SUSTAINABLE INFRASTRUCTURE

ALTERNATIVE PAVING MATERIALS

SUBCOMMITTEE REPORT

October 3, 2003

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Excerpt from Committee Charter:

Topic Description: *Alternative pavement materials in lieu of traditional asphalt or concrete may have benefits to the City's stormwater runoff, the City ecosystem, street trees, and neighborhood aesthetics. While we are anxious to employ some new products and new designs that material producers and other municipalities have alerted us to, benefits, designs and limitations need to be identified before widespread application in Portland. Our research and development program needs to be organized, formalized, and framed to market our approach to City bureaus, neighborhood, and other neighboring metro cities.*

Objectives*: The team will develop a comprehensive database of materials that may be used in lieu of traditional asphalt and Portland cement concrete pavement for use in streets, driveways, parking areas, and sidewalks. The comprehensive database will include research, locations where the material is used, suggested product applications, limitations, assessment of cost effectiveness, testing, and maintenance. Information will be assembled in a comprehensive report. The team may structure a forum for industry experts to present materials and conduct site visits.*

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Research Papers/ Magazine Articles

Restoration of Infiltration Capacity of Permeable Pavers

Development of an Assessment Procedure for Permeable Pavements

Microbial Ecology of Oil Degrading Porous Pavement Structures

Pollution Retention Capability and Maintenance of Permeable Pavements

Permeable Pavement Use and Research at Two Sites in Eastern North Carolina

Permeable Pavement Use and Research in Eastern North Carolina

Performance Assessment of Stormwater Infiltration Strategies: a Multi-Indicator Approach

Laboratory Study of Permeable Pavement Systems to Support Hydraulic Modeling

Studies on the Environmental Design of Permeable Concrete Block Pavement for Reducing Stressors and Contaminants in an Urban Environment

Expert Opinion: Institute for Planning Green Spaces and for Landscape Architecture University of Hannover

Infiltration and Structural Tests of Permeable Eco-Paving

Expert Opinion: Prof. Dipl. Ing. Burkhard Bretschneider on Uni Eco-Stone

Stormwater Management Benefits of Porous Pavements

BMP- Permeable Interlocking Concrete Pavement

Porous Asphalt Pavement with Recharge Beds: 20 Years and Still Working

Porous Asphalt, the Right Choice for Porous Pavements

Thinking Green with Porous Asphalt

Drainage Design of Porous Pavement Systems for Urban Runoff Control

Enhanced Parking Lot Design for Stormwater Treatment

Permeable Parking Lot Demonstration Project- The Six-Year Follow-Up

The University of Washington Permeable Pavement Demonstration Project- Background and First-Year Field Results

Stormwater Magazine Article on Permeable Surfaces- Reducing Runoff Volume and Temperature

<u>Miscellaneous Product Information</u>

ICPI (Interlocking Concrete Pavement Institute) "Permeable Interlocking Concrete Pavements" and PowerPoint Presentation Slides

Uni-Group "Design Considerations for the Uni Eco-Stone Concrete Paver", "Drainage Design and Performance Guidelines for Uni Eco-Stone Permeable Pavement", and Uni Eco-Stone Brochure

Mutual Materials Information Packets (2)

Enviropave Structural Paver Spacers Brochure and Specification Sheet

ECOCRETO of Texas, Inc. Recommended Specifications for ECOCRETO admixture for Portland Cement "Pervious" Concrete

Porous Paving Technical Memorandum Prepared by Lloyd D. Lindley, ASLA

Executive Summary

This subcommittee was formed in February of 2003 by the City's Sustainable Infrastructure Committee to develop a comprehensive database of materials that may be used in lieu of traditional asphalt and Portland cement concrete pavement for use in streets, driveways, parking areas, and sidewalks. Because of the pressing need to develop stormwater management techniques for streets and other impervious surfaces within a limited amount of space, as a committee it was decided to put additional focus on pervious materials.

