Is Pervious Pavement Pervious?

A Literature Review of Pervious Pavement

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Annalise Mannix, P.E., B.E., M. ASCE

Annalise Mannix Engineering and Consulting, LLC

Abstract

The future of the environment depends primarily on land use, and, as land use is primarily decided at the local level, the most effective way to bring about positive change is the education of local elected, appointed, and staff land use officials (University of Connecticut, 2012). Links between land use and water quality are well correlated by the scientific community, however, many local land use decision makers are provided little nonpoint source, or stormwater related, pollution education and assistance to help them foster better land use decisions. It is believed that improved communication of relevant information may maintain or improve community character and health (University of Connecticut, 2012). Pervious pavements are one method of reducing stormwater runoff, reducing utility costs and improving nearshore water quality in the Keys. This paper provides information on pervious pavements and highly recommends their use wherever possible.

History

The development of cities brought with it fixed infrastructure and increases in impervious surfaces which fail to allow rainwater to flow to the underlying soils. This interruption of the natural system reduces water recharge into underground aquifers, disrupts natural flow patterns, and increases the deposits of contaminates to receiving water bodies (Brattebo and Booth, 2003). According to the EPA (USEPA, 1997), there is strong evidence that poor water quality is correlated with loss of fish population and habitat, increased temperatures, and sedimentation. Local governments are now saddled with regulations to limit stormwater pollution and sometimes limit the total maximum daily load (TMDL) during rain events.

Pervious concrete pavements were first developed in the 1960's and a variety of other types, including perforated pavers and soil filled polyethylene forms, were developed later in the century. These products reduce rainwater, or stormwater, runoff by allowing it to infiltrate through the system, be stored and more slowly released into the ground. The principle behind the function is providing storage volume through pore spaces which allow rapid acceptance of water. Pervious concrete have void spaces ranging from 15 percent to 35 percent (Brown, 2003), which is often a greater volume than natural soils.

The EPA reported that a study in Tampa, Florida determined that less than 20% of rainfall was converted to runoff when using permeable pavements while a University of Washington study found increased perviousness of a treatment system was correlated to a reduction of runoff volume and pollutant loadings (USEPA, 1999 p.ii).

Pervious Permitting in Florida

The control of peak storm events are generally controlled through the use of storm sewer systems and in low lying areas with direct outfalls to the nearshore waters. The systems collect runoff from impervious areas and store or discharge it to a storage system or water body. The design, operation, and maintenance of such systems are typically governed by regulations of state, regional or local government agencies.

The Florida Department of Environmental Protection provides stormwater management credit for pervious concrete (Wanielista, Chopra, Spence, & Ballock, 2007, p. 6) while the State of Florida proposed a Statewide Unified Stormwater Rule which, among other items, addresses the use of "treatment trains" and "low impact development" (LID), the rule however, has yet to be adopted. The South Florida Water Management District's (SFWMD) mission is to "manage and protect water resources of the region by balancing and improving water quality, flood control, natural systems, and water supply". It promotes effective construction practices and stormwater systems which reduce the need for water detention systems on sites as well as reducing runoff and flood impacts while allowing stormwater to recharge groundwater. The SFWMD highlights pervious pavement as part of a treatment train in ecologically friendly LID (SFWMD, 2009) and drafted a memo (SFWMD, 2012) providing guidance on how to approach permitting the systems. Guidance, though not a rule, recommends treatment credit based storage volume, and design recovery storage volume. These pervious systems include such material as pervious concrete, pervious paver systems, pervious asphalt, and pervious aggregate/binder products, like Plexi-Pave, a product used successfully by the City of Key West, FL for its heavily traveled sidewalks and tree wells on Duval Street. Furthermore the SFWMD Environmental Permitting Manual (SFWMD, 2012), which is the state rule for water related land use permitting in South Florida, has incorporated a definition of impervious that excludes pervious pavement allowing their use as pervious material:

> "2.15 "Impervious" - Land surfaces which do not allow, or minimally allow, the penetration of water. Examples include building roofs, normal concrete and asphalt pavements, and some fine grained soils such as clays."

As a small island city with low elevation, stormwater management is an important aspect of the City of Key West, Florida public works services. Reduced nutrient loading as well as limiting puddles and flooding are regulatory and customer driven goals. Pervious pavement can assist in each area. Like the SFWMD, The City of Key West ordinance provides a definition of impervious which allows the use of this time tested BMP,

> "*Impervious surface* means a surface which is highly resistant to infiltration by water. It includes surfaces such as compacted sand, limerock, or clay, as well as most conventionally surfaced streets, roofs, sidewalks, porous and nonporous parking lots and other similar structures." (Key West, 2002, Sec. 108-714).

The City code also recommends that developments use soil percolation as a method to reduce reliance on City infrastructure:

> "Areas and lots shall be developed to maximize the amount of natural rainfall which is percolated into the soil and to minimize direct overland runoff into adjoining streets and watercourses." (City of Key West, 2002, Sec.108-785(1)).

With already high utility fees for stormwater management, the City could see a savings in capital and maintenance projects if pervious pavement was promoted as a modern land use development technology on residential and commercial installations.

Pervious Systems

Pervious concrete consists of small stone aggregate, cement, water, and admixtures, exempting the standard concrete sand mixture. This provides for rapid passage of water and subsequent infiltration. Pervious concrete is considered by the EPA (USEPA, 1999) to be a best management practice (BMP) for stormwater retention. The SFWMD (2002, p.19) recommends source control through LID to manage stormwater cost effectively on parcels with landscape features rather than conveyance to costly facilities located at the bottom of drainage basins.

