# Specifiers Guide to
# Pervious Concrete Pavements
# in the Greater Kansas City Area v1.4.17

The Concrete Promotional Group
of Greater Kansas City

Missouri/Kansas Chapter of the
American Concrete Pavement Association

Provision:

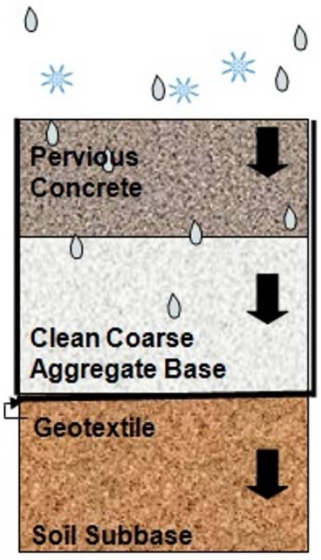
The Concrete Promotional Group and the MO/KS ACPA have prepared this document as a guide only. The information within the document is based on the best information and judgments available at the time of publication. The advancements in pervious concrete research and experiences continue to change how pervious concrete is placed and how mix designs are developed. Materials may be subject to change. In no event will the members of either trade association be liable for any direct, indirect, punitive, incidental, special or consequential damages. Any person or bodies of persons utilizing all or parts of the following information assumes all risks in connection therewith.

## Forward

This guide has been assembled for specifiers who consider pervious concrete for stormwater mitigation. It takes into consideration the local climate (freeze/thaw) and clay soils typical of the Kansas City Metro region, as well as local resources/materials.

The information found within this document is meant to facilitate the design and installation of pervious concrete pavement systems for stormwater mitigation. The EPA Phase II, NPDES stormwater mandates require post-development runoff to be equal to or less than pre-development runoff. Pervious concrete pavement filters, cools and detains (temporary storage) stormwater, while also serving as a parking lot, sidewalk, or pavement. Pervious concrete becomes a multipurpose product, fulfilling stormwater requirements while reducing site footprint and providing a productive pavement surface. Pervious concrete pavement is a recognized green building construction material. For those seeking USGBC LEED® certification or other green building systems, pervious concrete can aid in achieving points in these categories: Reduced Site Disturbance: Development Footprint, Stormwater Management: Rate & Quantity, Landscape & Exterior Design to Reduce Heat Islands, Improved Energy Efficiency to Adjacent Buildings, Regional Materials, possibly Recycled Content and other Innovative Credits.

The pervious concrete pavement systems consist of a surface layer of specially designed concrete consisting of 20% to 25% voids to allow rainwater to rapidly flow through the pavement. This layer sits on a subbase of clean coarse aggregate ~40% voids) to act as temporary storage for rainwater. (Other parts of the world with sandy soils may not need this storage layer, but because of the clay soils in the Kansas City area it is mandatory in this market.) The last part of the system consists of a filter fabric placed under the aggregate storage layer and on top of the soil subgrade. This filter fabric shall also wrap up the sides of the subbase and pervious layers from infiltration of surrounding soils or fines which can migrate into and "clog" up the system. Refer to the diagram below for a visual understanding of the description.




The Concrete Promotional Group of Greater Kansas City (CPG) in conjunction with the MO/KS Chapter of the American Concrete Pavement Association (MO/KS ACPA) provides Pervious Concrete Pavement Certification in Kansas City. It is mandatory for the Concrete Contractor placing the pervious concrete as well as the Ready Mixed Concrete Supplier to be Pervious Concrete Certified. The National Ready Mixed Concrete Association (NRMCA) also offers a Pervious Concrete Contractor Certification. The programs are similar and both are equally acceptable. The CPG & MO/KS ACPA version not only has a written exam (must pass 80% or better), but also has a field placement exam. The certification is open and recommended to all parties involved in the pervious construction process including: engineers, architects, landscape architects, stormwater engineers, general contractors, inspectors, field testing personnel, etc.

Actual project conditions may require modifications or additions to this guide. Specific site conditions, constructability issues, weather conditions, code regulations all vary by project. Refer to Pervious Handbook on the CPG website as a companion piece for additional information.