The need to manage stormwater from streets, sidewalks, parking lots, and pedestrian plazas within a limited amount of space is creating the need for non-traditional solutions. One of these potential solutions is porous or pervious pavement systems. These systems have been used to various degrees and in various capacities around the world. The United States has relatively little experience with these materials, however an increasing awareness within the last few years has produced several pervious pavement projects.

As a city we need information on these products in order to make long-term decisions on their role as a part our infrastructure. This information can be gained by studying existing projects from around the country, or the construction and monitoring of demonstration projects here in the Northwest.

Three basic types of pervious pavement systems were identified that show promise for use in the public right-of-way:

1) **Pervious paver block systems**: Concrete paver blocks with small gaps between them that allow stormwater to pass through to the sub-base and infiltrate into the underlying soils.

Pervious paver block (Uni Eco-Stone) parking lot at Multnomah Arts Center (SW 31st & Capitol Hwy)

2) **Pervious concrete mixes**: Concrete mixes that exclude fine particles, usually sand size and smaller. The resulting concrete contains many small void spaces that allow stormwater to pass through the actual pavement section and into the sub-base, where it infiltrates into the underlying soils.

Installation of pervious concrete at NE 94th & Broadway pump station site.

3) **Pervious asphalt mixes**: Asphalt mixes that exclude a percentage of the fine particles, resulting in an asphalt layer with many small void spaces that allow stormwater to pass through the actual pavement section and into the sub-base, where it infiltrates into the underlying soils.

Pervious Asphalt installation near SE 162nd & Foster

The committee concludes that several demonstration projects should be identified, constructed, and monitored for three to five years or longer, as needed, to come to a definitive conclusion regarding use. Depending on project size, two to four projects of each recommended material type should be allowed in the public right-of-way on local service streets. More demonstrations may be required if varying construction techniques produce inconsistent results.

Projects should be monitored for constructability, durability, maintenance needs, hydraulic performance (if applicable), aesthetics, safety, and public acceptance. At the end of this monitoring period, a multi-bureau team should be assembled to evaluate the performance of each material type and make a recommendation for future use. A final report should be compiled for city review. Steps should be taken to include successful materials in the City of Portland Standard Construction Specifications as options for recommended applications.

Current demonstration projects slated for construction in the public right-of-way include:

1) N Gay Avenue pervious concrete (construction date: spring of 2004)
2) SE Rex Street pervious concrete pavers (construction date: spring of 2004)

Existing pervious pavement projects in the Portland Metropolitan area that fall outside the public right-of-way include but are not limited to:

1) Multnomah Arts Center pervious paver block parking lot (SW Capitol Hwy & 31st Ave.)
2) Lucky Lab Brew Pub pervious paver parking lot (SW Capitol Hwy & 31st Ave.)
3) Tri-Met Merlo Yard pervious concrete employee parking lot (Beaverton)
4) NE 94th and Broadway Pump Station pervious concrete
5) SE 162nd and Foster area pervious asphalt driveway
6) Ecotrust Building pervious asphalt parking lot (721 NW 9th Ave)
7) Pervious concrete parking lot in Mt. Angel
8) Pervious paver block parking lot in SW Washington (La Center)
9) Oregon Natural Resources Council Office pervious paver block parking lot (5825 N. Greeley)
10) Pervious concrete parking lot at Sherwood elementary school

The following additional projects are recommended for construction in Portland in the public right-of-way:

1) Two to four pervious asphalt projects
2) One to three pervious concrete projects
3) One to three pervious concrete paver projects

Projects should be funded by willing private developers, Metro, State or Federal grant money whenever possible. Capitol projects within the right-of-way may consider the use of alternative paving materials if the requirements of the City's Stormwater Management Manual are triggered, and other options for achieving the requirements have been exhausted. Capitol projects outside of the public right-of-way, such as Parks and public

building sites, are encouraged to use recommended alternative paving materials to achieve stormwater management requirements on site.

