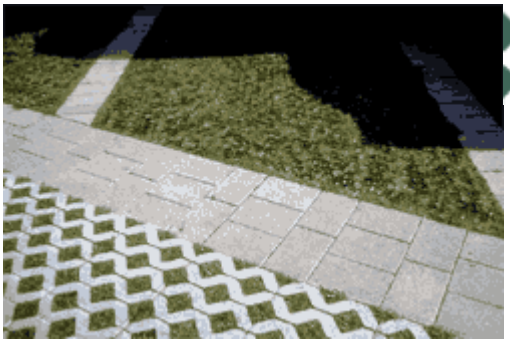
The Advantages of Pervious Surfaces

Lake Superior, Duluth Streams.org

http://www.lakesuperiorstreams.org/stormwater/toolkit/paving.html

Pervious Pavement

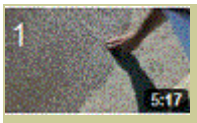


Pervious pavement is designed to allow percolation or infiltration of stormwater through the surface into the soil below where the water is naturally filtered and pollutants are removed. In contrast normal pavement is an impervious surface that sheds rainfall and associated surface pollutants forcing the water to run off paved surfaces directly into nearby storm drains and then into streams and lakes.

Click here for additional detail about the properties of impervious surfaces and their impact on water quality. The 2005 MPCA Stormwater Manual offers a Fact Sheet [387 KB pdf] about impervious surfaces that is also helpful and the Metropolitan Council in the Twin Cities also has some good web information [4 MB].

Pervious surface coverings if installed correctly and properly maintained duplicate the structural and functional features of traditional pavement.

Local Examples of pervious pavement and pavers (images link to videos)

		
Energy Plus **Hermanton, MN**	**University MN-Duluth**	**Diamond Vogel Paints** **Duluth, MN**

Applications

Scientific studies have linked high levels of impervious surfaces to water quality degradation. Two thirds of the impervious surfaces in developed communities are in the form of pavement related to automobile usage. Any design that uses alternatives to reduce impervious pavement is a positive step towards improving the quality of a community's water resource.

Pervious pavements are a recognized runoff reducing substitute for normal pavements in development or redevelopment of:

1. Driveways, including residential driveways, low-traffic roads, fire lanes and emergency access roads;
2. Parking areas; especially over-flow parking and those associated with office buildings, shopping centers and recreational facilities ;
3. Sidewalks;
4. Road shoulders and vehicle cross-overs on divided highways;
5. Boat launching ramps;
6. Others, including pool decks and patios.

The use of pervious pavement has been found to:

1. Reduce storm water runoff. (Even when pervious pavement structure is saturated, its rough surface texture continues to slow surface flow of stormwater);
2. Replenish groundwater;
3. Reduce flooding which may over-load combined sewer sewage treatment plants;
4. Require less land set aside and cost for development of retention basins;
5. Reduce pollutants in run-off;

6. Reduce irrigation of area plantings based on the seepage of rain into the sub soil surfaces;
7. Reduce thermal pollution (see also: temperature);
8. Lessen evaporative emissions from parked cars [85 KB];
9. Reduce glare and automobile hydroplaning (skidding) accidents;
10. Reduce pavement ice buildup.

In northern climates pervious pavement is easily compromised by plowing that dislodges pavers and sanding which clogs and disrupts the pavements filtration process.

Additional concern for heavy clay soils, often associated with northern climates, can limit the usefulness of pervious pavement. These soils are impervious and thwart expected water quality improvements. The use of a graveled water storage area built on top of clay soils is often not an acceptable solution because storage capacity is quickly overcome. Coupling drainage of graveled storage with additional stormwater management practices is possible but the expense of their design and development may be cost prohibitive. Other issues that may be necessary to address include problems for wheelchairs and other disabled individuals, effects of parking lot sweepings, and resistance to damage from snowplowing and de-icing operations. For more details see Siting and Limitations information below.

Examples

St. Germain's – Diamond-Vogel Parking Lot
Duluth, MN

There was a % impervious surface limit on this lot because it is within the Lake Superior coastal zone. See what they did.

