SPECIFIER'S GUIDE
FOR
PERVIOUS CONCRETE PAVEMENT WITH DETENTION

(OHIO READY MIXED CONCRETE ASSOCIATION – PCP- 2795)

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PERVIOUS CONCRETE PAVEMENT WITH DETENTION

FORWARD

This specifier's guide has been assembled for consideration by designers of post-construction stormwater management for sites with vehicular or pedestrian pavements in Ohio land development. Because of Ohio's freeze-thaw climate and common presence of clay soil for pavement subgrade, this specifier's guide is presented as a system rather than just another pavement design guide. It is intended to supplement American Concrete Institute (ACI) 522R-10 *Report on Pervious Concrete* and ACI 522.1-13 *Specification for Pervious Concrete Pavement*.

This guide was developed to facilitate the design, installation and performance of a system comprised of pervious concrete pavement constructed over a clean, coarse aggregate base for temporary stormwater storage, having an impervious liner or filter fabric interlayer on a properly tested and prepared subgrade. For the duration of its service life, and with routine maintenance, the finished system resulting from this guide should a) collect, clean and discharge the stormwater for which it was designed, b) protect the subgrade on which it was constructed as well as the adjacent buildings and other pavements, and c) carry the traffic for which it was also designed. A system of *Pervious Concrete Pavement with Detention* may be used in conjunction with other post-construction stormwater management practices such as rooftop rain gardens, roadside swales, filter strips, basins, bio-retention cells or wetlands. The Ohio Department of Natural Resources (ODNR) Division of Soil and Water Resources provides further information in their *Rainwater and Land Development Manual*; refer to Chapter 2 - Post Construction Stormwater Management Practices.

Pervious concrete pavements, as all permeable pavements, are stormwater infiltration-based management systems. These pavements convey water through the pavement and hence also effectively collect and trap fine materials. Routine maintenance efforts consisting of visually inspection, infiltration rate testing and cleaning to restore pavement porosity is required to keep the system performing. Water should continue to move through the pavement and not pond into the pavement layer, otherwise surface distress and damage to the pavement will result. Ideally the pavement needs to be designed to limit sediment exposure by isolating run-on from landscaped areas and limiting the draining of other non-permeable pavements elsewhere. In all cases early removal of vegetative and other sediment loads is the most effective way to maintain infiltration and prevent damage. Maintenance of the pervious concrete pavement is the responsibility of the property owner/manager.

In addition to stormwater control, *Pervious Concrete Pavement with Detention* may aid in achieving additional LEED® credits to a project for reduction of heat island effect, reduced site disturbance, and improved energy efficiency for adjacent buildings. LEED® (Leadership in Energy and Environmental Design) Certification by the U.S. Green Building Council is growing in importance for developers, designers and entire communities.

This guide may be used to develop the necessary communicative tools (plans, specifications, enforcement and other contract documents) which will convey the intentions of the project Architect/Engineer to the Permitting Agency, the Contractor and the Inspector. Actual project conditions will require modifications and additions to this guide.

SYSTEM COMPONENTS

Subgrade - Critical to the design and performance of a system of *Pervious Concrete Pavement with Detention*, is the subgrade on which it is to be constructed. Infiltration rate of the subgrade soil will affect design of the stormwater storage layer, and will determine (by this guide) whether a filter fabric or an impervious liner shall be used at the interface of the subgrade with the storage layer.

Test methods to determine the subgrade soil infiltration rate must be conducted by a qualified testing laboratory. If the subgrade soil has an infiltration rate of 0.5 in./hr (12.7 mm/hr) or greater, a filter fabric may be installed and the stormwater storage used for groundwater recharge. An impervious liner may be used and a positive outlet provided to drain all water from the storage layer when the soil infiltration is below 0.1 in./hr (2.54 mm/hr) or expansive soils are present. For soil infiltration values between 0.1 in./hr and 0.5 in./hr (2.54 mm/hr and 12.7 mm/hr) determination for system type may require further consideration. For this guide specification, if an impervious liner is used, the stormwater storage layer is referred to as a "detention layer", anticipating that the water will pass from storage via a pipe, daylighted aggregate drain or other form of positive conduit. If a filter fabric is used, the storage layer will be referred to as a "recharge bed", anticipating that a substantial amount of the stored water will pass through the fabric into the subgrade. Note that some local authorities may require a calculated storage volume that would contain a specific rainfall event (or the first-flush) for up to 72 hours. Ohio's standards for stormwater management is available through ODNR in their *Rainwater and Land Development Manual*; reference section 2.11 Permeable Pavement.

Per ACI 522, "Pervious concrete pavement is not recommended in freezing and thawing environments where the groundwater table rises to a level less than 3 ft (0.9 m) from the top of the surface of the subgrade." Pervious concrete pavement is also not recommended in hillside locations where saturated soils may cause landslides. Storage of stormwater from a pervious concrete pavement system is not recommended within 10 ft (3 m) of foundations for buildings, sign supports, utility poles and other structures, or public roadways.

Stormwater storage - Stormwater storage in the system envisioned by this guide is accomplished entirely within an aggregate base layer beneath the pervious concrete pavement. Because of Ohio's freeze-thaw climate, the design, construction and performance of this system must be focused on preventing water from ponding on the pervious concrete surface, and preventing retention of water within the pervious concrete pavement layer. The storage layer may be comprised of more than one layer of aggregate, each layer having a different size aggregate and void content. For additional storage volume the aggregate layer(s) may extend beneath adjacent impervious pavements on the site, and may include chambers, cisterns, vaults, tanks or other receptacles, as necessary to economically accommodate the design stormwater storage volume. In addition, designers may anticipate extended storage for future harvest by a landscape irrigation system.

Plan thickness requirements for stormwater storage in the aggregate layer of the system, whether designed for detention or recharge, may be approximated using the *Pervious Concrete Hydrological Analysis Program*[1]. Underdrain piping may be required to provide positive drainage and drawdown of the stormwater storage. Overdrain piping may be utilized to minimize pavement saturation and protection especially for sites with low soil infiltration rates during very large storm events.

The designer must take into account the slope of the subgrade a) to compute stormwater storage volume, and b) to consider need for cross-slope "check dams" for erosion prevention. Greater stormwater storage volume will provide additional freeze-thaw protection for storms that exceed the design event.

Connection of roof drains and/or foundation sump lines needs to be carefully considered and in most circumstances is not recommended. Roof drains outletting directly on pervious concrete will require additional maintenance/cleaning. Some communities may also restrict discharge into storage containment or outlet through underdrain piping.

