University of Kentucky
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Alternative Pavement Options for Residential Stormwater Management

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Urban areas are characterized by impervious surfaces such as roads, driveways, sidewalks, and building roofs. Stormwater occurs when precipitation runs off these impervious surfaces. Stormwater can present both water quality and water quantity issues in urban watersheds. Water quality of local waterways is threatened when stormwater carries pollutants to streams and rivers; increased water quantity in these local waterways can damage streambanks, cause flooding, and create more water quality problems.

Stormwater must be managed to prevent or minimize negative impacts from urban activities. Homeowners can consider alternative pavement options as a method of residential stormwater management. Options include replacing all or a portion of the impervious surface footprint with grass, permeable pavement, or other materials that allow water infiltration. These alternatives to traditional asphalt and concrete can reduce the overall quantity of surface runoff, increase infiltration, and help reduce urban heat island effects.

Reduced Impervious Surfaces/ Pavement Strips

Stepping-stone Paths and Walkways

In many residential settings, it is possible to replace concrete walkways with natural or manufactured stepping-stone paths (Figure 1). Turf, uncompacted gravel, decorative stone, mulch, or other permeable materials are potentially suitable materials to use in the spaces between the natural or manufactured stepping-stones to allow for water infiltration between the stones. This type of path can essentially serve as a disconnected impervious surface when compared to traditional concrete walkways. Improved infiltration in a pathway generates less runoff that may flow to nearby storm sewers.

It is important to consider whether this type of path will be feasible based on the needs of the residents and potential visitors. It may be difficult for low mobility individuals or those requiring wheelchairs or other mobility support devices to travel across these types of paths efficiently and safely. Check all applicable homeowners association rules, residential building codes, and municipal regulations to ensure this type of walkway is permissible.

Ribbon Driveway

Ribbon driveways offer an option to reduce the overall impervious surface of a driveway and allow for an infiltration area between two concrete strips, or "ribbons." Each ribbon should be a minimum of two feet wide, and there should be five feet of space between the centerlines of the two ribbons. This configuration should accommodate the track width of most standard passenger vehicles. Variations on the concrete strips shown in Figure 2 could include the use of permeable pavement materials listed in the following section. Turf, uncompacted gravel, decorative stone, mulch, or other permeable materials are potentially suitable for use in the center strip of a ribbon driveway. Choose an option that meets your desired maintenance and upkeep level, knowing that gravel and stone may require weeding. During construction, installers should take care to avoid compaction in the center strip as much as possible to maintain the infiltration capacity of the center strip. Check all applicable homeowners association rules, residential building codes, and municipal regulations to ensure this type of driveway is permissible.

Permeable Pavement

Another method of stormwater management is to reduce runoff by increasing infiltration with permeable or pervious

Figure 1. Stepping-stone pathways can provide an alternative to concrete walkways.

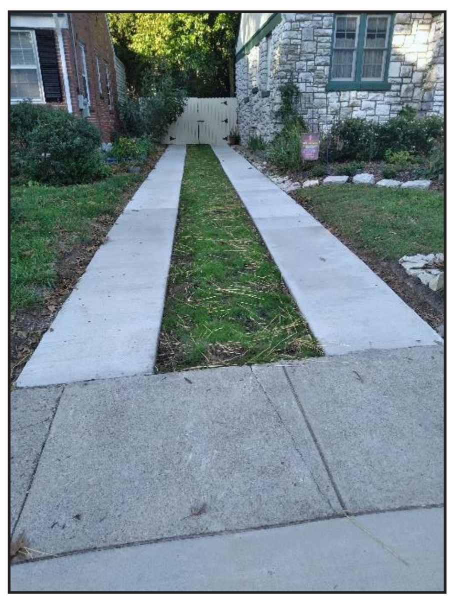

Figure 2. A ribbon driveway allows infiltration between the "ribbons."

pavement (Figure 3, upper portion). Permeable pavement allows stormwater to percolate through the pavement and infiltrate the underlying soils, thereby reducing runoff from a site, unlike standard pavement, which prohibits infiltration (Figure 3, lower portion). Permeable pavement looks similar to standard asphalt or concrete, except void spaces are created by omitting fine materials. Compacted gravel is not considered permeable pavement.