Introduction/ Problem Statement/ Current State of Affairs

Increased runoff from urbanized areas has caused a multitude of downstream problems, including degraded stream systems, flooding, erosion, combined sewer overflows, and basements flooding with sewage. At the same time, as part of the effort to preserve surrounding undeveloped land and minimize urban sprawl, Metro and the City of Portland have goals of increasing density within the city limits. Increased density necessitates an increase in impervious surface in the form of rooftops, roads, and walkways. In order to minimize downstream problems associated with urbanization, stormwater management systems must be developed that provide water quality, flow rate control, volume control, and complete infiltration in some cases, and do so in a limited amount of space. Other challenges associated with stormwater management include future operations and maintenance, and high costs.

Traditional at-grade asphalt and concrete structures such as streets, sidewalks, parking lots, and pedestrian plazas are nearly 100% impervious, and therefore generate a high volume and rate of stormwater runoff. This runoff must be collected, conveyed, treated, detained, and disposed of. New innovations in the field of paving technology have made it possible to pass the rainwater through the pavement section and into the subgrade and underlying soil. In some cases, this can eliminate the need for additional stormwater management facilities, including catch basins, pipes, manholes, ponds, swales, drywells, and sumps.

The new Oregon State DEQ UIC (Underground Injection Control) rules have made the criteria for acceptance of sumps and drywells much more stringent. As a result, stormwater systems that filter the water prior to infiltration, and systems that infiltrate at the ground surface level rather than deep below the surface must be evaluated for use. Our primary focus to-date on this effort has been the development of an "Infiltration Swale" to filter and infiltrate stormwater at the ground surface. However, this type of system requires additional land to be set aside, which can be extremely difficult in highly urbanized settings, retrofit situations, or the public right-of-way. All of these issues point to the need for systems that can treat and infiltrate stormwater at the surface, with little or no need for additional land.

Note the following definitions from Webster's New Collegiate Dictionary:

Permeable: Having pores or openings that permit liquids or gases to pass through.
Pervious: Accessible or permeable.
Porous: Possessing or full of pores, permeable to liquids.

According to these definitions, any of these terms can be used to describe the pavement types of this report. Some pavement types are made of impervious materials, such as concrete paver blocks, but as a whole the pavement system with its network of spacer holes is pervious. Other pavements allow water to pass through the actual structural surface layer, such as pervious concrete and asphalt mixes. Although all three of these

terms are used to describe these pavement systems, for the purpose of consistency the term “pervious” will be used throughout this report.

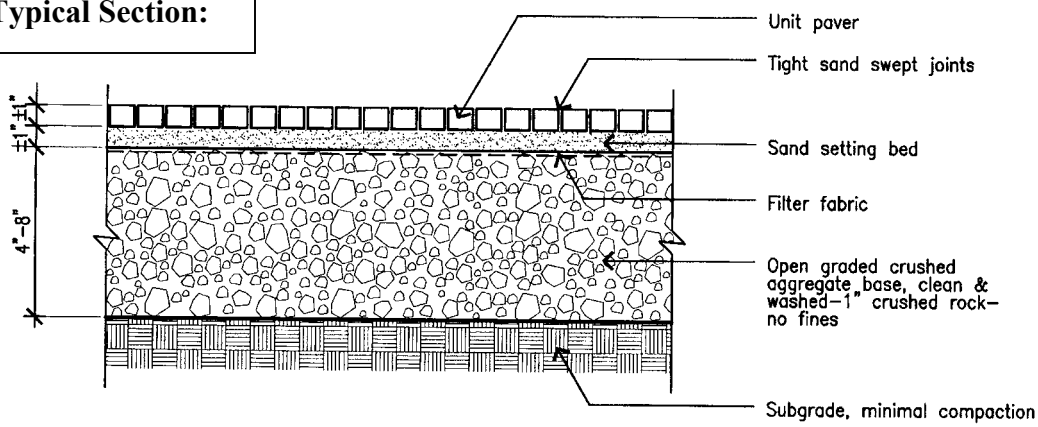
Uncertainties in material properties and performance have justifiably made government jurisdictions and pavement institutions leery of accepting the new products. Several studies (see attachments) have been conducted on pervious pavement systems from around the world, but a single source of reliable information is lacking. For this reason, we believe that the construction and monitoring of demonstration projects is the next step toward gaining the information needed to make rational decisions on the future use of pervious paving materials in the City of Portland.