[1] Program by Malcolm, Leming and Nunez, of the Civil Engineering Department, North Carolina State University, Raleigh, North Carolina. The software is available from the Ohio Ready Mixed Concrete Association, the National Ready Mixed Concrete Association or the Portland Cement Association.

For a large site the designer may choose to subdivide the storage into separated cells for consideration of future maintenance or underground utility installation.

Pervious concrete - Like conventional concrete, pervious concrete is a rigid, inorganic material having a chemical composition similar to natural limestone. As such, it is neither visco-elastic (flexible) nor biodegradable. Pervious concrete can withstand the water, oxygen and sunlight of the "aquatic-terrestrial" environment anticipated with stormwater control. Generally the permeability of pervious concrete is greater than 100 in./hr (254 cm/hr) and can be over 1000 in./hr (2540 cm/hr). As a rigid pavement, pervious concrete will not rut, meld or knead under traffic. However, like conventional concrete, improper design, construction or maintenance practices of a pervious concrete pavement with detention system could lead to freeze-thaw damage.

Pervious concrete pavement – Pervious concrete pavement does not look like nor behave like conventional concrete pavements. The finished surface is not tight and uniform, but is open and varied, to admit large quantities of stormwater. Surface irregularities and minor amounts of surface raveling are normal. Pervious concrete pavement may be colored for aesthetic purposes or left plain, uncolored. Traditional concrete testing procedures for strength and slump are not applicable to this construction. Instead, pervious concrete pavement is tested for density (unit weight), void content and thickness; using standard test methods identified in this guide, to help assure a long life, drainable pavement.

Maintenance is critical to the long-term performance of pervious concrete pavement, especially those activities that prevent clogging of the surface pavement and subsequent clogging of the subsurface layers by accumulated sediments and organic matter. Changes in infiltration rates can be monitored throughout the life of the pavement using ASTM C1701 - Standard Test Method for Infiltration Rate of In-Place Pervious Concrete. Establishment of a base infiltration rate at the completion of pavement construction will allow for routine inspection and subsequent infiltration rate testing of potential clogged areas within the pavement to be addressed by a maintenance program. A routine inspection schedule is required to check for infiltration rate changes that would prompt the restoring procedures required to remedy porosity levels.

Developers, architects and engineers are strongly encouraged to visit locations where pervious concrete pavement with detention (or groundwater recharge) systems have been installed before making the decision to use this concept. Ideal site locations to place pervious concrete pavements with detention are in the project's parking stalls. Caution is suggested to avoid placement of pervious concrete in areas with repeated dynamic torsional forces such as turning lanes, entrance/exit aprons and tight radius locations.

Technical assistance and installation training is available in Ohio from the Ohio Ready Mixed Concrete Association (ORMCA)/Ohio Concrete. ORMCA/Ohio Concrete can also provide planning, design, materials and construction information.

SECTION 02795
PERVIOUS CONCRETE PAVEMENT WITH DETENTION

PART 1 GENERAL

1.01 Scope of Work:

A. The Work described by this guide addresses the labor, materials and equipment necessary for construction of pervious concrete pavement, including subgrade testing and preparation for a stormwater storage layer for temporary detention or groundwater recharge in conformance with the plans, specifications and other contract documents, for streets, parking lots, driveways, paths, sidewalks and other pedestrian areas.

1.02 References:

A. American Concrete Institute (ACI)
   1. ACI 211.3R "Guide for Selecting Proportions for No- Slump Concrete"
   2. ACI 305 "Hot Weather Concreting"
   3. ACI 306 "Cold Weather Concreting"
   4. ACI 522 "Report on Pervious Concrete"
   5. ACI 522.1-13 "Specification for Pervious Concrete Pavement"
   6. ACI Flatwork Finisher Certification Program
   7. ACI Field Technician Certification Program

B. American Society for Testing and Materials (ASTM)
   1. ASTM C 29 "Test for Bulk Density (Unit Weight) and Voids in Aggregate"
   2. ASTM C 33 "Specification for Concrete Aggregates"
   3. ASTM C 42 "Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete"
   4. ASTM C 94 "Specification for Ready-Mixed Concrete"
   5. ASTM C 117 "Test Method for Material Finer than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing"
   6. ASTM C 150 "Specification for Portland Cement"
   7. ASTM C 172 "Practice for Sampling Freshly Mixed Concrete"
   8. ASTM C 260 "Specification for Air-Entraining Admixtures for Concrete"
   9. ASTM C 494 "Specification for Chemical Admixtures for Concrete"
   10. ASTM C 595 "Specification for Blended Hydraulic Cements"
   11. ASTM C 618 "Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete"
   12. ASTM C 979 "Specification for Pigments for Integrally Colored Concrete"
   13. ASTM C 989 "Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars"
   14. ASTM C 1077 "Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation."
   15. ASTM C 1116 "Specification for Fiber-Reinforced Concrete"
   16. ASTM C 1542 "Standard Test Method for Measuring Length of Concrete Cores"
   17. ASTM C 1602 "Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete"
   18. ASTM C 1688 "Test Method for Density and Void Content of Freshly Mixed Pervious Concrete"
   19. ASTM C 1701 "Test Method for Infiltration Rate of In Place Pervious Concrete"

20. ASTM C 1754 "Standard Test Method for Density and Void Content of Hardened Pervious Concrete"
21. ASTM D 448 “Classification for Sizes of Aggregate for Road and Bridge Construction”
22. ASTM D 1557 “Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3)”
23. ASTM D 1751 “Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)”
24. ASTM D 1752 “Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction”
25. ASTM D 2434 “Test Method for Permeability of Granular Soils (Constant Head)”
26. ASTM D 3385 “Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer”
27. ASTM D 3665 "Standard Practice for Random Sampling of Construction Materials"
28. ASTM D 5084 “Test Methods for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter (Falling Head, Method C)”
29. ASTM D 5093 “Test Method for Field Measurement of Infiltration Rate Using a Double-Ring Infiltrometer with a Sealed-Inner Ring”
30. ASTM D 6391 “Test Method for Field Measurement of Hydraulic Conductivity Limits of Porous Materials Using Two Stages of Infiltration from a Borehole”
31. ASTM D7357 “Specification for Cellulose Fibers for Fiber-Reinforced Concrete”
32. ASTM E 329 “Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction”

C. National Ready Mixed Concrete Association (NRMCA)
   1. NRMCA Pervious Concrete Contractor Certification
D. Ohio Aggregate & Industrial Minerals Association (OAIMA)
   1. ‘Going Green with Rocks’ Technical Guide for Void Percentages
E. State of Ohio Department of Transportation (ODOT) Construction and Material Specifications
   1. Item 703.02 Aggregate for Portland Cement Concrete
F. Ohio Department of Natural Resources (ODNR), Division of Soil and Water Resources
   1. Rainwater and Land Development Manual
      a. Chapter 2 - Post Construction Stormwater Management Practices

1.03 Quality Assurance:

A. Prospective Bidder/Contractors shall attend a pre-bid meeting where the pervious concrete pavement construction process will be described (see Section 1.08) by industry representatives from the Ohio Ready Mixed Concrete Association/Ohio Concrete or other comparable entity.
B. Prior to award, the Bidder/Contractor shall submit evidence of two successful pervious concrete pavement projects, each greater than 1,000 ft² (93 m²), including but not limited to the following:
   1. Project name and address, owner name and contact information.
   2. Fresh density (unit weight) and void content test results per ASTM C1688 and, if determined, in-place hardened density (unit weight) and void content of pervious concrete mixture per ASTM C 1754.