Figure 3. Pervious pavement (upper portion) offers a number of environmental benefits as compared to standard asphalt (lower portion).

Benefits of Permeable Pavement

Permeable pavement offers multiple environmental benefits. Increasing the amount of stormwater infiltrated can result in lower stream flow levels after storm events, increased normal streamflow due to increased groundwater recharge, and increased stream stability through reduced stream velocities and peak flows. The benefits of providing stream stability range from erosion control to habitat protection for aquatic life. Evaporation from beneath the permeable pavement can produce a cooler surface, helping reduce the heat island effect often experienced in urban settings. Permeable pavement can also aid in the health and development of urban trees by providing root systems with greater access to water and air.

The materials used in permeable pavement and its foundation are capable of retaining soluble and fine particulate nutrients, sediments, heavy metals, and other pollutants from stormwater runoff, thus improving the quality of surface waters and groundwaters.

Permeable Pavement Types and Design

Numerous types of permeable pavement are available. Pervious concrete is most common today, but porous asphalt, interlocking concrete pavers, concrete grid pavers, and plastic reinforced grids filled with either gravel or grass are also available. The pavement type itself typically refers only to the surface layer of a structure consisting of multiple layers.

A filter course comprised of finer aggregate (0.5 inch diameter) typically lies beneath the surface layer (porous paving course). This filter course overlays a stone reservoir (1.5 to 3.0 inches in diameter), the thickness of which depends on the stormwater storage needs and load-bearing requirements. Below the stone reservoir, a filter fabric layer rests on the undisturbed soil. The filter fabric layer prevents soil particles from entering the stone reservoir due to fluctuations in the water table or any pumping action from repeated loadings. Filter fabric should also be used along the sides or perimeter of the permeable pavement system to prevent soil from entering at those locations. Figure 4 shows a typical cross section of a permeable pavement installation.

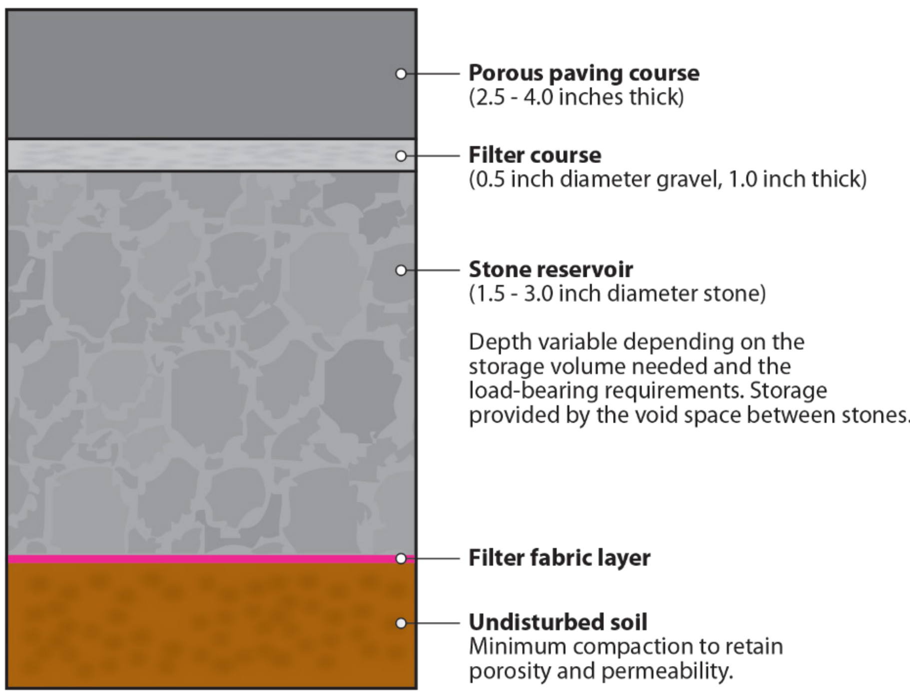

Figure 4. Cross section of a typical permeable pavement installation.

