10.0 Permeable Pavement

10.1 Overview of Practice

Traditional asphalt and concrete pavements are impermeable, which convert nearly all rainfall to runoff. These pavements were designed to withstand heavy traffic loads. Permeable pavement allows water to pass through it, reducing runoff (Figure 10.1). This pavement is best used in low traffic situations similar to those found in patios, parking pads, and driveways, which makes it a good "backyard" stormwater control measure. Permeable pavements may be constructed of permeable asphalt, pervious concrete, permeable interlocking concrete pavers (PICP), concrete grid pavers, and grassy pavers (Figure 10.2). They are typically underlain by a gravel support layer ranging in thickness from 4 to 12 inches. Permeable pavements function best when sited on sandy soils, such as those found on barrier islands, the Coastal Plain, and the Sandhills. Permeable pavement should not be placed near active construction zones, as they are prone to clog. An example of a patio constructed of permeable pavement is shown in Figure 10.3, and a residential driveway application is shown in Figure 10.4.

Figure 10.1 Illustration of permeable pavement function – garden hose dispensing onto permeable concrete.

Figure 10.2 Four types of permeable pavements (starting top left corner and moving clockwise): permeable concrete, permeable interlocking concrete pavement, grass pavers, and concrete grid pavers.

Figure 10.3 Permeable pavement patio outside a café in Swansboro, NC.

Figure 10.4 Permeable pavement driveway.

10.2 Permeable Pavement Siting

In parts of North Carolina, NC DENR awards a runoff reduction credit if permeable pavement is used in place of impermeable pavement. This blanket credit for permeable pavement as a stormwater control measure is only available in the Sandhills, Coastal Plain, and Barrier Islands; however, credit on a case-by-case basis can be given in the Piedmont and Mountains. The CCAP will only provide funding for permeable pavement projects in the Coastal Plain, Sandhills, and barrier islands. The reason for this geographic limitation is that the stormwater infiltration is limited by the native soils. Sandhill and Coastal Plain soils are often sandy and well-drained.

It is imperative that in situ soils are analyzed in depth before permeable pavements are installed. A three foot hole should be dug in multiple locations in the proximity of the proposed permeable pavement site. The soils should be well drained (See Section 3.7), with no signs of wetland characteristics within the soil profile. (See Section 3.8) Additionally, the infiltration rate at the site should exceed 0.5 in/hr throughout the top 3 feet of soil. Field determination of infiltration rate is described below in Section 10.3.1.

The site where the SCM is to be installed must currently consist of impervious area that will be removed and replaced with permeable pavement. The area should ideally have a very slight slope (less than 0.5%) to allow maximum stormwater storage to lessen engineering design. This practice should only be used for backyard patios, sidewalks, and residential parking pads. The sites that are selected for permeable pavement installation should not experience heavy vehicular traffic such as garbage trucks. The traffic load should be consistent with normal residential use. Any parking lot either associated with a business or larger than 2 stalls should be designed by an engineer to ensure structural stability. Any permeable pavement lot that is to be sited on an existing slope of more than 0.5% should also be designed by an engineer.

Permeable pavement should not be used to treat runoff from any adjoining areas larger than the square footage of the permeable pavement itself. It is imperative that these pavements are surrounded by a stable catchment. No disturbed soil should be present in areas draining to the permeable pavement. Permeable pavement is used primarily to infiltrate the rain that falls onto it. Typically, if grassed and rooftop areas are to be treated at a given residence, a SCM other than permeable pavement may be more desirable.

10.3 Permeable Pavement Design

10.3.1 Initial Soil Analysis Field Test

The infiltration rate at the site should be 0.5 in/hr throughout the top 3 feet of soil. To test this, three holes will be required, each at least 4 feet away from the other (again, this should be done in multiple locations around the proposed site). Each of the 3 holes will have a different depth: 1-foot, 2-foot, and 3-foot. Each hole should be filled with water. The 1-foot hole should be drain in 6 hours, the 2-foot hole in 12 hours, and the 3-foot hole in 18 hours. This test is performed to ensure no impermeable layer is present in the top 3 feet of soil. Permeable pavement should never be installed without field testing of soil infiltration rate. Additionally, field tests of infiltration rate may be performed with a double-ring infiltrometer or a constant head permeameter and may be preferable to the simple field test described above.

In general, the soil classification should be no finer than a Loamy Very Fine Sand as defined by the United States Department of Agriculture – Natural Resources Conservation Service. More detail on permeable pavement is available in Chapter 18 of the North Carolina Stormwater BMP Manual (NCDENR, 2007). If these infiltration criteria are met, the soils at the site will meet the screening criteria for permeable pavement installation; however, detailed soil analysis should be performed to ensure that the site is suitable. If soils at the site are questionable for permeable pavement installation, it is recommended that a soil scientist or a competent professional in evaluating soils be consulted to determine the soil's permeability.