   This requirement may be waived by the Architect/Engineer provided the Bidder/Contractor demonstrates successful experience in the concrete industry and constructs test panel(s) for inspection and testing, per Section 1.06 of this guide.
C. The Bidder/Contractor shall employ no less than one NRMCA certified Pervious Concrete Craftsman who must be on site, overseeing each placement crew during all concrete placement, or employ no less than three NRMCA certified Pervious Concrete Installers, who shall be on site as members of each placement crew during all concrete placement, or employ no less than five

NRMCA certified Pervious Concrete Technicians, who shall be on site working as members of each placement crew during all concrete placement unless otherwise specified. The minimum number of certified individuals listed above must be present on each pervious concrete placement including any test panel placements (see section 1.06), and a certified individual must be in charge of the placement crew and procedures.

D. If the placing contractor and concrete producer have insufficient experience with pervious concrete pavement (less than two successful projects), the placing contractor shall retain an experienced consultant to monitor production, handling, and placement operations at the Contractor's expense.
E. Qualifications of testing laboratories -The testing laboratory shall have its laboratory equipment and procedures inspected at intervals not to exceed 2 years by a qualified national authority as evidence of its competence to perform the required tests and material designs. Acceptable national authority will include the AASHTO Materials Reference Laboratory (AMRL) or the Cement and Concrete Reference Laboratory (CCRL) as appropriate. In addition, testing machines and equipment must be calibrated annually or more frequently by impartial means using devices of accuracy traceable to the National Bureau of Standards.

   Field tests of pervious concrete shall be performed by individuals certified as both an NRMCA Certified Pervious Concrete Technician or equivalent and as an ACI Concrete Field Testing Technician – Grade I. In fields other than those covered by the referenced ASTM standards, the testing laboratory shall accept only those assignments which it is able to perform competently by use of its own personnel and equipment. Any work to be subcontracted must be to laboratories meeting the same criteria.

   The testing laboratory shall have demonstrated its competence in the applicable fields for a period of not less than 3 years.

   The inspection and testing services of the testing laboratory shall be under the direction of a full-time employee registered as a professional engineer in the State of Ohio. He shall have a minimum of 5 years of professional engineering experience in inspection and testing of concrete construction.

1.04 Special Equipment: Pervious concrete requires specific equipment for compaction and jointing. The pervious concrete pavement shall be jointed and compacted using the methods listed, or alternatives as demonstrated and approved by the Architect/Engineer. For example, large installations may warrant mechanized placement techniques.

A. Rolling compaction shall be achieved using a steel pipe roller or a motorized or hydraulically actuated rotating tube screed that spans the width of the section placed and exerts a vertical pressure of 10 psi (68.95 kPa) to 30 psi (206.85 kPa) on the concrete.
B. Plate compaction (for small areas) shall be achieved using a standard soil plate compactor that has a base area of at least two square feet and exerts a minimum of 10 psi (69 kPa) vertical pressure on the pavement surface (through a temporary cover of ¾ in. (19 mm) plywood).
C. When contraction joints are created in pervious pavements, they may be constructed by rolling, forming or sawing. Rolled joints shall be formed using a "pizza cutter roller" to which a beveled fin with a minimum depth of ¼ the thickness of the slab has been welded around the circumference of a steel roller.

1.05 Submittals: Administrative Requirements, for submittal procedures.

Prior to commencement of the work the contractor shall submit the following:

A. Concrete materials:
   1. Proposed pervious concrete mixture proportions including all material weights, water-cementitious ratio, absolute volumes including density (unit weight) and void content of freshly

mixed pervious concrete mixture per ASTM C 1688. *(The fresh density and void content calculated from this procedure will differ from in-place density and void content and is only used to check mixture proportion consistency).*

2. Aggregate type, source, grading, dry-rodded unit weight, percent passing number 4 sieve and void content.
3. Cement, supplementary cementitious materials, synthetic (polypropylene) or cellulose fibers and chemical admixture manufacturer certifications.
4. In-place hardened density (unit weight) and void content of proposed pervious concrete mixture per ASTM C 1754 from previous work completed in the last 24 months, if tested, when required by the Architect/Engineer. *(The in-place density and void content calculated from this procedure will differ from the fresh density and void content and is only used for quality assurance).*

B. Aggregate base materials: Washed aggregate type, source, grading and void content (percent porosity).
C. Qualifications: Evidence of qualifications listed under Quality Assurance in Section 1.03 of this guide.
D. Project details: Specific plans including a jointing plan, details, schedule, construction procedures and quality control plan.
E. Subcontractors: List all materials suppliers, subcontractors and testing laboratories to be used on the project.

1.06 Test Panels: Prior to construction, test panel(s) shall be placed with the crew meeting the requirement of NRMCA certified personnel per section 1.03 C. and approved by the Architect/Engineer. The Architect/Engineer may waive this requirement based on Contractor qualifications. At Contractor's option, test panels may be constructed on approved sections of project aggregate detention (or groundwater recharge) layer.