To prevent clogging, only cleaned, washed stone that meets municipal roadway standards should be used. Depending on design needs, perforated pipes can be

Figure 5. Pervious concrete can easily withstand relatively light loads from pedestrian and bicycle traffic.

Figure 6. Porous asphalt can be used in low-volume, low-speed vehicular traffic applications.

added near the top of the stone reservoir to discharge excess stormwater from large events. Also, instead of allowing stormwater to infiltrate into the underlying soil or where the permeability of the underlying soil is not optimal, perforated underdrain pipes can be installed to route water to an outflow facility structure. It is recommended that an observation well be installed at the down-gradient end of the permeable pavement to monitor performance.

Pervious Concrete

Pervious concrete is a mixture of Portland cement, coarse aggregate or gravel, and water. Unlike conventional concrete, pervious concrete contains a void content of 15 to 35 percent (average of 20 percent) that is achieved by eliminating the finer particles, such as sand, from the concrete mixture. This empty space allows water to infiltrate the underlying soil instead of either pooling on the surface or being discharged as runoff. Mixed-use paths, driveways, and parking lots are ideal applications for pervious concrete. The structural strength of pervious concrete, although typically less than standard concrete mix designs, can easily withstand the relatively light loads generated by pedestrian and bicycle traffic (Figure 5). The loads placed on pervious concrete in driveways and parking lots can be much more substantial and require consideration when selecting the concrete mix and pavement thickness. While the structural strength of porous concrete can be increased by adding larger amounts of cement, the porosity will decrease, thus decreasing infiltration rates.

Porous Asphalt

Porous asphalt is a standard asphalt mixture of both fine and coarse aggregate bound together by a bituminous binder, but it uses less fine aggregate than conventional asphalt. The void space in porous asphalt is similar to the 15 to 35 percent in pervious concrete. The surface appearance of porous asphalt is similar to conventional asphalt, though porous asphalt has a rougher texture. The surface layer of asphalt is usually thinner than a comparable installation of pervious concrete. While the compressive strength of pervious concrete is usually less than that of conventional concrete, the compressive strength of porous asphalt is comparable to that of conventional asphalt. Porous asphalt can be used for pedestrian applications such as walkways and low-volume, low-speed vehicular traffic applications such as parking lots, curbside parking lanes on roads, and residential or side streets (Figure 6).

Pavers

Permeable interlocking concrete pavers (PICPs) and clay brick pavers (PICBPs), as well as concrete grid pavers (CGPs), are similar in installation and function, although they are made from different materials. PICPs are solid concrete blocks that fit together to form a pattern with small aggregate-filled spaces in between the pavers that allow stormwater to infiltrate. These spaces typically account for 5 to 15 percent of the surface area. PICBPs are the same as PICPs, except the material is brick instead of concrete. With CGPs, large openings or apertures are created through their lattice-style configuration (Figure 7). These openings, which can account for 20 to 50 percent of the surface area, usually contain soil or grass, though small aggregates can be used. While CGPs have larger openings than PICPs and PICBPs, they are not designed for use with a stone reservoir but instead can be placed directly on the soil or an aggregate base. As such, the infiltration rate of PICPs and PICBPs is much higher than that of CGPs.

Plastic turf reinforcing grids (PTRGs) are made of interlocking plastic units with large open spaces. PTRGs are generally used to add structural strength to topsoil and reduce compaction. Typically grass fills the open spaces, although small aggregate can be used as well. Infiltration is improved when grass is used, as the plant roots help increase the permeability of the underlying soil.

