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A Second Look at Porous Pavement/Underground Recharge

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The optimal stormwater management practice prevents both water quality and quantity impacts. In theory, practices that rely on maintaining the mechanism of soil infiltration are ideal. Allowing the hydrologic cycle to continue in a pre-disturbance condition, so that aquifers are recharged and increased surface runoff pollutant loadings are prevented, is clearly the goal. However, practical engineering solutions based on the infiltration concept have been difficult to design and even more challenging to implement.

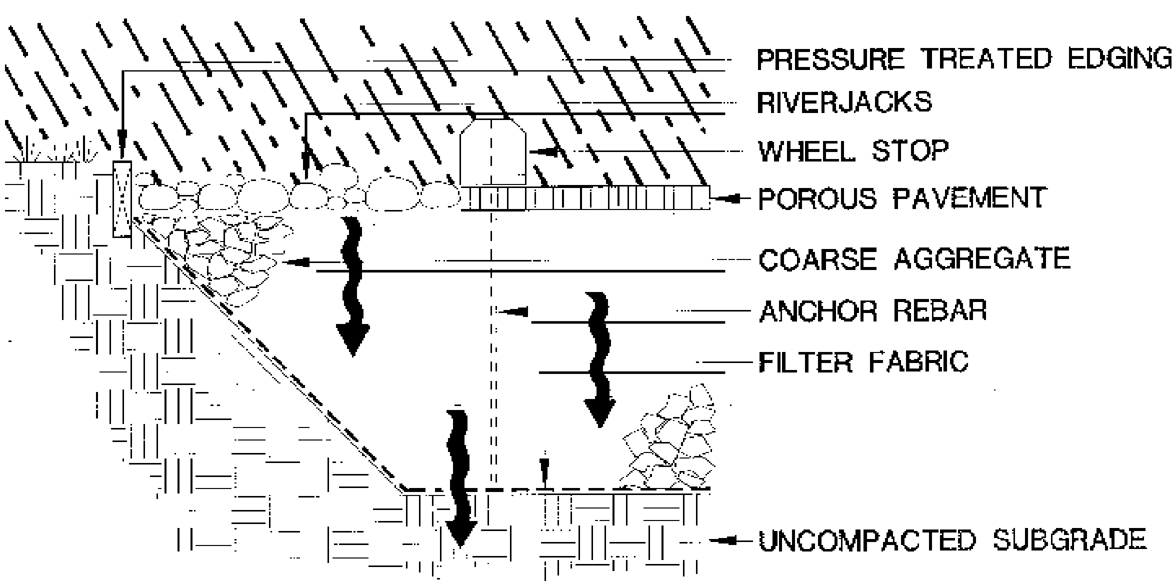
The quandary is illustrated vividly by porous pavement, a technique proposed over 20 years ago. After numerous unsuccessful installations, use of porous pavement is routinely rejected by most engineers, designers, and stormwater program managers. Contrary to prevailing wisdom, however, porous pavement/underground recharge bed stormwater practice applications *can* be developed successfully.

Cahill Associates (CA), a suburban Philadelphia environmental engineering firm, has been designing and constructing porous pavement/recharge bed installations in Middle Atlantic state locations for over 12 years. Their porous pavement installations serve a range of building parking needs and customers include office centers, fast food restaurants, libraries, and condominiums. Areas covered range from 3,000 to 147,000 square feet.

Experience has shown that most porous pavement failures occur because of a lack of erosion/sediment control during construction. In many instances, contractors, unfamiliar with *what* they were doing and *why* they were doing it, allowed substantial quantities of sediment to erode onto the pavement surface after installation. Construction traffic also tracks heavy loads of clay particles onto the surface. Void spaces in the porous asphalt became permanently clogged, preventing stormwater from even entering the recharge bed below.

The fine silts that managed to pass through the porous pavement and through the underlying rock-filled recharge beds then settled out on the recharge bed bottom, reducing the recharge bed's ability to infiltrate over time. These failures have made stormwater managers generally very reluctant to recommend porous pavement as a stormwater practice, rejecting the technology as impossible to apply in the real world.

Figure 1: A Typical Porous Pavement/Recharge Bed Design



Source: Cahill Associates

Success has been frequently demonstrated, however, when project designs have adhered to the following guidelines. Importantly, these specifications add only marginally to total project costs.

- **Site conditions such as permeability of the soil must be verified.** Field verification of a soil layer of reasonable thickness (four feet or more) with acceptable drainage qualities (percolation rate of 0.5 inches per hour or more) is essential. The most cost-effective method of field testing will vary with each site and its geological complexity.

- **All sediment-laden runoff must be directed away from the porous pavement/recharge bed.** Total site design and stormwater drainage planning must be tailored to porous pavement/recharge bed requirements. While all runoff from impervious surfaces (roof tops, roads, parking areas, walkways, and so forth) should be directed onto the porous pavement and then into the recharge bed, pervious zones being re-landscaped after construction must be redirected away from the bed, or pretreated so as to eliminate sedimentation and resultant clogging. Strict erosion and sedimentation controls are a must.

- **Special safeguards/redundancies should be included in the porous pavement/recharge bed design.** Project success has resulted in part because of certain engineering features in porous surface/recharge bed design (see Figure 1 and Table 1).