**Notable Updates to the Specifiers Guide as of 2017**

Pervious concrete has now been used in significant quantities in the United States since the early 2000s. Originally the design and construction guidance was developed out of experiences in climates and markets in warmer and more humid locations than Kansas City. Consequently, certain practices common in those locations do not produce consistently durable pervious concrete and have been removed from this guide. The most notable and significant changes are:

- Water reducing admixtures used in pervious concrete mixture should be a polycarboxylate. Polycarboxylate admixtures are more effective and durable than older water reducer types. For broad application polycarboxylate water reducing agents, the dosage rate should be adjusted to achieve high-range reduction.
- Hydration stabilizing admixtures (not retarders) are required to maintain sufficient workability. A dosage rate chart has been included to allow adjusting dosage for air temperature, humidity, and concrete haul time.
- Large aggregates produce an overly rough texture which is not appealing for an owner's perspective. The maximum recommended aggregate size is now 3/8 inch.
- Joints are installed in concrete to control random cracking. However, joint durability in pervious concrete is especially problematic. Generally sawn joints have performed better than formed joints, but pose issues of plastic handling and slurry cleaning. Since pervious concrete already possess a much different texture than conventional concrete, random cracks are much less of a visual issue. In attempt to reduce problems related to joints in pervious concrete, joints are no longer required. A sufficient dosage of fibers is required to help control random cracking.
- Ground granulated blast furnace slag, also known as slag cement or just slag, is not recommended in pervious concrete in other areas of the U.S. The concern is that concrete containing slag appears to be more susceptible to deicer damage and to react adversely with the hydration stabilizer. We are hesitant to use slag and advise to proceed with caution. We are open to ongoing research and keeping an eye on slag use in pervious.
- Ordering and delivery of pervious concrete should have a 4 yard minimum and an 6 yard maximum for dry batch plants, and an 8 yard maximum for wet batch plants. 6 yard batches are the norm.

## SECTION 1 – GENERAL

### 1.1 Scope

This guide addresses the equipment, materials, and processes necessary for pervious concrete pavement construction in the Greater Kansas City Area. It includes preparation of subgrade for temporary detention of stormwater. It is to be used in conformance with job specific plans, specifications and other contract documents for parking lots, sidewalks, paths, playground underlayment, driveways, and other pedestrian areas.

### 1.2 References

A. American Concrete Institute (www.concrete.org)

| | |
|---|---|
| ACI 301 | Specification for Structural Concrete |
| ACI 305 | Hot Weather Concreting |
| ACI 306 | Cold Weather Concreting |
| ACI 522R-10 | Report on Pervious Concrete (reissued 2011) |
| ACI 522.1-13 | Specification for Pervious Concrete Pavement |

B. American Society for Testing & Materials (www.ASTM.org)

| | |
|---|---|
| ASTM C29 | Test for Bulk Density (Unit Weight) & Voids in Aggregate |
| ASTM C33 | Specification for Concrete Aggregates |
| ASTM C42 | Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete |
| ASTM C94 | Specification for Ready-Mixed Concrete |
| ASTM C138 | Test Method for Density (Unit Weight), Yield and Air Content (Gravimetric) of Concrete |
| ASTM C140 | Test Methods for Sampling and Testing Masonry Units and Related Units |
| ASTM C150 | Specifications for Portland Cement |
| ASTM C171 | Standard Sheet Materials used for Curing Concrete |
| ASTM C172 | Practice for Sampling Freshly Mixed Concrete |
| ASTM C260 | Specification for Air-Entraining Admixtures for Concrete |
| ASTM C494 | Specification for Chemical Admixtures for Concrete |
| ASTM C595 | Specification for Blended Hydraulic Cements |
| ASTM C618 | Specification for Coal Fly Ash |
| ASTM C979 | Specification for Pigments for Integrally Colored Concrete |
| ASTM C989 | Specification for Ground Granulated Blast Furnace Slag use in Concrete and Mortars |
| ASTM D994 | Specification for Preformed Expansion Joint Filler for Concrete |
| ASTM C1017 | Specification for Chemical Admixtures for Use in Producing Flowing Concrete |
| ASTM C1077 | Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation |
| ASTM C1116 | Specification for Fiber-Reinforced Concrete |
| ASTM C1240 | Specification for Silica Fume in Cementitious Mixtures |
| ASTM D1751 | Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types) |

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|---|---|
| ASTM D1752 | Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction |
| ASTM C1761 | Specification for Lightweight Aggregates for Internal Curing of Concrete |
| ASTM D448 | Classification for Sizes of Aggregate for Road & Bridge Construction |
| ASTM D2434 | Test Method for Permeability of Granular Soils (Constant Heard) |
| ASTM D3385 | Test Method for Infiltration Rate of Soils in Field Using Double Ring Infiltrometer |
| ASTM E 329 | Specification for Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction |

C. Pervious Concrete Specific Standards

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|---|---|
| ACI 522.1-13 | Specification for Pervious Concrete Pavement |
| ASTM C1688 | Test Method for Designed Weight and Voids Content for Pervious Concrete |
| ASTM C1701 | Standard Test Method for Infiltration Rate of In-Place Pervious Concrete |
| ASTM C1747 | Standard Test Method for Determining Potential Resistance to Degradation of Pervious Concrete by Impact or Abrasion |
| ASTM C1754 | Standard Test Method for Density & Void Content of Hardened Pervious Concrete |

D. National Ready Mixed Concrete Association (www.nrmca.org)
NRMCA Pervious Concrete Contractor Certification

E. Portland Cement Association (www.cement.org)

F. The American Concrete Pavement Association (www.acpa.org)

G. The Concrete Promotional Group of Greater Kansas City Pervious Concrete Certification (www.concretepromotion.com)

H. MO/KS Chapter American Concrete Pavement Association (www.moksacpa.com)

I. Iowa State University Pervious Concrete Research (www.iastate.edu) (www.cptechcenter.org)

J. University of Missouri, Kansas City, MO, Dr. John Kevern, Pervious Concrete Researcher (www.UMKC.edu)

**1.3 Quality Assurance**

A. A mandatory Pre-Bid Meeting shall be held with prospective bidders to include contractors, producers and specifiers where the pervious concrete pavement construction process will be described. Have a copy of the specification to be used on the job for reference and someone who understands it present.

B. Qualify bidders, prior to submitting the bid the contractor and ready mixed supplier placing the pervious concrete will show proof of current Pervious Certification (either CPG or NRMCA certification or equal). The person(s) holding the certification shall be on the jobsite during the entire pervious concrete prep and placement. This person(s) shall oversee the placement crew and shall review resume of past pervious experience and projects.

C. The inspectors for the project shall possess a current Pervious Concrete Certification Technician Certificate (or NRMCA Pervious Technician Certificate or equal).

D. At least 80% of the contractor crew placing pervious concrete shall be present and participatory in the test panel placement Section 1.7.

E. Hold a Pre-Construction Conference refer to Section 1.9.

F. Build Mock Up in accordance with the specification refer to Section 1.7

G. Placement Day refer to Section 3.1B.

H. Curing is critical to the success of Pervious, there are several curing scenarios, see Section 3.1.4.h.

I. Post Curing Period, Testing ASTM C1754, 3 cores for every 5,000 sf for hardened density, and ASTM C1701, 3 tests for every 5,000 sf, for in-place infiltration results, Section 3.2.

J. Testing performed as directed, refer to Section 3.2.

**1.4 Qualification of Laboratories**

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 Kansas or Missouri as appropriate for the job and meet the requirements of ASTM C1077. They shall have a minimum of five years of professional engineering experience in inspection and testing of concrete construction. The field technician shall have at a minimum the ACI Field Testing Technician Grade I Certification as well as CPG Pervious Concrete Technician Certification or equal.

**1.5 Equipment**

A. Placement shall be performed with a Roller Screed properly weighted with water or sand in the roller and using a Pervious Pan Skip Float is encouraged (Alternative placement techniques, refer to 3.4.d).

B. Cross Rollers shall be used behind the roller screed to aid in rolling out the ridges left by the roller screed and for final compaction.

C. Tampers shall be used on the edges against the forms to aid in better compaction where more wear and tear occurs and where consolidation is more difficult. These are typically 8” x 8” steel plates attached to a 52” handle.

D. Minimum of two working spray cans for the cure to be sprayed from each side of the paving process. Follow the dosage rate instructed by the manufacturer for pervious concrete pavement.

E. When using curb and gutter or previously paved section as a “form”, use some type of protective sheeting/flashing on the concrete surface and under the screed. This protects the roller screed and the previously paved section from damage.
F. Water source, hose and sprayer on site for filling the screed and wetting the subbase aggregate just prior to the pervious concrete placement. (Keeps the subbase aggregate from drawing water from the freshly placed pervious concrete).
G. Appropriate hand tools, such as squared shovels and come-alongs, for placing the pervious as it is deposited from the concrete truck’s chute or belt placement.
H. “Heavyweight” poly sheeting meeting ASTM C171 shall be used for pavement curing. Plastic should be pre-rolled and set, so as to quickly and efficiently, be available to immediately roll over the freshly placed pavement. Poly sheeting should be cut minimally 2 feet wider than the forms width.
I. When using internal curing methods, poly sheeting shall also be needed (Temperature, wind speed and humidity all can contribute to moisture loss at the surface. The sheeting is to hold in moisture during weather conditions.)
J. Anchors to properly hold down the poly sheeting to prevent the sheeting from blowing off or allowing air to billow under the sheeting. Wood 2 x 4’s (or equivalent) stretched along each side to continuously hold down the plastic with sand bags or equivalent every 5 to 6 feet. If wood forms are used the plastic can be stapled along the outside edge of the forms to keep the plastic down with sandbags added for security.
K. Pre-plan placement and pre-place the anchors along the paving operation for quick access.
L. Pervious concrete is NOT pumpable, most placements require belt placement.