A. Test panel(s) shall be constructed in accordance with the plans and specifications. Regardless of qualification, the contractor is to place two test panels, each approximately 225 ft^2 (20.9 m^2) at the required project thickness, consolidated, jointed and cured using materials, equipment, and personnel proposed for the project, and on the same aggregate base proposed. This is to demonstrate to the Architect/Engineer's satisfaction that the pervious concrete mixture as submitted is validated and also to confirm that the contractor's ability to place the mixture under anticipated project conditions produces a satisfactory pavement intended for the site location which can be quantitatively and qualitatively evaluated.
B. Test panel(s) cost and removal, if necessary, shall be included as a line item in the contract proposal and contract. Test panels may be placed at any of the specified pervious concrete pavement locations on the project or at another test site.
C. Quality: Test panels shall have acceptable surface finish, joint details, thickness, porosity and curing procedures and shall comply with the testing and acceptance standards listed in the Quality Control section (C.8.)of this specification. Test density and void content of fresh concrete for the test panels in accordance with ASTM C 1688. Select three core locations per ASTM D 3665, obtain hardened 4 inch (100 mm) diameter concrete cores from the test panels in accordance with ASTM C 42 and determine individual core thicknesses in accordance with ASTM C 1542. Determine the hardened densities (unit weights) and void contents in accordance with ASTM C 1754 when the test panel is found satisfactory per below D.
D. Satisfactory performance of the test panels shall be determined by**:**
    1. Fresh concrete results
        a. Density (unit weight) plus or minus 5 lb/ft^3 (80 kg/m^3) of the submitted fresh density (unit weight) using ASTM C 1688 procedures.
    2. Hardened thickness tolerances

a. Average length of three cores not less than 3/8 in. (10 mm) and not greater than 1.5 in. (38 mm) of specified pavement thickness.
b. Length of any individual core not less than 3/4 in. (19 mm) of specified pavement thickness.

E. If test panels are found to be unsatisfactory, they shall be removed at the Contractor's expense and disposed of in an approved landfill or recycling facility. If test panels are found to be satisfactory, they may be left in-place and included in the completed work, at no additional cost to the project. If accepted, use the average hardened density (unit weight) from the accepted test panel(s) as a basis for acceptance of the remainder pavement when required by the Architect/Engineer.

1.07 Project Conditions

A. Weather Limitations
1. The Contractor shall not place pervious concrete for pavement when the ambient temperature is predicted by the National Weather Service Point Forecast for the jobsite to be 40 ºF (4 ºC) or lower during the seven days following placement, unless otherwise permitted in writing by the Architect/Engineer. (*Note: In cold weather the pervious concrete is more susceptible to freezing because its porous nature prevents pervious concrete from generating and retaining heat of hydration. Any freezing of the pavement will likely result in damage. Construction should not be scheduled when there is a chance for liquid precipitation or when a cold front with freezing temperatures is expected. Due to rapid evaporation causing insufficient water for cement hydration, hot water should not be used in batching pervious concrete mixtures. Besides protecting the freshly placed concrete from freezing, the concrete must be maintained at a reasonably warm temperature for the first 7 days to sustain hydration of cementitious materials. Curing duration before opening to traffic may need to be extended in cold weather.)*
2. The contractor shall not place pervious concrete for pavement when the ambient temperature is predicted by the National Weather Service Point Forecast for the jobsite to rise above 90 ºF (32 ºC) during placement, unless otherwise permitted in writing by the Architect/Engineer. Extra measures may be required to assure that concrete receives proper moist curing following placement.
3. Pervious concrete pavement shall not be placed on frozen coarse aggregate or subgrade.
4. Evaporation control measures shall be applied from the time of discharge until the pavement is covered with polyethylene sheeting to prevent moisture loss during placement operations (refer to section 2.09).

1.08 Pre-paving Conference

A pre-paving conference with the Architect/Engineer shall be held within one week prior to beginning placing the pervious concrete. The contractor shall have the pervious concrete supplier, contracted testing agency, the foreman and the entire concrete crew that will form and place the concrete in attendance at this meeting. A qualified representative from ORMCA/Ohio Concrete shall also be in attendance for assistance.

As a guide for the meeting, the document *Checklist for the Concrete Pre-Construction Conference* (available from the National Ready Mixed Concrete Association or the American Society of Concrete Contractors) shall be used to review all requirements of the contract during the meeting. Meeting emphasis shall be on how paving with pervious concrete differs from paving with conventional concrete, maintaining moisture retention of fresh mixture, timing and proper placement of cure sheeting, and securing of sheet throughout curing period (minimum seven days).

PART 2 PRODUCTS

Stormwater Detention layer or Groundwater Recharge Bed

2.01 Testing to determine the subgrade soil infiltration rate shall be conducted by a qualified testing laboratory, by either the field or laboratory methods listed below:

- Field methods – ASTM D 3385, ASTM D 5093 or ASTM D 6391;
- Laboratory methods – ASTM D 5084 or ASTM D 2434.

If the subgrade soil has an infiltration rate of 0.5 in./hr (12.7 mm/hr) or greater, a filter fabric may be installed and the stormwater storage used for groundwater recharge. An impervious liner may be used and a positive outlet provided to drain all water from the storage layer when the soil infiltration is below 0.1 in./hr (2.54 mm/hr) or in presence of expansive soils. For soil infiltration values between 0.1 in./hr (2.54 mm/hr) and 0.5 in./hr (12.7 mm/hr) determination for system type may require further consideration. (Note: Local ordinances may dictate storage and discharge requirements. For this guide specification, if an impervious liner is used, the stormwater storage layer is referred to as a detention layer, anticipating that the water will pass from storage via a pipe, daylighted aggregate drain or other form of positive conduit. If a filter fabric is used, the storage layer will be referred to as a recharge bed, anticipating that a substantial amount of the stored water will pass through the fabric into the subgrade.) Note: Sizing and locations of any pipes, etc. is to be designed by others, and is not a part of this guide.

2.02 **Coarse aggregate for stormwater detention layer** (or groundwater recharge bed) shall an open graded, clean coarse aggregate, with a wash loss of no more than 5%, per ODOT Item 703.02, Table 703.02A.2, or approved equal. An optional choker base course of aggregate meeting the same requirements above may be used also as the top layer to facilitate construction operations. Crushed, angular type is preferred to allow ready mix transit vehicle access and minimize rutting.

2.03 Actual size(s) of washed, open graded, coarse aggregate for stormwater detention layer (or groundwater recharge bed), shall be at contractor's option for best availability, percent void and economics. Refer to the Ohio Aggregates & Industrial Mineral Association (OAIMA) table of void percentages of common Ohio coarse aggregates, available at www.oaima.org. Plan thickness requirements for stormwater storage in the system, whether designed for detention or recharge, may be approximated using the *Pervious Concrete Hydrological Analysis Program*[2]. That software assumes a flat subgrade; calculations may require adjustments for subgrade slope. Even for soils with infiltration rates in excess of 1.5 in./hr (38.1 mm/hr), minimum total thickness of coarse aggregate for stormwater storage shall be 8 in. (203 mm).

2.04 **Impervious liner** – shall be 15 mil Stego Wrap or Permalon, PLY-X 150, or approved equal (for stormwater detention).

2.05 **Filter fabric -** shall be a nonwoven geotextile, Marafi 140N or Typar fabric, style 3341, or approved equal (for groundwater recharge).

