Design of Porous Pavements

Termpaper - CE682: Infrastructure and Transportation Planning

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March 6, 2010

How does Porous Pavements help

- Environmental - reduced stormwater runoff, recharge groundwater, efficient land use by reducing the need for retention ponds.
- Economic - the management effort made in preventing excess runoff during heavy rainfall is prevented. Reduces cost to maintain large detention ponds.
- Safety - increased safety for drivers, improves driving in wet weather conditions, reduces nighttime glare and lessens the risk of hydroplaning.
- LEED Credit - american rating agency to evaluate the environmental performance of a building. Gain in credit with the help of stormwater design, water efficient landscaping, recycled content, regional materials.

Categories of Pervious Paving Surfaces

- Porous Asphalt - very small proportion of fine aggregates, interconnected void space provides the permeability characteristics, can withstand repeated traffic.
- Pervious Concrete - concrete with permeable spaces.
- Single-size aggregate - used without any binder, least expensive, high utility in areas with low traffic conditions like parking stalls.
- Porous turf - used in parkings, counteracts “heat island” with water transpiration.

Porous Asphalt
Design of Porous Asphalt

Porous Asphalt consist of atleast four layers

- a 2-4 inch layer of asphalt
- a 1-2 inch filter layer of 1/2 inched crushed aggregate
- a minimum 12 inch reservoir layer of 1-3 inch aggregate
- a layer of geotextile material

Porous Asphalt
Design of Porous Asphalt

- the void space of porous asphalt is approximately 16%, as opposed to $2-3\%$ for conventional asphalt
- the crushed aggregate filter layer aids with pollutant removal
- treated runoff is stored in reservoir layer, a highly permeable layer of open-graded clean-washed aggregate with atleast 40% void space.
- nonwoven geotextile material placed between reservoir bed and uncompacted subsoil prevents migration of fines into the stone reservoir which could clog the system.
- the treated water then percolates through the subsoil to recharge the groundwater supply.

Porous Asphalt

Performance of Porous Asphalt

Advantages:

- contaminants on the surface of pavement tend to become part of runoff but with porous asphalt, they flow down to the soil, where beneficial bacteria and other natural processes cleanse them.
- open-graded asphalt roads have shown lower nighttime surface temperatures as compared to impervious pavements.
- benefits include noise reduction, a decrease in splash and spray kicked up by vehicles in heavy downpours.

Pervious Concrete

Applications of Pervious Concrete Pavements

- Retention Structures: ponds or basin designed for retention and detention purposes. Retention pond holds water for infiltration to soil, detention pond to capture runoff for discharge into manmade channels over extended time to reduce maximum flow rate.
- Passive/Active Mitigation System: Passive mitigation is just replacement of impervious surface with pervious surface. Active mitigation is to capture a sizeable portion of runoff from other areas as well as rail falling on its own "footprint". Active pervious concrete can also be designed as boundary features in conjunction with conventional pavements to create locally active but site-wise passive feature.

Pervious Concrete
Mix Design and Materials

Fine aggregate typically is eliminated, and the size distribution of the coarse aggregate is kept narrow to allow little particle packing.

- Cementitious Materials: portland cements, blended cements, supplementary cementitious material like fly ash, pozzolans and slag can be added.
- Aggregate: narrow grading. Larger aggregates provides a rougher surface. Both rounded aggregate (gravel) and crushed aggregate(stone) have been used.
- Water: water-cement ratios of 0.27 to 0.34 are commonly used along with addition of proper chemical admixtures.
- Admixtures: Because of rapid setting time associated with pervious concrete, retarders or hydration-stabilizing admixtures are commonly used.

Pervious Concrete
Structural Design Concepts

- Subgrade and Subbase Soils: should normally provide a 6-12 inch layer of permeable subbase. Offers good suppport values.
- Traffic Loads: truck traffic impact pavement much more than cars, the estimate of trucks using the pervious concrete pavement is critical to designing a long life pavement.
- Other Design Factors: terminal serviceability, load transfer at joints (aggregate interlock) and edge support.

Pervious Concrete

Hydrological Design Concepts

- Runoff Characteristics: Estimating volume and rate of runoff.
- Infiltration and runoff: both depend on soil type. Runoff is also dependent upon the slope of land, extent of vegetation. The infiltration will vary with the amount of moisture already in soil.
- Permeability and Storage: excess surface runoff must not result due to lower permeability or inadequate storage. Generally permeability is not a limiting criteria since permeability is mostly higher than the infiltration rate.
- Storage capacity: capacity of pervious concrete pavement plus that of base course. The capacity of pervious concrete depends on the effective porosity (that portion that can be readily filled in service).

Pervious Concrete
Hydrological Design Concepts

- Effect of Slope: if the slab is not levelled, the rainfall will quickly run to one end of the slab and after some time will overflow limiting the beneficial effects of pervious concrete. The depth of pervious concrete or rather just the thickness of base course increased to accomodate desired runoff goals.
- Design Storms: storms are designated by their 'return periods'. '20year storm' will be larger than a '10year storm'. Selection of Appropriate Retun Period: one of primary concern is water quality, pervious pavement often designated to capture '2year storm'. When flood control is a major issue, performance checked '10year storm'.

Pervious Concrete

Construction of Pervious concrete

- Subgrade and Subbase preparation: uniformity of subgrade support. Since pervious pavement contains minimal water and high porosity, care required to prevent premature dryout.
- Batching and Mixing: requires tighter control of mixture proportioning to extract useful properties of impervious pavement. Water content is limited to narrow range to provide adequate strength and permeability.
- Transportation: low slump may make discharge from transit mixers slower than conventional concrete.
- Placement and Consolidation: Placement should be continuous, and spreading and strikeoff should be rapid. Because of rapid hardening and high evaporation rates, delays in consolidation can cause problems.

Pervious Concrete

Construction of pervious concrete

- Joint Placement: joint spacing is usually larger than conventional pavements since pervious concrete shrinks less. Joint installation should be soon after the consolidation.
- Finishing: For majority of pavements finishing step is 'compaction'. This leaves a rougher surface but can improve traction.
- Curing and Protection: the open structure and rough surface makes curing more essential.
- Opening to traffic: it is generally recommended that the pavements are opened for construction or traffic load not before 7 days. Continuous curing is recommended until the pavement is opened.