10.3.2 Soil Analysis Lab Test

If the initial field soil test described in section 10.3.1 indicates that the soils may need further analysis, soil samples should be taken from the area where this SCM is to be implemented. These samples should be taken to a laboratory for analysis to ensure that they will be structurally sufficient to support the permeable pavement and will be suitable for infiltrating the captured stormwater. One sample should be taken for every 200 square feet of surface area to be constructed. Samples may be taken along the periphery of the existing impermeable area.

At each sampling location, a hole should be dug to a depth of 3 feet. The topsoil can be discarded (top 6 inches); however, all other soil excavated from the hole should be placed in a bucket and mixed until all soil layers are combined homogeneously. A sample should be taken from this bucket and placed into a vessel that is approved by the laboratory that will be analyzing the sample (the laboratory selection should be approved by SWCD staff). The

laboratory should perform a sieve analysis to determine what percentage of the soil sample consists of fines (total clay and silt particles). If the percentage of fines is less than 8%, or the amount passing the 270 sieve, which means the sample consists primarily of sand and loamy soils, the soils are suitable as a base for the permeable pavement.

10.3.3 Concrete Edging

Concrete edging should be used around the perimeter of the paved area whenever permeable interlocking concrete pavers are installed (see Figure 10.5). The edging should be approximately 18 inches deep and have a width of 6 inches. This edging will reduce the movement of the pavement blocks under the traffic load. Permeable concrete and concrete grid pavers will not require this edging provided that the edge of the paved area is not exposed to vehicular traffic.

Figure 10.5 Pavers abutting a concrete edge.

10.3.4 Gravel Base

The gravel base that is laid over the existing soils is used to (1) store captured stormwater and (2) provide structural stability (Figure 10.6). The depth and type of stone in the gravel base will vary depending on whether permeable concrete or PICP are installed. If the soil criteria described in sections 10.3.1 and 10.3.2 is met, the total gravel base should be approximately 6 inches deep. Any stone used as a gravel base should be washed to reduce the amount of fines in the gravel. These fines if not removed will migrate to the soil sub base and clog the soil pores. This clogging would result in reduced infiltration and, thus, reduced permeable pavement performance.

Figure 10.6 Gravel layers under permeable pavers.

When permeable concrete is used for a given location, the gravel base will consist of a washed #57 stone that is approximately 6 inches thick. The permeable concrete can be poured on top of this gravel base after the base has been properly compacted. Compaction is usually completed using a plate compactor. If washed #57 stone is unavailable, a semi-angular to angular stone alternative can be used. Round support stone will not interlock, allowing shifts in pavement to occur, such as rocking or splitting.

When permeable block pavers or plastic grid pavements are used for the SCM, 4 inches of washed #57 stone can act as the gravel base that is placed on top of the in situ soil; however, the pavers must sit on a bedding layer of smaller stone. This bedding layer should consist of washed #78 stone and be approximately 2 inches thick. The #78 stone should also be used to fill any voids present in between the permeable paver blocks after they are installed (Figure 10.7). Once again, compaction of the gravel base will need to be undertaken with a plate compactor to ensure that the gravel base does not shift under loading. The plate compactor should be used to compact the #57 stone after it has been placed to a 4 inch depth. Next the #78 stone should be added, and the plate compactor used again to lock all of the gravel in place. The #78 stone should be screeded, and the PICP can then be installed.

Figure 10.7 Filling permeable paver voids with gravel.

10.3.5 Permeable Pavement Sizing Criteria

Permeable pavement SCMs used as part of the CCAP will treat only direct rainfall and run-on from an area of equal area to the permeable pavement. The size of the permeable pavement lot will generally be the same as the square footage of impervious area that was removed. The thickness of the permeable pavers is determined by the manufacturer (normally approximately 3.25 inches). Plastic grid pavers tend to be 2 inches thick. Permeable concrete should be poured to a thickness of 6 inches.

10.4 Permeable Pavement Construction

Due to the scale of many permeable pavement installations, it is recommended that a certified permeable pavement contractor install permeable pavements. Installing permeable concrete or PICP requires experience and expertise and should not be attempted by the general public. A list of professionals who are certified to install permeable interlocking concrete pavers (PICP) and concrete grid pavers (CGP) is available from the Interlocking Concrete Pavement Institute (ICPI) at www.icpi.org. Carolinas Ready Mixed Concrete Association (CRMCA) can be contacted for a list of professionals with experience in installing permeable concrete (www.crmca.com). The only exception to this would be small, backyard patios that will be installed using permeable block pavers.

The construction steps below can be completed by an experienced contractor with minimal instruction. The key points from each section should be conveyed to the contractor, and a SWCD staff member or the design engineer should be on-site during construction.

10.4.1 Soil excavation

For permeable pavement to be used as part of the CCAP, a certain amount of impervious removal must be performed. After the impervious area has been removed, such as an driveway, sidewalk, parking pad, or patio, the site excavation can commence.

Excavation depth should be measured from the soil surface down. Fill should not be used to bring the surrounding soil to the top of pavement level. To prevent compaction, the excavated area should not be driven on by any construction equipment to avoid reducing the soil's infiltration capacity. During the construction, a SWCD staff member should be on-site to verify that the excavated area is brought to the correct depth. A survey instrument (such as a site level, laser level, or total station) would be beneficial for this process.