2.06 **Underdrain Piping –** shall be perforated plastic pipe, x inch diameter, located per the plans typically at the base of the stormwater detention layer (or groundwater recharge bed).

[2] Program by Malcolm, Leming and Nunez, of the Civil Engineering Department, North Carolina State University, Raleigh, North Carolina. The software is available from the Ohio Ready Mixed Concrete Association, the National Ready Mixed Concrete Association or the Portland Cement Association.

2.07 Overdrain Piping - shall be perforated plastic pipe, y inch diameter, located per the plans typically at the top of the stormwater detention layer (or groundwater recharge bed).

2.08 Isolation (Expansion) joint material - Isolation joint material shall be full depth of pavement, ¼ in. (6.35 mm) or ½ in. (12.7 mm) Proflex Vinyl (Isolation) Expansion Joint by Oscoda Plastics, or equal, in compliance with ASTM D 1751 or ASTM D 1752.

2.09 Curing materials

A. Polyethylene sheeting - The primary method of curing pervious concrete shall be the placement of a waterproof covering, consisting of a minimum of 6 mil thick clear polyethylene sheeting.
B. Other moisture loss control - For prevention of moisture loss prior to the primary method of curing:
   1. Monomolecular film (evaporation retardant), SikaFilm by Sika Corporation, EucoBar by Euclid Chemical Co., Confilm by BASF (Master Builders Technologies) or Catexol Cimfilm by Axim Concrete Technologies, or approved equal, applied per manufacturer's instructions.
   2. Soybean oil sealer. Note: Soybean oil is recommended for added protection. It reportedly reduces surface color markings from plastic sheeting, may enhance strength and does not reduce porosity.
   3. Fogging equipment designed to raise the relative humidity of the ambient air over the slab and reduce evaporation to include fog nozzles that atomize water using air pressure to create a fog blanket over the slab. Note: garden hose nozzles are not sufficient to create fog and may wash paste off the aggregate.

Pervious concrete pavement

2.10 Cement: Portland cement Type I, Type II or V conforming to ASTM C 150 or Portland cement Type IP or IS conforming to ASTM C 595.

2.11 Supplementary Cementitious Materials:

A. Fly ash conforming to ASTM C 618
B. Ground Granulated Blast-Furnace Slag conforming to ASTM C 989

2.12 Admixtures:

A. Air entraining admixtures with ASTM C 260.
B. Chemical admixtures shall comply with ASTM C 494.
   1. Mid-range water reducing admixtures (water reducers) Type A or High Range water reducing admixtures Type F or G are permitted due to low water-cementitious ratios specified for pervious concrete.
   2. Extended set control admixtures (hydration stabilizers) meeting requirements of ASTM C 494 Type B Retarding or Type D Water Reducing/Retarding admixtures are recommended to increase concrete placement time or to improve finishing operations. Note: this stabilizer suspends cement hydration by forming a protective barrier around the cementitious particles, which delays the particles initial set. If this mix heats up in the truck a standard retarder will not prevent premature hydration where the stabilizer will.
   3. Viscosity modifying admixtures (VMA's) are permitted to facilitate discharge of the concrete from the truck and placement in the forms.
C. Superabsorbent Polymer (SAP). SAP is a crushed crystalline partial sodium salt of cross-linked polypromancic acid rated at 2,000 times absorption for pure water.

2.13 Fiber Reinforcement:

A. Synthetic fiber shall be in accordance to ASTM C 1116 Type III made of polypropylene.
B. Cellulose fibers shall be in accordance to ASTM C 1116 Type IV made of natural fibers conforming to ASTM D 7357.
C. Macrosynthetic fibers are gaining acceptance and use in certain areas.

2.14 Aggregates for pervious concrete:

A. Coarse aggregate shall meet the size and grading requirements as defined in ASTM D 448 (or Standard Sizes of Coarse Aggregate, Table 4, AASHTO Specifications, Part I, 13th Ed., 1982 or later) and shall comply with ASTM C 33 and ODOT Item 703.02. Use No.67, No. 7, No. 8, No. 89 or No. 9 unless an alternate size is approved for use based on meeting the project requirements. Data for proposed alternate material shall be submitted for approval per Section 1.05A of this guide. Fine aggregate complying with ASTM C33, if used, shall not exceed 3 ft^3 per yd^3 (0.11 m^3 per 1.0 m^3).
B. Larger aggregate sizes may increase porosity but can decrease workability. No. 8 (3/8 in. or 9.5 mm) size coarse aggregate is the common size used in pervious concrete pavements. Well graded aggregates shall be avoided as they may reduce porosity, and may not provide adequate void content.

   Note: Suggested maximum limit when using a number 8 coarse aggregate pervious mix is 15% passing No. 4 sieve (4.75 mm)

   a. For 5 to 10% passing No. 4 sieve (4.75 mm), add 125 lb/yd^3 (74 kg/m^3) fine aggregate
   b. For 0 to 5% passing No. 4 sieve (4.75 mm), add 200 lb/yd^3 (119 kg/m^3) fine aggregate

2.15 Water: Water shall be potable and comply with ASTM C 1602.

2.16 Pigments – Use pigments complying with ASTM C 979 if specified in the project plan documents. Trial mixtures and placements to be conducted when required per the project documents for acceptance approval.

2.17 Mixture Proportions: The Contractor shall furnish a proposed mix design with all proportions of materials prior to commencement of work. The data shall include densities (unit weights) and void contents determined in accordance with ASTM C 1688 for fresh mixed properties and, when required by the Architect/Engineer, ASTM C 1754 for hardened concrete properties of the same proposed mixture. The composition of the proposed concrete mixture shall be submitted to the Architect/Engineer for review and/or approval and shall comply with the following provisions unless an alternative composition is demonstrated to comply with the project requirements. Mixture performance will be affected by properties of the particular materials used. Trial mixtures must be tested to establish proper proportions and determine expected behavior. Concrete producers may have mixture proportions for pervious concrete optimized for performance with local materials by use of available software programs. Appendix 6 of ACI 211.3R provides a guide for pervious concrete mixture proportioning. General mixture proportions are as follows:

A. Aggregate/cementitious ratio: range of 4:1 to 5:1.
B. Concrete mixture unit weight: range of 115 lb/ft^3 to 135 lb/ft^3 (1840 kg/m^3 to 2080 kg/m^3)
C. Concrete mixture void content: range of 13% to 30%.
D. Cementitious content: range of 450 lbs/yd^3 to 600 lb/yd^3 (267 kg/m^3 to 356 kg/m^3), total cementitious content.
E. Supplementary cementitious content: Fly ash: 25 % maximum; Slag: 25 % maximum, or Combined supplementary cementitious content: 35 % maximum.
F. Water - cementitious ratio: range from 0.28 to 0.35.
G. Fiber reinforcement is recommended for added performance:

a. Synthetic polypropylene, target 0.1% volume of mixture or range 1 lb/yd^3 to 1.5 lb/yd^3 (0.593 kg/m^3 to 0.890 kg/m^3)
b. Cellulose, range 1.5 lb/yd^3 to 3 lb/yd^3 (0.890 kg/m^3 to 1.78 kg/m^3)
c. Macrosythetic fibers, range per manufacture's recommendation.