Other local examples


Tejas Texas Grill & Saloon, the Hartley Nature Center, and the University of Minnesota-Duluth

Materials and Installation

1. **Materials:**

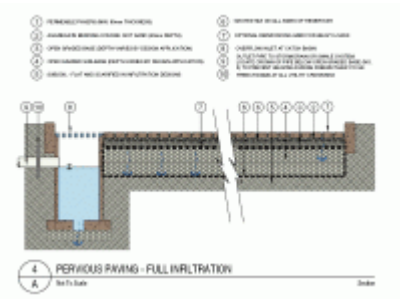
   There are various types of pervious pavement available and include:

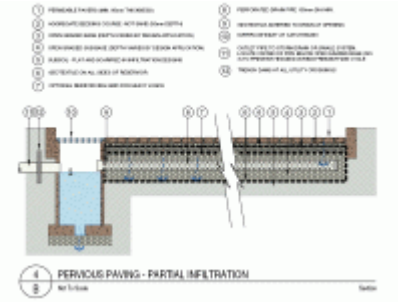
   - **Poured-in-place pervious asphalt** requires the same mixing and application materials and the same 'blacktop'appearance of traditional impervious asphalt. The formula is different with small stone and fine particulate matter being removed and the quantity of tar reduced. Sealants to waterproof new surfaces are not applied.
   - **Poured-in-place pervious concrete surfaces** like pervious asphalt require similar machinery to standard concrete pavement. Permeability is accomplished by using larger pea gravel with lower water-to-cement ratio creating a pebbly surface that is compacted with a roller.
   - **Block and concrete modular pavers** are designed to funnel water between blocks into a basement layer of washed sand and gravel where water slowly drains away through the soil. The open areas in the paving system provide 20-50% more opportunity for the drainage of water than in the normal paved system. Pavers are best used for driveways, parking areas, shoulders along airstrips and highways, roadway medians, boat launching ramps, emergency access roads, fire lanes, sidewalks, grassed rooftops, pool decks and patios.
   - **Grid pavers** made from either recycled plastic or concrete. The grid pattern is usually honeycombed or lattice shaped and the voids collect water during rain events, which then slowly drains into the soil below.
     - The grid pattern is filled with gravel and/or grass to create a visually appealing appearance. If grass is desirable, better growing conditions are best encouraged by the addition of soil to the subase sand and gravel mix.
     - The grid's physical structure provides support for vehicular use and helps prevent erosion.

- The flexibility of plastic type grid pavers allows their use at sites with an uneven topography.
- Grid pavers are ideal for natural landscape projects involving gardens or recreational areas that support both vehicular and pedestrian traffic and includes sidewalks, parking areas, golf cart paths, residential driveways, fire lanes and emergency access roads.

2. **Siting**
    - Pervious pavement should be limited to low traffic areas.
    - Soil infiltration rate should be tested. A minimum rate of 0.27 inches per hour is required and a rate of 0.5 inches per hour is preferred.
        - As a rule of thumb if septic tanks are used in a region the soil will allow sufficient water percolation for instillation of pervious pavement.
        - Pervious pavements to be installed in low permeability (clay) soils require the base materials to act as temporary storage for storm events and subsequent drainage through the soil. The base should be composed of clean washed stone with 25-35%voids. Capacity of the base material storage should be incorporated into design criteria and related to the desired performance of the system during storm events. Typically design should accommodate runoff for the 6 month-24 hour duration storm event.
        - The system should fully drain after a storm event within a minimum of 12 hours, and a maximum of 72 hours (the recommended time is 24 hours).
    - Pervious pavement sites should not be located:
        - Within four feet above bedrock or a water table's high point.
        - Within 100 feet of a well.
        - Within 10 feet of building foundation that is above proposed pavement location or 100 feet from a building foundation that is below the proposed pavement location.
        - Within close proximity of sources of contaminants e.g. gas stations.
        - On slopes that exceed five percent, the flatter the surface the better.

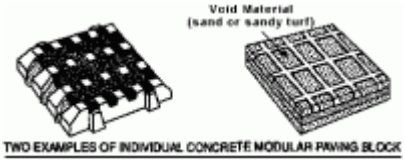
3. **Construction**
    - To ensure success it is critical to pay special attention and follow engineering design for substrate base and hydraulic design for entire project. Geotechnical testing should be conducted prior project start, to determine site conditions (see Siting above) and derive engineering design plan.
    - Excavation and grading need to accomplished with light equipment to prevent soil compaction.
    - Be sure to protect planned pavement area from storm water runoff before and during construction by diverting stormwater runoff. Stormwater events during construction will contaminate cleaned and washed basement materials by adding sediments that will fill the void spaces designed to store water from storm events thereby compromising desired pervious function of pavement. If site stormwater protection is compromised all base materials need to removed and again washed clean
    - Basement layers and pavement can be laid, closely following given engineering design criteria. A typical cross section of layers involved in developing pervious pavement include:
        - Pavement –three quarters (asphalt) to four inches thick (pavers)
        - Filter Course - two inches thick made of half-inch crushed stone
        - Reservoir Course - thickness based on runoff storage required and frost penetration, made with one and a half to three inch diameter stone
        - Filter fabric
        - Existing soil managed to have minimal compaction to retain soil porosity
    - For information on plant selection and applications consult Appendix E of the State of Minnesota Stormwater Manual-2005 [2.2 MB].