**1.6 Submittals: Administrative Requirements for Submittal Procedure**

A. Prior to commencement of work, the contractor shall submit the following:
   1. Proposed concrete mixture submittals should include design in-place unit weight, ASTM C1688 fresh unit weight, and designed or desired ASTM C1701 values, all material weights, volumes, and water/cementitious ratio.
   2. Aggregate type, source, and grading per ASTM C33 for Pervious Concrete.
   3. Cement, supplementary cementitious materials and chemical admixture manufacturer certifications all meeting the appropriate ASTM requirements.
   4. Fibers shall conform to ASTM C1116.
   5. In-place test results from previous work from same contractor & ready mix team completed in the last 24 months, to include density, void content, mix design proportions, thickness, and void content of cores extracted from the pervious pavement.
B. Proposed aggregate for use in stormwater storage or detention layer: aggregate type, source, grading and void content (percent porosity).
C. For hot weather placement (over 90 degrees for 7 days following placement) or cold weather (40 degrees or lower during the next 7 days following placement) submit a curing and procedural plan to monitor/protect the concrete.
D. Personnel qualifications: Evidence of qualifications listed under Quality Assurance Section 1.3 of this document.

**1.7 Test Panels**

Prior to construction, test panels shall be constructed in accordance with the plans and specifications. A test panel takes a minimum for 7 days to cure before it is reviewed for approval by the owner/specifier. A panel that fails would indicate another test panel placement until one is approved.

A. The test panel will be constructed in accordance with the plans and specifications. The test area will be a minimum of 4 cubic yards or 10' X 20' area, as determined by the specifier at the designed depth. The panel shall be installed, consolidated, jointed and cured using the materials, equipment and personnel proposed for the project. The test panels are to demonstrate to the specifier that in-place unit weights can be achieved, acceptable permeability can be achieved and satisfactory pavement can be installed at the site location.

B. The test panel can be constructed on-site in an area for demolition after test approval or in a predetermined area that may be saved and used (for example a pad under a picnic table) or with prior approval in a small part of the actual project. If the test proves to be unsatisfactory by the specifier it will be removed and replaced until accepted. If the actual site is too small or limiting the specifier and contractor shall come to an agreement for an alternative test site.

C. Test panels' 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 site or other test site.

D. Quality: Test panels shall have acceptable surface finish, thickness, porosity and curing procedures and shall comply with the testing and acceptable standards listed in the quality control section of this document.
   1. The ASTM C1688 test will establish the target fresh unit weight, to use in the field for acceptance at the actual placement. The acceptance level is +/- 3 pcf from this established ASTM 1688 weight.
   2. The ASTM C1701 test will establish infiltration rate of in-place pervious concrete after the 7-day curing period (Test a minimum of 3 locations within the pavement).
   3. The ASTM C1754 test will establish Density & Void Content of Hardened Pervious Concrete (coring in a minimum of 3 locations).
   4. The ASTM C1747 will determine the potential raveling made by impact or abrasion.

E. Satisfactory performance of the test panels shall be determined by:
   1. Organized construction team with all the proper equipment at hand and used on the test pour, consolidating the surface to a satisfactory thickness and smoothness.
   2. Use ASTM C1754 to establish the in-place density and void content. Hardened unit weight to be within +/- 5% of the design.
   3. An average infiltration value of 400 in./hr. is desirable for sites not accepting additional contributing run-on with no individual value below 250 in./hr nor above 1,000 in./hr, ASTM C1701.

**1.8 Project Conditions: Weather Limitations**

A. The Contractor shall not place pervious concrete pavement when the ambient temperature is predicted by the National Weather Service Point Forecast for the jobsite to be 40°F (4.4°C) or lower during the seven days following placement, unless otherwise permitted in writing by the Architect/Engineer.

B. The Contractor shall not place pervious concrete pavement when the ambient temperature is predicted by the National Weather Service Point Forecast for the jobsite to rise above 90°F (32.2°C) during the seven days following placement, unless otherwise permitted in writing by the Architect/Engineer.