We currently have two capitol improvement and a handful of private development pervious pavement projects slated for construction in the public right-of-way in the near future. These projects will be monitored for a number of years for constructability, durability, maintenance needs, hydraulic performance, aesthetics, safety, and public acceptance. More projects are needed to fully understand the technical aspects of each pervious pavement type and to ultimately make decisions on long-term use.

Materials Information

Pervious Paver Block Systems

Typical Section:



Pervious concrete block (Uni Eco-Lock) installation in La Center, Washington.

Pervious concrete block (Uni Eco-Lock) installation in La Center, Washington.

Pervious concrete block (Uni Eco-Stone) parking lot at Multnomah Arts Center (SW 31st & Capitol Hwy).

Description: Pervious paver systems consist of a layer of concrete paving blocks with small gaps or holes between each block or group of blocks, underlain with a granular leveling coarse, and finally with a base rock section. There may or may not be a layer of geotextile (or filter) fabric that separates the leveling coarse from the base rock, or the base rock from underlying native soils. There also may be a perforated pipe underdrain system where native soils do not infiltrate well or where it is undesirable to infiltrate. The base rock section is typically void of fines to maximize void ratio while providing for adequate compaction. The base rock section is typically designed to temporarily store the volume of stormwater generated from a design storm (usually 10 or 25-year recurrence interval, 24 hour storm) and infiltrate it into underlying soils or into an underdrain system.

Material Applications: Pervious paver systems have been used in parking lots, private streets, driveways, and pedestrian access areas. There is potential use in pubic streets for low-use, low-speed applications, pending demonstration project testing.

Installation: Generally, pervious paver block systems can be installed without a high level of specialized training. Mechanical installation is also now available to make the installation process quicker and cheaper.

Maintenance: Pervious paver systems require periodic vacuum sweeping to keep the pore spaces clear of debris and infiltrating properly. An advantage of pervious paver systems is that utility cuts don't need to be made- rather the pavers can be taken up and replaced after utility installation.

Limitations/ Uncertainties: Pervious paver systems should be limited to low-speed traffic areas (<35 mph). The concern is that backfill gravels can be kicked up and the paver surface can be compromised with high speeds. Also, the rough surface texture is not amenable to high-speed traffic. Maintenance frequency is an uncertainty that will

depend on a number of factors, including traffic loading, debris loading (leaves are of particular interest), and soil infiltration rate.

Costs: Pervious paver systems can range in cost depending on the size of the installation and the installation technique used. Recent cost estimates generated from BES's SE Rex St. project indicate that the paver system will cost roughly $5 per square foot installed, including base rock.

Project Locations: There are several pervious paver systems installed on private property in the Portland area. See page 20 for a list of installations.

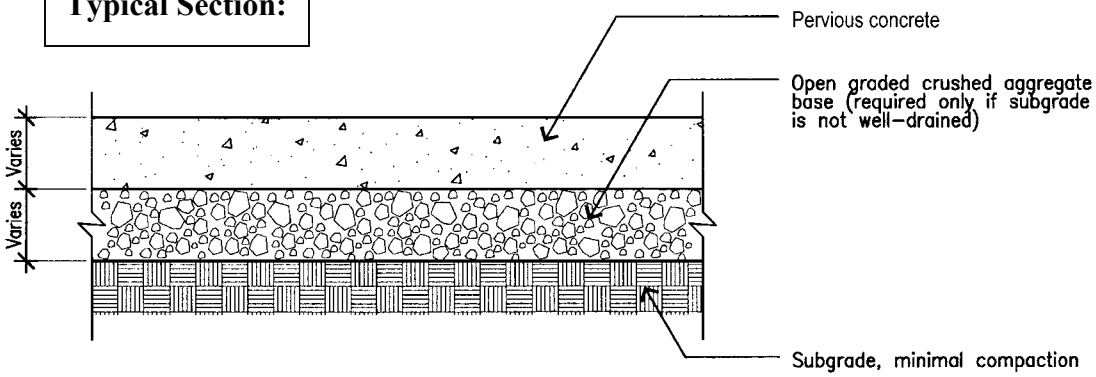
Testing Results: Testing done on a pervious paver parking lot in Canada over an 8-year period demonstrated a high level of permeability over time, particularly in the parking stalls. The parking aisles required periodic vacuum sweeping, which restored permeability to a high level. See results documented in the attachment entitled "Restoration of Infiltration Capacity of Permeable Pavers". This is the seventh in a series of related studies since 1993 at the University of Guelph. Also see several other attached studies on the performance of pervious paver block pavements.