10.4.2 Gravel base

Washed or double washed stone should be used for any permeable pavement installation. The gravel base installation will vary slightly depending on whether permeable concrete or permeable pavers are being installed.

If permeable concrete is being installed, a 6-inch layer of washed #57 stone can be placed in the excavated area. The stone should be spread and leveled to the appropriate slope. The stone should then be compacted with a minimum 10 ton static roller (at least 4 passes). The stone should be compacted until there is no visible movement within the gravel base (Smith, 2000).

If permeable pavers are being installed, the same procedure that is described for the permeable concrete gravel base would be performed with a 4 inch thick layer of washed #57 stone. Next, a 2 inch layer of #78 stone should be added to the top of the #57 stone layer. This layer should be compacted using the same process that was used for the first layer. The gravel base will now be structurally ready to support permeable pavement.

10.4.3 Concrete edging

When permeable interlocking concrete pavers are installed, some edging will be required to keep the pavers stable along the edges of the new permeable area. As stated in section 10.3.3, a 6 inch wide, 18 inch deep concrete curb should be sufficient. It is easiest to construct the curbing prior to placement of gravel. The curbing should run along the perimeter of the permeable area to provide support to the pavers on the edge of the lot.

10.4.4 Permeable pavement installation

As stated above, installing permeable concrete or permeable pavers should be performed by a professional familiar with proper installation. The methods used to install permeable concrete vary from those used to install standard concrete. Because permeable pavement contains void spaces which allow stormwater to infiltrate, the integrity of these pores must be maintained. Vibratory screens, such as those used in some cases to compact standard concrete, should not be used during permeable concrete installation. Such instruments can smear the surface of the concrete resulting in reduced or restricted infiltration. Additionally, concrete vibrators, which are employed to reduce air pockets, are not to be used. A heavy steel roller is used in place to

provide adequate compaction without smearing the concrete. Finishing exercises such as floating and brooming are not necessary and could result in surface sealing on the lot. Permeable concrete does not contain the same curing compounds as traditional concrete; thus, plastic is placed over the concrete for up to a week to prevent drying (Ferguson, 2005). The plastic should never be drug across the pavement, as smearing could result.

Installing PICP is similar to installing regular block pavers; the difference in these systems is that voids are maintained between the pavers, allowing water to infiltrate. The blocks are placed on top of the compacted #78 stone. Once set into place, the blocks are compacted before additional #78 stone is added to the top of the pavement area and allowed to fall into the voids in between the permeable paver blocks. Excess #78 stone is swept off of the area and the permeable paver blocks are compacted one final time. Tight placement of the blocks is essential to maintaining the structural integrity of the system (Smith, 2000).

10.5 Permeable Pavement Maintenance

Like any other SCM, permeable pavement requires maintenance to be effective over time. The greatest concern related to these systems is clogging of the surface void spaces. Once these surface voids become clogged, the system loses its function and effectively becomes an impervious area.

One means of removing sediment and debris from the permeable pavement area is to vacuum and sweep the area. On most commercial sites, this can be done easily by running a vacuum truck over the area. This may not be possible in a backyard SCM setting; however, the site should be swept regularly and cleared of all debris. As mentioned in section 10.4.5, the area around the permeable pavement lot should continually be evaluated to verify that sediment from adjoining areas is not washing onto the permeable pavement. This sediment can clog the permeable pavement over time. Additionally, any weeds or mosses that grow in the pavement voids can be removed using herbicide or be flamed.

Finally, over time, the stone that is used to fill the voids in PICP can be lost as tires track it off of the lot and as the gravel settles. This rock should be replaced periodically to restore the proper amount of gravel in the void spaces. Table 10.1 shows the maintenance activities associated with permeable pavements and the frequency with which these activities should take place.

Table 10.1 Permeable Pavement Maintenance Activities.

Location	Potential Problem	Maintenance Activity	Frequency
Perimeter of the Permeable Pavement	Bare soil contributing sediment	Re-grade soil and establish ground cover. Provide lime and fertilizer once if needed.	As Needed
	Grass clippings on permeable pavement	Remove grass clippings after mowing.	As Needed
	Leaves and Trash	Remove from areas surrounding pavement.	Once per month, more frequently during leaf-fall.
	Structure of Curbing is Damaged or Degrading	Seek guidance from an engineer familiar with permeable pavement, re-pour curbing.	As Needed
Permeable Pavement Surface	Clogging of Pavement Surface	Sweep and/or vacuum pavement surface.	Once per month
	Weeds growing in permeable pavement	Spray herbicide on weeds. Do not pull out weeds, as this may dislodge gravel.	Once every 6 months
	Replacement of Gravel Between Pavers	Use washed #57 stone. Sweep in with a push broom.	Every 6 months initially, less frequently with time
	The Pavement does not drain between storms	Sweep or vacuum the pavement. If it still does not dewater, consult a professional.	As Needed
	Structure of pavement surface is damaged or degrading	Consult an engineer familiar with permeable pavement.	As Needed