C. Pervious concrete pavement shall not be placed on frozen subgrade.

D. Heated water typically used by ready mix producers to mitigate cold weather concreting may **not** be used for batching pervious concrete.

**1.9 Pre-paving Conference**

A. A pre-paving conference with the specifier, concrete contractor supervisor (pervious concrete certified), general contractor, ready mixed supplier (pervious concrete certified) and inspection party shall be held at least one week prior to pervious pavement.

B. A review of the completed test panel placement. Make available the ASTM C1688 unit weight, ASTM C1701, ASTM C1754 and ASTM C1701 data results.

C. Review the Pre-Construction Conference Checklist in the back of this document.

**SECTION 2 – MATERIALS**

**2.1 Filter Fabric**

The filter layer shall consist of a minimum 4 oz. non-woven geotextile fabric.

**2.2 Coarse Aggregate for Storage Layer**

This layer shall be a minimum of 12 inches (sidewalks will vary) depending on the design parameters. The material shall conform to ASTM C33 standards and be capable of having minimum voids of 38% by weight measured in accordance with ASTM Standard C29.

2.3 **Curing and Sealing Materials**

A. Polyethylene sheeting – The primary method of curing pervious concrete shall be the placement of a waterproof covering. This sheeting shall be a classified as heavy duty in accordance with ASTM C171.

B. Soy bean oil (cure), enough to cure the pavement according to the manufacturer recommendation. The soy bean oil is also used on the forms as a bond breaker and to spray the roller screed and other placement equipment/tools. This is construction grade soy bean oil, not a food grade product.

C. Other curing compounds must conform to ASTM C309, to be used as alternate surface cure to the soy bean oil, when using one of the internal curing options below.

D. Internal Curing

   a. Pre-wetted lightweight fine aggregates in accordance to ASTM C1761.

   b. Super absorbent polymer (SAP) material for pervious concrete use, following manufacturer recommendations.

E. Joint Sealants in accordance with ASTM D994, D1751 or D1752, if joints are required. Note this guide discourages use of joints in pervious concrete.

**2.4 Cement**

A. Portland Cement Type I, Type II, or Type I/II shall conform to ASTM C150.
B. Type IP shall conform to ASTM C595.

**2.5 Supplementary Cementitious Materials**

A. Fly ash shall conform to ASTM C618
B. Silica fume in accordance with ASTM C1240
(Note: When fly ash is used, initial set time will be delayed, and long term strength gain is typically increased. When silica fume is used initial set will be accelerated.)
C. Slag (use with caution, pending ongoing research and observation with slag in pervious concrete mix designs) shall conform to ASTM C989.

**2.6 Admixtures**

A. Air-entraining admixtures shall conform to ASTM C260. (Note: There is not a current way to test pervious for air in the plastic state at this time. Normal air testing procedures will not work with pervious concrete.)
    1. Air entraining admixtures shall be used in pervious concrete. Air-entraining admixtures should be used at a dosage rate which produces an acceptable 6% air content in stiff, conventional concrete such as a curb mix. If the pervious concrete mixture contains silica fume, the air-entraining admixture dosage rate should be increased by 50%.
B. Water Reducing Admixtures shall conform to ASTM C494.
    1. Polycarboxylate water reducing admixtures shall be type A, B, D or F, mid-range or high-range versions for broad application products, dose for high-range water reduction.
    2. Hydration stabilizers/extended control admixtures meeting requirements of ASTM C494 Type B Retarding or Type D Water Reducing/Retarding shall be used. This admixture is CRITICAL to the success of the mix design. (The warmer the weather, the more admixture is used. Pervious concrete mixes use more of this chemical than dosage rates for conventional concrete. All pervious concrete projects shall have these products, or equal. They shall be available at the jobsite for re-dosing as needed.) Please refer to the chart below for dosage rates:

**Recommended Hydration Stabilizer Dosage Rates for Pervious Concrete**

Notes:

- Dosage rate is shown as ounces of hydration stabilizer per 100 lbs of cementitious materials (oz/cwt).
- Dosage rates shown are appropriate for mixing times of 0 to 60 minutes.
- If concrete is mixed between 60 and 90 minutes, increase dosage by 12 oz/cwt.
- If concrete is mixed between 90 and 120 minutes, increase dosage by 24 oz/cwt.
- Dosage rates shown are **NOT** appropriate for pervious concrete mixtures containing blast furnace slag. Hydration stabilizer significantly increases setting time when mixtures contain blast furnace slag, making curing especially important. If slag is used several trial mixtures should be performed to evaluate appropriate dosage rates to achieve acceptable (<24 hr) setting time.