Overall Recommendation: The committee recommends that in addition to the projects currently being designed with pervious pavers, one to three pervious paver demonstration projects be constructed in the public right-of-way, as needed to monitor and come to a conclusion regarding future use.

Pervious paver block (Uni Eco-Stone) parking lot at Lucky Lab Brew Pub in SW Portland (SW 31st & Capitol Hwy)

Pervious Concrete Mixes

Typical Section:



Finished pervious concrete surface at NE 94th Avenue & Broadway pump station site.

Installation of pervious concrete at NE 94th Avenue & Broadway pump station site.

Core-Sample of Pervious Concrete, Dyed Brown

Description: Pervious concrete mix pavements consist of a layer of pervious concrete paving, underlain with a base rock section. There may or may not be a layer of geotextile (or filter) fabric that separates the base rock from underlying native soils. There also may be a perforated pipe underdrain system where native soils do not infiltrate well or where it is undesirable to infiltrate. The base rock section is typically void of fines to maximize void ratio while providing for adequate compaction. The base rock section is typically designed to temporarily store the volume of stormwater generated from a design storm (usually 10 or 25-year recurrence interval, 24 hour storm) and infiltrate it into underlying soils or into an underdrain system.

Material Applications: Pervious concrete mix pavements have been used in parking lots, private streets, driveways, and pedestrian access areas. There is potential use in pubic streets for low-use, low-speed applications, pending demonstration project testing.

Installation: Pervious concrete mix pavements must be installed by knowledgeable professionals that have been trained on the special properties of the material. Typical installation procedure consists of the following:

1) Excavation to bottom of base coarse
2) Install 6" to 18" of open-graded base rock – no fines
3) Pervious concrete mix is placed, screeded to ½" above finish grade, covered in plastic, and compacted with a drum roller or vibratory compactor to finish grade.

Maintenance: Pervious concrete mix pavements require periodic vacuum sweeping to keep the pore spaces clear of debris and infiltrating properly.

Limitations/ Uncertainties: Pervious concrete mix pavements should be limited to low-volume, low-speed traffic areas. The concern is that surface aggregates can be displaced when the striking force from tires gets too high. Maintenance frequency is an uncertainty that will depend on a number of factors, including traffic loading, debris loading (leaves are of particular interest), and soil infiltration rate.

Costs: Pervious concrete mix pavements can range in cost depending on the size of the installation. Recent cost estimates generated from BES's N Gay Avenue project indicate

that the pervious concrete street will cost roughly $100 per square yard installed, including base rock.

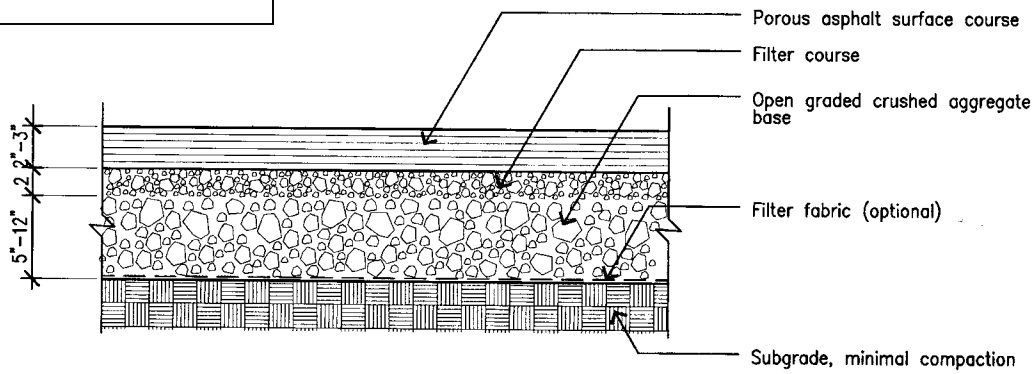
Project Locations: There are a few pervious concrete installations in the Portland Metropolitan area. See page 20 for a list of installations.