The Florida Department of Transportation funded a study by the University of Central Florida of in-the-ground pervious pavements in the Southeast United States. The study included field investigation of pervious concrete parking lot sites and laboratory infiltration tests on sample cores gathered during the field investigation. A total of eight pervious concrete parking areas, all of which had been operational for several years, were investigated. Five of the sites were in Florida.

The installations ranged in age from 6 to 20 years with an average of 12.8 years, and the results from the Central Florida samples indicated that infiltration rates ranged from 1.4 to 627 inches per hour, and, with outliers removed they had a mean of 8.1 and median of 4.4 inches per hour (Wanielista et al., 2007, p.34). The concrete and soil infiltration rates at 3 sites were sufficient to capture 80% or more of the rain over one year. (Wanielista et al., 2007, p. 30)

Wanielista et al. (2007, p. 34) found these rates indicate that properly installed pervious concrete can continue to infiltrate even without routine maintenance. For new construction, the infiltration rates of the pervious concrete exceeded that of the parent earth sub-soils, however rates may reduce over time. Wanielista et al. (2007, p.34) argued that in recent installations infiltration rates of the pervious concrete exceeded that of the parent earth sub-soils, “thus at first, the limitation to infiltration rate and storage of rain was the sub-soils." Water quality was not tested in the study.

Water quality as well as flow management is an important aspect of stormwater management. A high level of water quality treatment in pervious pavement was reported by Roseen, Ballestero, Houle, Briggs, and Houle, (2012, p. 2) with exceptional performance for petroleum hydrocarbons, zinc, and total suspended solids, with most values below detection limits and the challenging phosphorous removal at a 42% removal efficiency. The level of water quality treatment provided by these systems is indicative of a dual purpose use for pervious pavements: storage and contaminate removal.

Wanielista et. al. (2007, p.1) also noted that "Pervious concrete, already recognized as a best management practice by the Environmental Protection Agency (USEPA, 1999, p.1), has the potential to become a popular alternative for dealing with stormwater runoff." Further the EPA concludes these pavements "can reduce the percent imperviousness for urban areas, which allows for greater infiltration rates and reduced runoff volumes. In addition these alternate pavement types function as stormwater pollutant removal mechanisms (USEPA, 1999, p.32).

Youtube.com Videos

The University of Connecticut installed a new pervious pavement parking lot as part of its TMDL reduction program. The porosity of the pavement is presented by two educators in a video accessible through YouTube.com at http://www.youtube.com/watch?NR=1&v=LVOUKHFvFi8&feature=endscreen . DRS Asphalt Paving (2007) of Madison Wisconsin produced a video showing the effectiveness of a section of porous asphalt adjacent to standard asphalt through the use of a fire hose. The video of pervious pavement's ability to receive water may be viewed at: http://www.youtube.com/watch?v=gXCcC4iH8IQ . The Morris Arboretum, in Philadelphia, PA, claims no water exited its pervious parking lot during Hurricane Floyd so failed to contribute to the nearby flooding (Greentreks Network Inc., 2009). It successfully integrated this BMP to improve water quality in the local creek. A YouTube.com presentation can be viewed at http://www.youtube.com/watch?v=J-yx4ItjErw .

Conclusion

Population growth and associated infrastructure growth demands a holistic approach in water resource management to support and maintain eco systems and quality of life. Since stormwater is a local source of pollution to the nearshore waters in Florida, local governments must take responsibility for reducing or controlling runoff. Site planning should proceed with not only basic components, like sidewalks and open spaces, but with an understanding of the causes of stormwater pollution. Design solutions should incorporate cost effective and efficient stormwater control practices not only for the site but considering city infrastructure and the health of the environment as well. BMPs (bioretention areas, treatment trains, reduced road sizes, pervious pavements) should be used with multiple objectives to reduce both runoff and contaminates. Local programs should be updated to stay current with best practices and changes in the environment. BMP implementation may provide supplemental benefits of climate resiliency and quality of life aesthetic enhancements developed through thoughtful landscape and stormwater planning.

In conclusion, the City of Key West would benefit through the use of pervious pavements as walkways and driveways and also as part of an integrated stormwater management plan.

These products and other BMP's can be part of a more sustainable future for the island. It is strongly recommended that the City of Key West encourage the use of pervious pavement.

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Annalise Mannix is a Florida Licensed Professional Engineer and the principal engineer of Annalise Mannix Engineering and Consulting , LLC specializing in site and utility design, residential and commercial structures as well as municipal climate planning and sustainability issues. A graduate of New York's Maritime College, she is currently completing a Master's degree in Management. She spent over 20 years in municipal government as building inspector and plan reviewer, engineering, stormwater services, and environmental programs manager. She was an energy engineer for commercial and industrial natural gas applications.

She is Chair Monroe County Climate Advisory Board and managed the development of the City of Key West Climate Action Plan. As a Fair Insurance Rates of Monroe Board Member and Executive Director she works tirelessly to improve wind insurance modeling and to ensure wind insurance rates are fair. She has been an expert witness during Insurance rate hearings and for presentations to the legislature and state committees.

Annalise may be contacted at amannix@aol.com or (305)797-0463.

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