| | Humidity | | | |
|---|---|---|---|---|
| **Temperature** | <10% | 10-30% | 30-60% | >60% |
| <50°F | 14 | 12 | 9 | 6 |
| 50°F-72°F | 17 | 15 | 12 | 9 |
| 72°F-90°F | 20 | 19 | 15 | 13 |
| >90°F | 26 | 24 | 20 | 18 |

C. Viscosity modifying admixtures (optional) shall meet the requirements of ASTM C494.
D. Miscellaneous admixtures. Give new admixtures a chance, proprietary admixtures exist which may or may not meet referenced ASTM Standards. These shall be tested prior to the placement to ensure positive outcomes and durability and proven in the test panel process.
E. Fibers shall be used in pervious concrete pavements.
    1. Mono-filament micro fibers shall be polypropylene, cellulose, nylon or polyvinyl alcohol and dosed between 1.0 and 2.0 pcy.
    2. Fibrillated fibers shall be polypropylene and dosed between 1.5 and 3.0 pcy.
    3. Macro fibers shall be polypropylene or nylon and dosed between 3.0 and 5.0 pcy.
    4. Micro and fibrillated fibers are generally used to improve surface durability, raveling resistance, and to prevent over compaction while macro fibers are generally used to control random cracking. A combination of the two is allowable and appropriate to achieve both aims.
    5. Micro and fibrillate fibers should be removed from bags and distributed in 2-3 gallons of water before addition to the mix to prevent balling materials and promoting even distribution.

**2.7 Aggregates for Pervious Concrete**

Aggregate used will have a direct influence on the permeability, surface texture, and the appearance of the pervious concrete slab. It is extremely important that the ready mix supplier monitor and measure the SSD (saturated surface dry) aggregate moisture content when batching pervious concrete. **The water to cement ratio is low in pervious concrete. Changes in aggregate moisture affect the success or failure of the pervious mix design.**

A. Coarse aggregate shall be crushed stone or crushed gravel and shall meet the size and grading requirements as defined in ASTM D448 and shall comply with ASTM C33. Gradation choice shall be limited to sizes ¼" –3/8" unless otherwise approved by the architect/engineer. The specific gravity shall be > 2.5 and the absorption shall be < 2.5% to aid in durability and performance.
B. Fine aggregate for pervious concrete shall meet the size and grading requirements as defined in ASTM D448 and shall comply with ASTM C33. Sand will be included in the total combined aggregate gradation. General limits of 7% sand shall be allowed in the mix.

**2.8 Water -** Water shall comply with ASTM C94.

**2.9 Mix Design – Proportions**

A. The contractor shall furnish to the specifier a proposed mix design with proportions of materials prior to commencement of work in compliance of ASTM C1688 and ASTM 1754. The composition of the proposed concrete mixture shall be submitted to the specifier for review and/or approval and shall comply with the following provisions unless an alternative composition is demonstrated to comply with the project requirements.
B. Generally pervious concrete shall be designed and placed with a water/cement ratio between 0.30 and 0.35.
C. Heated water (typically used by ready mix suppliers in cold weather) shall not be used in the making of pervious concrete by the supplier (see section 1.8 of this document).

**SECTION 3 – EXECUTION**

The specifier shall be notified 24 hours prior to subbase installation and 24 hours prior to pervious concrete pavement installation.

3.1 **Installation**

A. The Stormwater Storage Layer

1. Subgrade Prep –
    a. Conduct an ASTM D3385 test to determine the soil condition. Remediate/scarify to improve infiltration as needed.
    b. Existing subgrade under stormwater detention layer areas shall not be compacted or subject to excessive construction equipment traffic prior to coarse aggregate bed placement and may be scarified to improve infiltration rates.
    c. Cuts necessary to establish proper subgrade level shall not be compacted or be subject to excessive construction equipment traffic prior to coarse aggregate bed placement and may be scarified to improve infiltration rates.
    d. When fill is needed to establish proper subgrade level some compaction may be necessary. Compaction to 92% proctor is sufficient.
    e. Fill and lightly re-grade any areas damaged by erosion, ponding, or traffic compaction before the placing of filter fabric and coarse aggregate.
2. Installation of Filter Fabric and Storage Layer
    a. Upon completion of subgrade preparation, the Architect/Engineer shall be notified and shall inspect at their discretion before the contractor may proceed with stormwater detention layer/installation.
    b. Filter fabric layer and stormwater storage 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 filter fabric at the contractor's expense.
    c. Place geotextile filter fabric in accordance with manufacturer's standards and recommendations. Adjacent strips of filter fabric shall overlap a minimum of 16 in. The filter shall be placed on the floor of the excavation and up the sides, directly over the soil subbase and under the coarse aggregate storage layer. The contractor shall secure fabric at least 2 ft. outside of bed and take steps necessary to prevent any runoff or sediment from entering the storage bed.
    d. Install coarse aggregate in 6 inch maximum lifts. Lightly compact each layer with equipment, keeping equipment movement over storage bed subgrade to a minimum. Install aggregate to grades required on the drawings.
    e. Hay bales or equivalent 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.