Uses of Permeable Pavement

Permeable pavement can be installed in most places that conventional concrete or asphalt pavement is presently used. However, some properties of most permeable pavements limit their applicability. Permeable pavement is not generally used in applications where high traffic loads, in terms of volume and weight, or high rates of speed are encountered. Its use should be limited to pedestrian and light to medium vehicle traffic. Mixed-use paths, sidewalks, driveways, and overflow parking lots are ideal locations. Permeable pavement is typically designed to absorb only the stormwater that falls directly on it, although stormwater from rooftops or adjacent impervious surfaces can sometimes be directed to permeable paved areas.

Check all applicable homeowners association rules, residential building codes, and municipal regulations to ensure these designs and materials are permissible.

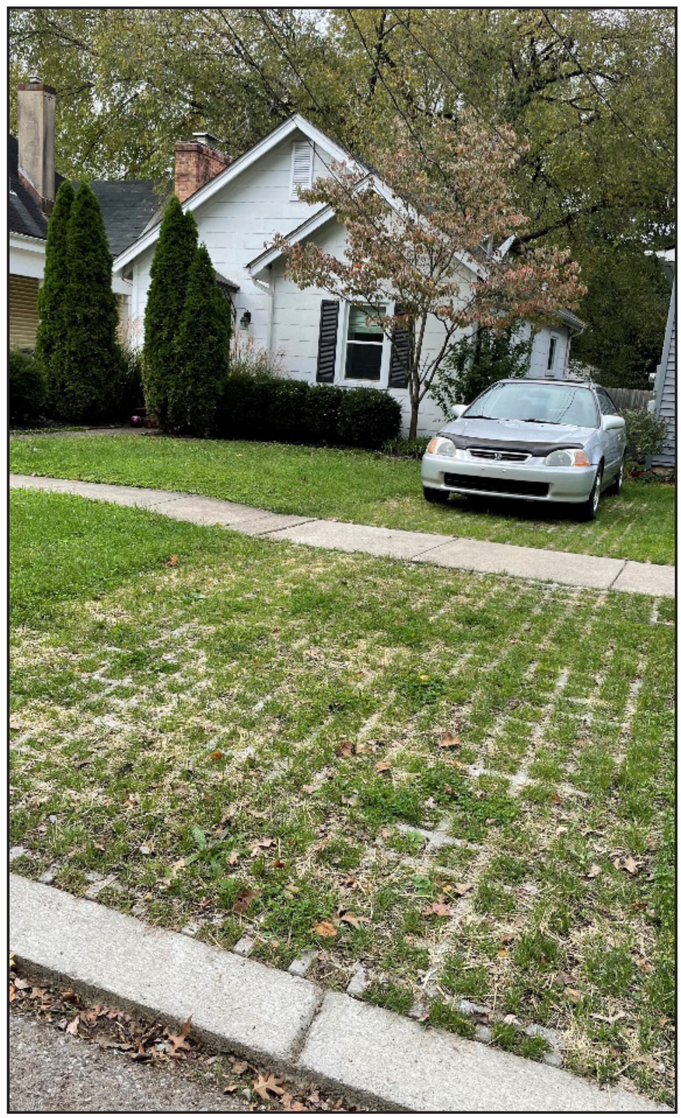

Figure 7. Concrete grid pavers contain spaces that allow stormwater to infiltrate between the pavers. Spaces can be filled with small aggregates (left) or soil and grass (right).

References and Further Reading

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Figure credits: Photos by Lee Moser (figures 1 and 2); photos by Jonathan Villines (figures 3, 5 and 6); graphic adapted from Porous Asphalt Pavement, 1992, by the City of Rockville, Maryland (figure 4); and photo on left by Jonathan Villines, and photo on right by Amanda Gumbert (figure 7).

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