). These properties also create an extremely low working time, meaning it has low viscosity and is difficult to maneuver out of the cement trucks.

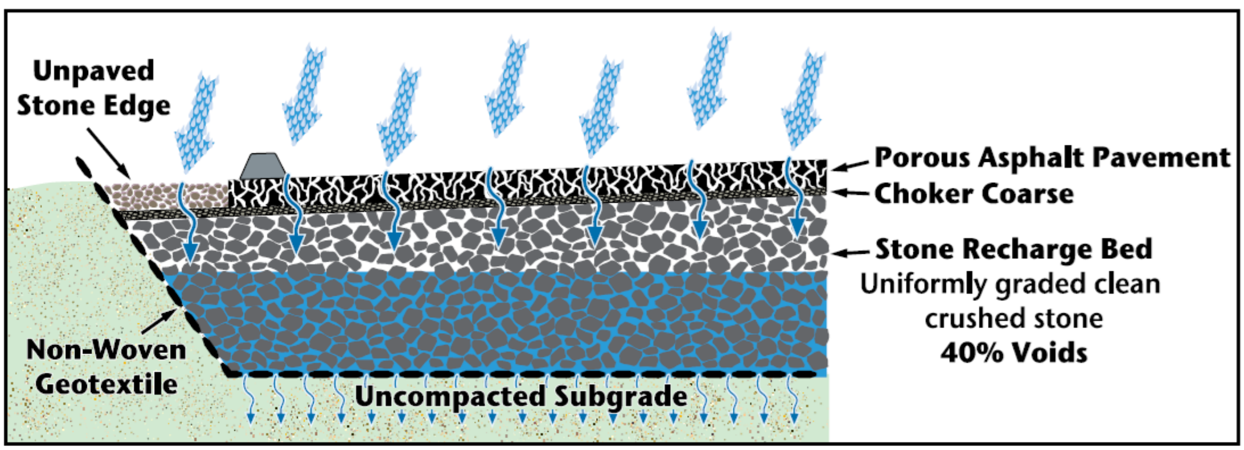

Figure 4: Porous Asphalt Cross Section

Above is a figure which depicts the cross section of porous asphalt. Each layer serves a purpose. The porous asphalt pavement is the surface which allows the water to filter through. The Choker Coarse is mainly utilized to stabilize the surface during construction. The Stone Recharge Bed is used as a buffer layer. It holds water after storms and slowly drains the water into the soil 12-72 hours later. Additionally, there is the Non-Woven Geotextile layer which catches subgrade particles, not allowing them to enter the Subgrade. Finally, there is the Uncompacted Subgrade. It allows for maximum infiltration (IAPA 2018). Porous Asphalt is a great option as it is typically a cheaper option and due to its applicableness. It can be placed over any impervious surfaces. It has also been found to significantly reduce the pollutants from storm runoff, more so than porous concrete and alternative porous methods.

Conclusion

The purpose of this research paper was to investigate the various applications of porous pavement and its various benefits. Through understanding the history and intended purpose of porous pavement, one can see that it had developed and adapted to better serve both the community and surrounding environments. Porous pavement's greatest strength is reducing runoff; this not only allows for a safer method of travel but also traps and filters many pollutants. More so, porous pavement can reduce life-time costs as it requires very little maintenance and repairs if treated properly and has a life cycle of 20 years, which makes it very cost efficient. After comparing the two major options for porous pavement, porous asphalt proved to be the better of the two. Not only is it typically cheaper, but it also has very impressive abilities to capture and reduce pollutants from runoff. With everything being considered, porous pavement continues to be a very cost efficient and environmentally friendly option, but one should thoroughly research their project and proposed area before choosing porous pavement as their material. There are times when there will be better options or that the characteristics of porous pavements are just not applicable.

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