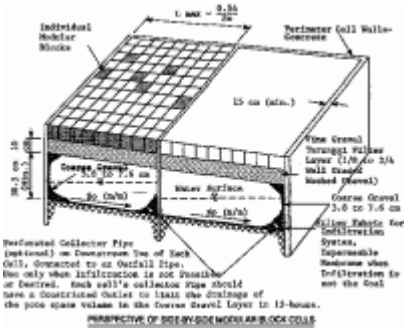




- Click image to enlarge -

From: Stormwater Source Control Design Guidelines 2005; Greater Vancouver Regional District/ LANRC Consultants Ltd. Kerr Wood Leidal Associates Ltd/ Goya Ngan.
[3.3 MB]





- Click image to enlarge -

From: Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring Fact Sheet - Porous Pavements. US Dept Of Transportation - Federal Highway Administration.

Tips and Wisdom

1. Always check a municipalities building code to see that pervious pavement is allowable. Environmental legislation is creating a greater concern for water quality. Municipalities are beginning to seek modifications to building codes to encourage developing technologies that are environmentally progressive.
2. Use of pervious pavements should be limited to low-traffic areas. Only occasional truck traffic and no heavy semi traffic should be allowed.
3. Engineering requirements for pervious pavement are similar to laying regular pavement and include:
    - Pavement with sufficient thickness to protect subgrade materials from being overstressed
    - Use quality subgrade materials that can support expected loads
    - Placement on a stable surface
    - Compaction of materials to provide strength.
4. Longevity of pervious pavement depends on a commitment to following a rigid and detailed plan that starts with site selection and carries through to a long term maintenance program. The significant parts of a plan include:

- Continual inspection and enforcement of specifications during construction
- Stringent control of sediment deposition on all areas of pervious pavement, including:
  - Pre-treatment of sediment laden runoff onto pavement e.g. the use of a 25 foot wide vegetative strip around areas of pervious pavement subject to off-site drainage flows
  - Scheduled vacuuming and jet washing of pavement surfaces
  - Limited use of sanding materials and other deicing chemicals
- Limiting heavy traffic use and excluding heavy vehicles
- Resurface areas where pavement has failed

5. Cost of laying pervious pavement exceeds that of traditional pavement, historically:
   - Porous asphalt is 10-15% higher than regular asphalt
   - Porous concrete is approximately 25% grater than regular concrete
   - Pavers can be as much as four times the expense of either regular concrete or asphalt
   - Correct site preparation may also increase these costs. Costs that are site specific such as proximity and cost of gravel supplies and site permeability must be factored into estimates
   - Prescribed maintenance costs for pervious pavement amount to about $200 per acre per year (1999 dollars).

   However higher instillation costs can be off-set by elimination of the need for curbs, gutters, storm drains and large retention ponds. Many communities will reduce stormwater fees in recognition of these practices.
6. The use of grid pavers filled with gravel or grass may present a tripping problem with certain types of footwear (high heels). The problem can be best addressed by provision of small, narrow impervious walkways that allow automobile access and loading.
7. The use of pervious pavement may be coupled with other stormwater management practices such as bioretention and vegetative swales for optimum drainage results.
8. Pervious pavement does function in the removal of pollutants. Removal is accomplished through absorption, filtration and microbiological degradation. Long term studies show removal efficiencies of:
   - 82-95% of sediments
   - 65% total Phosphorous
   - 80-85% total Nitrogen
   - high removal rates are also reported for Zinc, Lead and Chemical Oxygen Demand (COD)

   Practices that support continuing effective pollutant removal are:
   - A strong maintenance program
   - Extra treatment of site runoff (see # 7 above)
   - Clean-washed sub-bedding materials (aggregate)
   - Highly permeable soil
   - Organic matter in sub-soil
   - Sub-bedding zone that drains within 24 hours. If soils are not able to dry out between rain events anaerobic (without Oxygen) conditions may develop and slow microbiological decomposition