H. Aggregate content: The bulk volume of aggregate per cubic yard (cubic meter) shall be 27 ft^3 (1 m^3) when calculated from the dry rodded density (unit weight) determined in accordance with ASTM C 29 using the jigging or rodding procedure.

I. Admixtures: Admixtures shall be used in accordance with the manufacturer's instructions and recommendations.
1. Air-entraining admixture is required and the recommended dosage shall be a minimum of 2 oz/cwt (130 mL/100kg) of cementitious material.
2. Hydration stabilizing admixture suggested dosage range: 7 - 18 oz/cwt (455 mL/100kg - 1170 mL/100kg)
3. Viscosity modifying admixture suggested dosage range: 0.5 - 1.0 gal/cy (2.5 - 5.0 L/m³)

J. Mix Water: The quantity of mixing water shall be established to produce a pervious concrete mixture of the desirable workability to facilitate placing, compaction and finishing to the desired surface characteristics. Note: Mix water shall be such that the cement paste displays a wet metallic sheen without causing the paste to flow from the aggregate. (A cement paste with a dull-dry appearance has insufficient mix water for hydration.) Insufficient mix water results in inconsistency in the mix and poor bond strength. Jobsite addition of mix water is permitted to adjust for dry mixtures in concrete transit mixers; add water at 0.5 gal/cy (2.5 L/m³) and remix for two minutes. Note: High water content results in the paste sealing the void system primarily at the bottom and poor surface bond. Use of hot water is not permitted as mix water.

PART 3 EXECUTION

The Architect/Engineer shall be notified at least 24 hours prior to all detention layer (or recharge bed) placement and pervious concrete paving work. Careful consideration for the construction sequence is prudent and, to the greatest extent possible, the surrounding earthwork/landscape operations should be completed and stabilized prior to stormwater storage and pervious concrete placements.

3.01 Installation

A. Stormwater Detention Layer

1. Subgrade Preparation and Protection of Adjacent Building or Pavement Foundations
    a. Existing subgrade under detention layer areas shall be shaped to drain and compacted per plan lines, grades and specifications.
    b. Protect adjacent footings and foundations from stored stormwater by installation of a concrete curb wall or impermeable membrane wall.
2. Detention Layer Installation
    a. Upon completion of subgrade work, the Architect/Engineer shall be notified and shall inspect at his discretion before proceeding with detention layer installation.
    b. Impervious liner, with pipe or other storage devices, and detention layer aggregate shall be placed immediately after approval of subgrade preparation. Any accumulation of debris or sediment which has taken place after approval of subgrade shall be removed prior to installation of impervious liner at the contractor's expense.
    c. Place impervious liner in accordance with manufacturer's standards and recommendations, including overlap width of adjacent strips. Secure liner to walls of detention layer excavation and take steps necessary to prevent any runoff or sediment from entering the detention layer excavation. For protection of existing adjacent building foundations, place impervious liner extending 6 ft (1.83 m) beyond toe of slope face at building face, secure as recommended by manufacturer.
    d. Install coarse aggregate in 6 in. (152 mm) maximum lifts. Lightly compact each layer with equipment, keeping equipment movement over detention layer subgrade to a minimum. Install aggregate to grades required on the plans.
    e. If required, install choker base course size No.57 (AASHTO) crushed angular aggregate evenly over surface of larger sized aggregate bed, sufficient to allow ready mix transit access for placement of pavement, and notify the Architect/Engineer for approval.
3. Following placement of detention layer aggregate, the impervious liner shall be folded back along all excavation edges to protect from sediment washout along excavation edges. At least a 2 ft (610 mm) strip shall be used to protect the detention layer from adjacent bare soil. This edge strip shall remain in place until all bare soils contiguous to detention layer are stabilized and vegetated. In addition, hay bales shall be placed at the toe of slopes which may be adjacent to detention layers to further prevent sediment from washing into the detention layers during site development. As the site is fully stabilized, excess impervious liner along the detention layer edges can be cut back to coarse aggregate edge.

B. Groundwater Recharge Bed

1. Subgrade Preparation (a flat subgrade is preferred for a recharge bed)
    a. Existing subgrade under recharge bed areas shall NOT be compacted or subject to excessive construction equipment traffic prior to coarse aggregate bed placement.
    b. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 8 in. (203 mm) with a York rake or equivalent and light tractor.

c. Bring subgrade of coarse aggregate recharge bed to line, grade, and elevations required.
d. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic compaction before the placing of coarse aggregate.

2. Recharge Bed Installation
   a. Upon completion of subgrade preparation, the Architect/Engineer shall be notified and shall inspect at his discretion before the contractor may proceed with recharge bed installation.
   b. Protect adjacent footings and foundations from stored stormwater by installation of a concrete curb wall or impermeable membrane wall.
   c. Filter fabric, with pipe or any other storage devices, and recharge bed aggregate shall be placed immediately after approval of subgrade preparation. Any accumulation of debris or sediment which has taken place after approval of subgrade shall be removed prior to installation of filter fabric at the contractor's expense.
   d. Place filter fabric in accordance with manufacturer's standards and recommendations. Adjacent strips of filter fabric shall overlap a minimum of 16 in. (406 mm). The contractor shall secure fabric at least 2 ft (610 mm) outside of bed and take steps necessary to prevent any runoff or sediment from entering the storage bed. For protection of existing adjacent building foundations, the contractor shall place impervious liner over filter fabric extending 6 ft (1829 mm) beyond toe of slope face at building face, and secure as recommended by manufacturer.
   e. Install coarse aggregate in 6 in. (152 mm) maximum lifts. Lightly compact each layer with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregate to grades required on the drawings.
   f. If required, install a minimum 2 in. (50 mm) nominal thickness choker base course size No. 57 (AASHTO) aggregate evenly over surface of larger sized aggregate bed, sufficient to allow placement of pavement, and notify the Architect/Engineer for approval.
   g. Following placement of bed aggregate, the filter fabric shall be folded back along all bed edges to protect from sediment washout along bed edges. At least a 2 ft (610 mm) strip shall be used to protect beds from adjacent bare soil. This edge strip shall remain in place until all bare soils contiguous to beds are stabilized and vegetated. In addition, hay bales shall be placed at the toe of slopes which may be adjacent to beds to further prevent sediment from washing into beds during site development. As the site is fully stabilized, excess filter fabric along the bed edges can be cut back to coarse aggregate edge.