Testing Results: See the attached document entitled "Permeable Pavement Use and Research at Two Sites in Eastern North Carolina. Also see several other attached studies on the use of pervious concrete mix pavement.

Overall Recommendation: The committee recommends that in addition to the projects currently being designed with pervious concrete, one to three pervious concrete demonstration projects be constructed in the public right-of-way for monitoring.

Pervious Asphalt Mixes

Typical Section:



Pervious asphalt driveway near SE 162nd & Foster.

Description: Pervious asphalt mix pavements consist of a layer of pervious asphalt paving (usually "F" or "E" mix asphalts), underlain with a pervious base rock section. There may or may not be a layer of geotextile (or filter) fabric that separates the base rock from underlying native soils. There also may be a perforated pipe underdrain system where native soils do not infiltrate well or where it is undesirable to infiltrate. The base rock section is typically void of fines to maximize void ratio while providing for adequate compaction. The base rock section is typically designed to temporarily store the volume of stormwater generated from a design storm (usually 10 or 25-year recurrence interval, 24 hour storm) and infiltrate it into underlying soils or into an underdrain system.

Material Applications: Pervious asphalt mix pavements have been used for many years by ODOT on the state's highways to keep surface puddles from forming, minimizing the chance of hydroplaning. ODOT has traditionally used "F" or "E" mix asphalts over impervious "B" or "C" mix asphalts, which doesn't result in a true pervious pavement section, but rather allows the water to travel laterally through the pervious layer to the

shoulder of the road. Pervious asphalt mix pavements have also been used in parking lots, private streets, driveways, and pedestrian access areas. There is potential use in pubic street applications, pending demonstration project testing.

Installation: Pervious asphalt mix pavements can be installed by knowledgeable professionals that have experience installing typical asphalt pavements. Typical installation procedure is very similar to typical asphalt installation, and consists of the following:

4) Excavation to bottom of base coarse
5) Install 6" to 18" of open-graded base rock – no fines
6) Pervious asphalt mix is placed and rolled to finish grade.

Maintenance: Pervious asphalt mix pavements require periodic vacuum sweeping to keep the pore spaces clear of debris and infiltrating properly. The asphalt will need to be ground and resurfaced as needed, similar to traditional asphalt pavement, to keep the surface free of blemishes.

Limitations/ Uncertainties: Maintenance frequency is an uncertainty that will depend on a number of factors, including traffic loading, debris loading (leaves are of particular interest), and soil infiltration rate.

Costs: Pervious asphalt mix pavements can range in cost depending on the size of the installation. Recent costs generated from PDOT's SE 162nd and Foster driveway project indicated that the pervious asphalt surface costs roughly $27 per square yard installed, including excavation, base rock, and filter fabric.

Project Locations: There are a few pervious asphalt installations in the Portland area. See page 20 for a list of installations.

Testing Results: See attachment entitled "Porous Asphalt Pavement with Recharge Beds: 20 Years & Still Working". Also reference several other attachments on the permeability and water quality monitoring of pervious asphalt pavements.

Overall Recommendation: The committee recommends that in addition to the projects currently being designed with pervious asphalt, two to four pervious asphalt demonstration projects be constructed in the public right-of-way, as needed to monitor and come to a conclusion regarding future use.

Conclusion

Alternative paving materials that allow stormwater to be filtered through the pavement section and/or infiltrated into underlying soils can provide a sustainable option for pedestrian, bike, and vehicular traffic as well as stormwater management. More information on these products is needed to make long-term recommendations for their use in public infrastructure projects.

The committee concludes that several demonstration projects should be identified, constructed, and monitored for three to five years or longer if needed to come to a definitive conclusion on use. Depending on project size, two to four projects of each recommended material type should be allowed in the public right-of-way. More demonstrations may be required if varying construction techniques produce inconsistent results.