   Pervious pavements have not been found to effectively treat fuel leaks from automobiles.
9. The sub-base or gravel layer becomes a water reservoir in a pervious pavement system. The size of the reservoir can be varied by design to better address local needs. The addition of a perforated pipe, placed near the top of the reservoir, to discharge excess water collected in the reservoir, to adjacent stormwater management structures facilitates storm water control.
10. Additional forms of stormwater reservoirs can be added to stone reservoirs below pavement surfaces. These should be designed to accommodate stormwater runoff for the local engineering design storm and allow infiltration through sub-surface soils.

Limitations

1. Proper site selection and instillation is vital to success. Many design engineers and contractors lack expertise with pervious pavement technology. Selection of an instillation team should be based on previous successful experiences.
2. The ability to perform regular maintenance is important to long term success and an expected useful life of 15-20 years. Maintenance contracts stipulating quarterly vacuuming and/or power washing are recommended. If equipment and resources are not available for maintenance, pervious pavement is not recommended.
3. Incorrect installation and inadequate maintenance are the primary cause for the high rates of failure experienced with pervious pavements. At Hartley Nature Center, when they first installed Grass Pave 2 for additional parking spaces they used Class 5 limestone gravel as an underlayment and for covering the grid system. This was a mistake because the limestone became fairly impermeable when wetted. Find out more.
4. Porous pavement should be used with caution in cold climates. Regular winter pavement maintenance such as:
    - Sanding compromises pervious pavement by clogging pavement pours. Materials that collect in the snow pack must be vacuumed after snow melt to prevent clogging. The use of salt treatment is expensive and will kill grass and adjacent plantings and also not environmentally acceptable in many communities.
    - Snow plowing can catch the edge of pavers and damage the pavements surface.

    An additional concern is the permeability of clay soils or basement rock beneath the pervious pavement. However, this can be addressed to some extent by engineering design. The sub-bedding or gravel placed below the pavement material will function not only as a water reservoir during storms but during winter will protect the surface pavement from frost heave.
5. Areas adjacent to pervious pavement and subject to erosion and sediment production require stabilization to prevent clogging of pavement.
6. There is a risk of contaminating groundwater and wells if pervious pavement is located inappropriately close e.g. siting should not occur any closer than 100 ft from a well, or if its determined that installed pavement is not sufficiently separated by the overburden and groundwater.

Suggested References: Guidebooks, websites and pamphlets-[= pdf file; it will be opened in a new window]

1. **Storm Water Technology Fact Sheet - Porous Pavement 1999**
   [67 KB] Overview fact sheet that provides good information on needed considerations, design criteria, costs (*dated*), and contact information.
2. **Planning for Stormwater - Permeable Pavements**
   The NEMO (Nonpoint Education for Municipal Officials) website provides good overviews of materials used in pervious pavements and how they fit into pervious landscape design.
3. **Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring-Fact Sheet**
   Porous Pavements by US Department of Transportation-Federal Highway Administration - an overview with good illustrations referring to typical application and design features of pervious pavements
4. **Permeable Paver Research Summary**
   [336 KB] Lake County Forest Preserve IL (2003). A summary of investigations into use of pervious paver. Includes a number of case studies, cost information and an extensive reference section.
5. **Sustainable Building Sourcebook/Green Building Program-Pervious Paving Materials**
   Considerations for the use of pervious paving with information rating practical commercial status and implementation issues. Useful sections on use of grass in combination with pavers, compared costs with traditional pavement and a suppliers list.
6. **Stormwater Source Control Design Guidelines 2005**; (pgs 12- 20)
   [3.3 MB] Greater Vancouver Regional District/ LANRC Consultants Ltd./ Kerr Wood Leidal Associates Ltd/ Goya Ngan - a useful, recent overview of pervious pavement use and its design requirements.
7. The **State of Minnesota Stormwater Manual (2005)** is a valuable tool for stormwater managers. The manual provides details on pervious pavement [1.1 MB, Chap. 12-3] and other stormwater filtration practices [1.2 MB, Chap. 12-6] applicable to Minnesota that help conserve, enhance, and restores high-quality water in our lakes, rivers, streams, wetlands, and ground water.
8. The **Hillsdale County, MI website** has a section that explains in detail the properties of impervious surfaces and their impact on water quality.