C. Pervious Concrete Pavement
1. Pavement Thickness:
   Pavement thickness for all applications (excluding heavy traffic loads) shall be single-course placement 6 in. (152 mm) thick unless otherwise specified in the plans. Pavements for vehicles heavier than single axle service/delivery trucks will require special design thicknesses which may require two-course construction.
   Note: Thicknesses greater than 6 in. (152 mm) have been successfully installed with single-course construction, and design has been verified with cores. Cores from a test slab may be used to confirm that consolidation and infiltration in the bottom of the slab is consistent with design objectives. Cores may also be used to determine relative compressive and flexural strengths.
2. Formwork:
   a. Form materials are permitted to be of wood or steel and shall be the full depth of the pavement. Caution: protect impermeable membranes from puncture or tear when placing forms and form pins. Forms shall be of sufficient strength and stability to support mechanical equipment without deformation of plan profiles following spreading, strike-off and compaction operations. Forms may have a removable spacer of ½ in. to ¾ in. (13 mm to 19 mm) thickness placed above the depth of pavement. The spacers shall be removed following

placement and vibratory strike-off to allow roller compaction. (Removable spacers may not be necessary if other means of strike-off and consolidation are used, such as a hydraulically actuated pipe roller screed.)

b. The Contractor will be restricted to pavement placement widths of a maximum of 20 ft (6.1 m) [*Note: Parking stall area is typically 19 feet (5.8 m) wide.*], unless the Contractor can demonstrate competence to provide pavement placement widths greater than the maximum specified to the satisfaction of the Architect/Engineer. Large scale mechanized placement of pervious concrete with slipform concrete paving machines, laser screeds or asphalt paving machines may preclude use of fixed forms.

3. Mixing and Hauling:
   a. Production: Pervious concrete shall be manufactured and delivered in accordance with ASTM C 94.
   b. Mixing: Mixtures shall be produced in central mixers or in transit (truck) mixers. When concrete is delivered in agitating or non-agitating units, the concrete shall be mixed in the central mixer for a minimum of 1.0 minute or until a homogenous mix is achieved. Concrete mixed in transit mixers shall be mixed at the speed designated as mixing speed by the manufacturer for 75 – 100 revolutions.
   c. Transportation: The pervious concrete mixture may be transported or mixed on site and discharge of individual loads shall be completed within one (1) hour of the introduction of mix water to the cement. Delivery times may be extended to 90 minutes when a hydration stabilizer is used.
   d. Discharge: Each truckload shall be visually inspected for consistency of concrete mixture. Water addition shall be permitted at the point of discharge to obtain the required mix consistency, provided a measurable quantity is discharged, and provided no more than half of the batch amount has been discharged. A minimum of 30 revolutions at the manufacturer's designated mixing speed shall be counted following the addition of any water to the mix, prior to further discharge. Discharge shall be a continuous operation and shall be completed as quickly as possible. Concrete shall be deposited as close to its final position as practical and such that discharged concrete is incorporated into previously placed plastic concrete. If consolidation occurs during concrete discharge, placement shall be halted and wet concrete removed (this may happen towards the end of some loads).
4. Placing and Finishing:
   a. Prior to placing concrete, the surface of the aggregate detention layer (or recharge bed) shall be soaked and in a wet condition at time of placement. Failure to moisten the aggregate surface will result in a reduction in strength of the pavement.
   b. Concrete may be deposited into the forms by mixer truck chute or buggy.
   c. Unless otherwise permitted, the Contractor shall utilize a mechanical vibratory screed to strike off the concrete ½ in. to ¾ in. (13 mm to 19 mm) above final height, utilizing the form spacers described in Formwork. An alternative method to strike off and compact the concrete is to use a hydraulically actuated pipe roller screed as described under 1.04 Special Equipment. If approved by the Architect/Engineer in writing, the Contractor may place the pervious concrete with either slip form or vibratory form riding equipment with a following compactive unit that will provide a minimum of 10 psi (69 kPa) vertical force to the concrete. Similarly, strike off by hand straightedge may be permitted for sidewalks and other small areas followed by compaction.
   d. Care must be taken to prevent closing the void structure of pervious concrete. After mechanical or other approved strike-off and compaction operation, no other finishing operation will be allowed. Internal vibration shall not be permitted. If vibration, internal or

surface applied, is used, it shall be shut off immediately when forward progress is halted for any reason.

e. Placed concrete shall not be disturbed while in the plastic state. Low spots after the screeding operation shall be over-filled for surface repair and either tamped to desired elevation with hand tampers or passing the screed a second time to correct the elevation.
f. Following strike-off, remove spacers and compact the concrete to the form level, utilizing a steel roller, a plate compactor on plywood or other method approved by the Architect/Engineer. Longitudinal rolling shall be followed immediately by cross rolling and joint rolling (if specified). Care shall be taken during compaction that sufficient compactive force is achieved without excessively working the concrete surface that might result in sealing off the surface porosity. Rollers may require cleaning and treatment to prevent aggregate pick-up during rolling operations.
g. Hand tampers and an edging tool with ¼ in. (6 mm) radius shall be used to compact the concrete along the slab edges immediately adjacent to the forms. After compaction, inspection and surface repair, no further finishing shall be performed on the concrete. Surface curing shall begin immediately.
h. The pervious concrete pavement shall be compacted to the required cross-section and shall not deviate more than +/- 3/8 in. in 10 ft (+/- 9 mm in 3 m) from profile grade.