  (1) Selected filter fabric is placed generously on the floor and sides of the recharge bed after excavation/bed preparation, providing an inexpensive barrier between the stone-filled recharge bed and the soil mantle interface. This filter fabric allows water to pass readily, but prevents soil fines from migrating up into the rock basin, reducing the effective storage volume of the recharge bed.

  (2) In the event that the porous pavement becomes clogged, the edge of the porous paved area is designed to function as a linear overflow inlet around the perimeter of the parking bay. The inlet is accomplished quite simply by allowing a width of the bed around the perimeter to go unpaved, later to be topped off with a decorative river stone of some sort. Wheel stops are placed at the edge of the pavement, preventing vehicles from disturbing this emergency overflow.

  (3) Most intense traffic is directed away from porous surfaces. Porous surfaces are limited to parking areas receiving least wear and tear. Roadways ringing the parking areas receive conventional pavement, but drain into the recharge beds.

- **Communication with contractors is essential.** Contractors/workers involved with the project must understand what is being done and why compliance with specifications is essential. The nature and purpose of the porous pavement/recharge bed technique must be liberally entered onto the construction drawings and included within the written specifications for the project. Before construction, these specifications must be reviewed verbally and in person with contractors.

- **Installation must be supervised and spot-checked.** Proper inspection/supervision during construction of the porous pavement/recharge bed should be budgeted into all projects. Spot-checking by the engineer early on is essential. Regulatory agencies such as the local conservation district cannot be relied upon to make sure that plans and specifications are being executed fully. Contracts, bids, and budgets must include necessary inspection by the design engineer. A written record must be maintained including review and approval at critical project junctures, such as excavation of recharge beds, placement of filter fabric, and quality control at the stone crushing plant and asphalt mix plant. In addition, site inspection and supervision must make sure that construction vehicles are not allowed to traverse excavated recharge beds or enter the completed porous pavement, and that all erosion control measures are in place.

Cahill Associates and others recommend that completed porous pavement be vacuum-cleaned twice per year under normal circumstances, using commercially available pavement vacuuming equipment (either through vendor services or through outright purchase). Although many installations continue to function, in most cases this maintenance has not been performed, primarily because of a lack of communication between the contractor and site owner. Therefore, in new projects, specifications include the requirement that site owner maintenance staff be given copies of porous pavement/recharge bed maintenance requirements for future use. Also required are permanent signs (one per parking bay; minimum of two per project) containing a short list of maintenance requirements. For educational value, signs can highlight major benefits of the installation.

The porous pavement/recharge bed stormwater practice is not ideal for all developments and all sites. Clearly, if soils and geology do not allow for minimum necessary rates of infiltration, this type of stormwater management strategy makes no sense. The majority of upland soils in the eastern U.S., however, do have at least moderate infiltration capacities. In some coastal areas with excessively coarse sands infiltration rates

may be excessively rapid, and the recharge approach may need to be augmented with a peat liner for water quality reasons.

Environmental benefits of the porous pavement approach to stormwater management are compelling. As with any new technique, mistakes must be anticipated. However, if reasonable safeguards are taken, the porous pavement approach offers a uniquely elegant engineering solution for many sites as well as providing compelling environmental and cost savings advantages when compared with most other stormwater practices.

Table 1: Ten Tips for More Successful Porous Pavement Applications

1. **Contract with a Design/Build Firm.** These firms have the incentive to perform a careful and thorough job during each stage of design and construction.

2. **Perform Detailed Geotechnical Tests at the Proposed Site**. After further testing of soils and water table, as many as 25% of "ideal" sites are found to be inadequate for porous pavement. By catching these problem sites early, future problems can be avoided.

3. **Only Consider if Client is Informed and Responsible.** The owner of a porous pavement site plays a key role in maintaining and operating the stormwater practice. Large corporate office park clients are ideal as they often continuously own and manage both the practice and the property over several decades.

4. **Design a Perimeter Stone Filter Inlet as a Backup.** Extending the stone filter course several feet outside the perimeter of the porous pavement provides a cheap and reliable means of getting runoff into the stone filter chamber in the event that the porous pavement ever clogs.

5. **Utilize a Choker Layer of Stone in the Filter Course.** The stone reservoir is normally constructed with a top layer of 1/2 inch gravel over a bottom layer of larger 1.5 to 3.0 inch stone. To avoid uneven surfaces, it is helpful to add a thin "choker layer" of fine gravel between the two layers of stone.

6. **Overlap Filter Fabric on Sides During Construction.** By generously extending filter fabric above the surface of the porous pavement (and staking it to adjacent pervious areas) an extra measure of sediment protection can be achieved during construction.

7. **Pave Roads and Intensively Traveled Areas with Conventional Pavement.** Heavily travelled areas tend to clog more rapidly. Therefore, these areas should be conventionally paved, and then graded to drain over to adjacent porous pavements.

8. **Use Terraces of Porous Pavement on Sloping Sites.** Porous pavement can be used on moderately sloping sites, if a series of stone reservoirs are used in an terrace-like arrangement.

9. **Avoid the Use of Porous Pavement in Hydrocarbon Hotspots.** Gas stations, truck stops and industrial sites are poor choices for porous pavement, given the higher risk that pollutant spills could enter groundwater.

10. **Direct Runoff from Pervious or Exposed Areas Away from Pavement.** It is critical to keep sediment away from porous pavement both during and after construction. This can be accomplished by grading adjacent pervious areas to drain away from the parking area and maintaining extensive sediment controls during construction.