B. Pervious Concrete Layer

1. Pavement Thickness:
    a. Pavement shall be placed to the depth specified in the plans.
    Typical parking lot pavement thickness range from 6 inches to 8 inches, sidewalks tend to be 4-5 inches.
2. Formwork:
    a. Form materials are permitted to be of wood, steel, or other material sufficient to support the placement equipment and the pervious concrete, and shall be the full depth of the pavement. Forms shall be of sufficient strength and stability to support mechanical equipment without deformation of plan profiles following spreading, strike-off and compaction operations.
3. Mixing and Hauling:
    a. Production:
    Pervious concrete shall be manufactured and delivered in accordance with ASTM C94.
    b. Mixing:
    Mixtures shall be produced in central mixers or in transit (truck) mixers. Concrete shall be mixed for a minimum time specified according to ACI C94.
    c. Transportation:
    The pervious concrete mixture may be transported to the site and the 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 dosages of hydration stabilizer are increased to maintain the concrete, or by the discretion of the specifier. Typical admixtures used in pervious concrete function effectively for up to 30 minutes. They start to lose effectiveness between 30 and 60 minutes mixing time. **Poor workability can be remediated with re-dosing admixtures at the jobsite at the time of placement.**
    d. Discharge and Adjustments:
    Each truckload shall be visually inspected for consistency of concrete mixture. Water addition to adjust the consistency shall be permitted at the point of discharge. (It is strongly suggested that the hydration stabilizer and/or water reducer be available for re-dose at the jobsite, as they can be a better alternative to adding more water). 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. Concrete shall be deposited as close to its final position as practical and such that discharged concrete is incorporated into previously placed plastic concrete.
4. Placing and Finishing:
    a. The sub-base shall be in a moist condition at time of placement to ensure no reduction in strength of the pavement. The contractor shall spray the aggregate base with water just prior to placing pervious.
    b. Concrete shall be deposited into the forms by mixer truck chute, conveyor or buggy. (Pervious concrete is <u>NOT</u> pumpable.)

c. Use a roller screed as described under 1.5 Special Equipment. Placement shall be done with a roller screed properly weighted with water or sand in the roller. Failure to weigh down the roller screed may result in poor surface quality.

d. The pervious pan skip float (not a pan float for traditional concrete) has been extremely successful in other markets. Using this is encouraged for a flat durable surface. This step should be done after the roller screed and before curing step.



e. If approved by the Architect/Engineer in writing, the contractor may place the pervious concrete with an alternate screed. The contractor must show proper information to substantiate his/her ability to successfully place pervious concrete with an alternate method.

f. Cross rollers shall be used behind the roller screed to aid in rolling out the ridges left by the roller screed and for final compaction. When poly is used for curing, cross rolling is conducted over the poly.

g. Jointing:

    1. Do not joint pervious concrete. If joints are executed, extra steps must be taken to protect the pervious from raveling at the sawn joint. A conventional concrete saw shall be 24 hours after placement or the earliest possible time without raveling the joint and before the pavement cracks on its own. Slurry/dust shall be vacuumed or washed. Saw cuts are ¼ to ⅓ the thickness of the pavement. Seal joints after sawing and curing, per the manufacturer's directions. When sawing pervious concrete, the sheeting may be removed as needed to make the cuts, and then re-secured. Taping the poly closed to finish the curing for a minimum of 7 days.
    2. Isolation joints shall be used when abutting fixed vertical structures such as manholes, light poles, signage poles, etc.
    3. Joints in pervious concrete, when implemented, are spaced similarly to conventional concrete. As a general rule of thumb space joints two times the thickness in feet or 15 feet, whichever is smaller. (Example: A typical 6-inch-thick pervious pavement should have a maximum spacing of 12 feet. Maximum joint spacing for pavements thicker than 7" is 15 ft.).

h. Curing:

    1. Curing procedures shall begin as soon as possible and no later than 5 to 10 minutes behind the screed.
    2. Curing compound shall be sprayed onto the pavement from both sides of the paving operation. (See reference 2.3 Curing Materials).