Projects should be monitored for constructability, durability, maintenance needs, hydraulic performance, aesthetics, safety, and public acceptance. At the end of this monitoring period, a multi-bureau team should be assembled to evaluate the performance of each material type and make a recommendation for future use. A final report should be compiled for city review. PDOT, BES, BDS, BOM, Parks, and OSD have particular interest in the topic. Steps should be taken to include successful materials in the City of Portland Standard Construction Specifications as options for recommended applications.

Current demonstration projects slated for construction in the public right-of-way include:

1) N Gay Avenue pervious concrete (construction date: spring of 2004)
2) SE Rex Street pervious concrete pavers (construction date: spring of 2004)

The following additional projects are recommended for construction in Portland in the pubic right-of-way:

1) Two to four pervious asphalt projects
2) One to three pervious concrete projects
3) One to three pervious concrete paver projects

Projects should be funded by willing private developers, Metro, state or federal grant money whenever possible. Capitol projects within the right-of-way may consider the use of alternative paving materials if the requirements of the City's Stormwater Management Manual are triggered, and other options for achieving the requirements have been exhausted. Capitol projects outside of the public right-of-way, such as Parks and public building sites, are encouraged to use recommended alternative paving materials to achieve stormwater management requirements on site.

Database of Information

Products

Currently known pervious paving materials include concrete paver systems, pervious concrete mixes, and pervious asphalt mixes. Other systems may be classified as turf or gravel reinforcement and are not included in this report. Please contact Steve Fancher at 503-823-7126 or email at stevef@bes.ci.portland.or.us to add a product or change product information.

Current proprietary products include: Uni Eco-Stone concrete pavers,
Uni Eco-Lock concrete pavers,
Formpave Aquaflow paving blocks,
SF Tegula-Tec paving stones,
Unilock interlocking concrete pavers,
Westcon SF-RIMA concrete pavers
Ecocreto of Texas, Inc. admixture for Portland Cement pervious concrete mix

Contacts

Current contacts for the supply and/or design of pervious pavement materials include but are not limited to the following. Please contact Steve Fancher at 503-823-7126 or email at stevef@bes.ci.portland.or.us to add a contact or change contact information.

Pervious paver systems:

Ron Putz
Mutual Materials

Pervious concrete mix pavement:

Bob Banka
Concrete Solutions, Inc.
3640 Kendra St., Suite 2C
Eugene, OR 97404
Telephone: 1-877-634-6788

James Powell, PE
Executive Director
NW Chapter American Concrete Pavement Assoc.
Olympia, WA

Dave Frentress
Glacier Northwest
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Portland, OR 97227-1719
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Tony McCauley
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10260 SW Greenburg Rd., Suite 400
Portland, OR 97223
Telephone: (503) 293-8459
Email: tmccauley@lehighcement.com

Texas, Inc. (Ecocreto)
9200 IH-35 South, Suite #C-3, Austin, Texas 78748
Telephone: (512) 292-7564, Toll free 866-ecocreto
Fax: (512) 280-4707

Pervious asphalt mix pavement: ODOT

Portland Metropolitan Area Projects

Existing projects in the Portland area include, but are not limited to the following. Please contact Steve Fancher at 503-823-7126 or email at stevef@bes.ci.portland.or.us to add a project to the list or to change project information.

Pervious concrete pavers: Multnomah Arts Center Parking Lot
(SW 31st Ave & Capitol Hwy)
Lucky Lab Brew Pub Parking Lot
(SW 31st Ave & Capitol Hwy)
Tualatin Police Station Parking Lot
School Parking Lot in La Center, WA
Oregon Natural Resources Council Office
(5825 N Greeley Blvd)

Pervious concrete mix: Tri-Met Merlo Yard Parking Lot
Mt. Angel site Parking Lot
NE 94th and Broadway Pump Station
Sherwood Elementary School Parking Lot

Pervious asphalt mix: SE 162nd & Foster Driveway
EcoTrust Building Parking Lot (721 NW 9th Ave)