5. Jointing
   a. Joints in pervious pavements can be precluded at the option of the owner, who may, instead, choose to accept or prefer the appearance of random cracking.
   b. Although longer joint spacings may control cracking, for conservative design, contraction (control) joints shall be installed at regular intervals not to exceed 20 ft (6.1 m), and slab length shall not exceed 1.25 times the width of the slab. Transverse contraction joints shall be installed at ¼ the depth of the thickness of the pavement. These joints can be installed in the plastic concrete or saw cut after the concrete has hardened; in either case, careful attention is necessary to prevent raveling.
   c. Jointing plastic concrete: Joints installed in the plastic concrete may be constructed utilizing a small rolling groover as described in the Special Equipment section of this guide specification. When this option is used it shall be performed immediately after roller compaction with one single pass and prior to curing. Note: Improper use of the rolling groover may cause "de-consolidation" of material within a 2-in. band along either side of the groove joint, and result in raveling under traffic. Rollers may require cleaning and treatment to prevent aggregate pick-up during rolling operations.
   d. Jointing hardened concrete: Saw-cuts shall be made as soon as the pavement has hardened sufficiently to prevent raveling and uncontrolled cracking. [Note: jointing of hardened concrete has successfully occurred after the seven day minimum curing period with minimal to no uncontrolled cracks.] Early entry sawing occurs later with pervious concrete than with conventional concrete. For either method, the curing cover shall be temporarily removed and the surface kept misted to prevent moisture loss during sawing. Sawdust or slurry shall be promptly removed to protect the pervious concrete pores. After sawing, the curing cover shall be securely replaced for the remainder of the curing cycle.
   e. Transverse construction joints: Transverse construction joints shall be installed whenever placing is suspended for 30 minutes or whenever concrete is no longer workable.
   f. Isolation joints: Isolation joints shall be used when abutting fixed vertical structures such as light pole bases, building foundations, etc.
   g. Edging, using a tool with ¼ in. (6 mm) radius, and additional compaction with hand tamping tools shall be performed along all form lines and along all isolation joints and construction joints to reduce potential for raveling under traffic.

6. Curing:
    a. Curing procedures shall begin immediately, no later than 10 minutes, from the time the pervious concrete is discharged from the truck. Placing, finishing and tooled jointing and edging must be completed within the10-minute window from discharge. The pavement surface shall be covered with a minimum of 6 mil thick clear polyethylene sheet or other approved covering material. Prior to covering, an evaporative reducer shall be sprayed above the surface when required due to ambient conditions (high temperature, high wind, and low humidity). The cover shall overlap all exposed edges and shall be secured (without using dirt or stone) to prevent dislocation due to winds or adjacent traffic conditions. For additional guidance on hot weather concreting, see ACI 305, and for cold weather concreting see ACI 306.
    b. Immediately after screeding, the surface shall be kept moist and evaporation prevented using a spray applied curing compound and/or evaporation retarder immediately after screeding. Note: The low water/cementitious ratio and high amount of exposed surface of pervious concrete makes it especially susceptible to drying out. Immediately after each transverse jointing the polyethylene sheet curing shall be applied then cross rolling shall be performed.
    c. The curing cover shall remain securely in place for a minimum of 7 days, uninterrupted. No vehicular traffic shall be permitted on the pavement until curing is complete (7 days) and no truck traffic shall be permitted for at least 14 days. Pedestrian traffic may be permitted on the curing concrete after 24 hours. The Architect/Engineer may permit earlier traffic opening times.

7. Sealing –When pervious concrete is produced with an integral color pigment, a UV resistant, non-yellowing acrylic based sealer per ASTM C 309 shall be lightly broadcast onto the cured pavement surface to brighten and highlight the color pigment without clogging the surface pores of the pervious matrix and disrupting its permeability. Some surface preparation may have to be conducted to prepare the sealer. Subsequent applications of the sealer shall be a part of the maintenance plan and not included in this contract.

8. Quality Control - Concrete:
    a. The Architect/Engineer shall employ a testing laboratory that conforms to the requirements of ASTM E329 and ASTM C1077. All personnel engaged in concrete testing shall be certified by the American Concrete Institute as ACI Concrete Field Technicians or equivalent.
    b. Traditional concrete testing procedures for strength and slump control are not applicable to this type of pavement material. Procedures to be used per this guide specification include: ASTM C 172, ASTM C 29, ASTM C 42, ASTM C 1688, and ASTM C 1754.
    c. Concrete tests shall be performed for each 50 yd^3 (38 m^3) or fraction thereof with a minimum of one set of tests for each day's placement.
    d. Sampling - Plastic concrete shall be sampled in accordance with ASTM C 172.
    e. Density (unit weight) – Density (unit weight) of the fresh concrete shall be measured in accordance with ASTM C 1688. The density (unit weight) of the delivered concrete shall be +/- 5 lb/ft^3 (80 kg/m^3) of the submitted fresh density (unit weight).
    f. When required by the Architect/Engineer, after a minimum of seven (7) days, hardened concrete shall be tested at a rate of one set of three cores per 50 yd^3 (38 m^3) of concrete placed on one day or fraction thereof. Select core locations per ASTM D 3665, obtain hardened 4 inch (100 mm) diameter concrete cores in accordance with ASTM C 42 and determine individual core thicknesses in accordance with ASTM C 1542. Cores shall be taken at minimum 2 ft (0.6 m) away from the edge of placement to ensure a representative sample.

g. Thickness – Untrimmed hardened core samples shall be used to determine placement thickness. The average length of three cores shall not be less than 3/8 in. (10 mm) and not greater than 1.5 in. (38 mm) of specified pavement thickness. Length of any individual core shall not be less than 3/4 in. (19 mm) of specified pavement thickness.

h. Core density (unit weight) - The average hardened density (unit weight) of cores trimmed from a lot and tested in the saturated condition, per ASTM C 1754 shall be +/- 5 % of the approved hardened density from the test panels.

9. Basis of Payment
   Pervious concrete pavement shall be paid for based on the square yards or square feet (square meters) of in-place product including materials and labor, thickness, and void content.
10. Performance and Inspection/Maintenance
    Excessive raveling – At or before 28 days after placement, any areas of excessive surface raveling, as determined by the Architect/Engineer, shall be removed and replaced or repaired by the Contractor, [optional language – a) at the unit price established in the contract; or b) at no additional cost to the project].

    Surface drainage – At or before 28 days after placement either the average infiltration rate of multiple locations or the infiltration rate of a determined localized area of the in-place pervious concrete shall be determined per ASTM C 1701. Any areas of insufficient surface porosity, as determined by the Architect/Engineer, shall be removed and replaced by the Contractor, [optional language – a) at the unit price established in the contract; or b) at no additional cost to the project].

    Inspection/Maintenance – At or before 28 days after placement, the contractor shall submit to the Architect/Engineer a written inspection/maintenance plan to prevent the clogging of the pervious concrete pavement. The plan shall include periodic testing of the infiltration rate per ASTM C1701 and methods to restore porosity if the rate drops below 75% of the original determined rate. Acceptable methods to restore levels of porosity are either to vacuum or vacuum with simultaneous power wash the pervious concrete sections. Fee for preparation of the inspection/maintenance plan shall be [optional language – a) at the unit price established in the contract; or b) at no additional cost to the project].

END OF SECTION