3. The pavement surface shall be covered with polyethylene sheeting or other approved covering material. The polyethylene sheeting shall be rolled on tubes prior to paving. The polyethylene sheeting rolls over the forms, covering the fresh pavement. There shall be a minimum of 12" overhang on each side of the form, to have enough extra polyethylene sheeting to properly anchor the sides down.
4. The plastic cover section: Any holes, tears, or cuts in the polyethylene sheeting shall be taped or repaired to prevent moisture loss and to prevent air infiltration under the sheeting.
5. Anchors, such as 2 x 4's and sand bags, to properly secure the edges of the pavement shall be placed with extra care. No wind driven billowing plastic is allowable during the entire 7 day cure. If using wood forms, the plastic can be stapled to the outside edge of the form, then 2 x4's placed on the upper outer edge for added continual anchoring and sand bags placed every 5 to 6 feet to hold them in place.
6. The curing cover shall remain securely in place for a minimum of 7 days, uninterrupted.
7. 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.

**3.2 Testing**

ASTM C09.49 and ACI 522 committees are working together to develop standardized testing for pervious concrete. There are four ASTM tests at this printing specifically for pervious concrete.

A. ASTM C1688 Method for Density and Void of Freshly Mixed Pervious Concrete (unit weight).
    1. Fresh unit weight is the primary quality control criteria during placement. The designed unit weight will be provided to the specifier. During the test panel (described in section 1.7) the in-situ unit weight is established by the construction team. The ambient temperature and the moisture condition of the aggregates have a heavy hand in the consistency of the pervious and the unit weights. The ready mixed producer may need to adjust the mix at this time as to achieve a workable mix for the contractor to place and achieve desirable consistency. Acceptance in ASTM C1688 is based on visual acceptance as well as ± 5 pcf from the test panel established fresh unit weight. Local experience has shown that ± 5 pcf is too broad and allows acceptance of inadequate concrete. Test every truck for density-unit weight, ASTM C1688 using parameters of +3 pcf of the unit weight from the accepted test slab.
B. ASTM C1754 Method for Density and Void Content of Hardened Pervious Concrete
    1. Hardened unit weight/voids +/- 5% of the unit weight from the hardened unit weight established at the test panel or mock up. Three cores for every 5, 000 sf.
C. Inverse Slump Flow Test (not an ASTM standard)
    1. Reproduces the discharge of pervious concrete from a ready mixed truck. This is an indicator of the workability at the job site and/or a change in the consistency of the pervious concrete between trucks. The following response is directly applicable to roller

screed type placement where highly workable mixtures are desirable. As a general rule of thumb for pervious concrete workability, manual placement should be very workable, while mechanized placement can be stiffer. Workability requirement for placement other than that using roller screed equipment should be determined during test placements.

2. Fill an inverted slump cone with the plastic pervious concrete without any compacting or rodding. Fill it roughly to the top of the inverted slump cone.
3. With a smooth even motion, lift the slump cone about knee height. If necessary give it a jostle or mild shake to loosen the material and let it begin to flow.
4. If the material flows from the cone it will discharge from the truck and place correctly for the contractor. If the materials stay lodged in the cone then the concrete is too stiff and will be difficult to evacuate the truck; this concrete is likely to have high porosity and low strength, potentially leading to surface raveling and lose of surface durability.
5. Concrete that will not flow through the cone indicates loss of admixture effectiveness. **Site Remediation** for pervious concrete that is too stiff/dry/lost workability: Add 0.5 gallon of water per yard of pervious concrete and mix. Retest. If more remediation is needed add 50% of the original dosage of either the water reducer or the hydration stabilizer, in addition to adding 0.5 gallon of water per cubic yard of pervious concrete and mix. If more trucks are coming, call the ready mix plant to have them adjust the next batch before arriving to the job site.

D. ASTM C1701 Method for Infiltration Rate of In Place Pervious Concrete.
   1. An infiltration ring is temporarily sealed to the surface of a pervious pavement. After pre-wetting the test location, a given mass of water is introduced into the ring and the time for the water to infiltrate the pavement is recorded. The infiltration rate is calculated.
   2. ASTM C1701 may be conducted after a test panel has hardened to establish if the infiltration meets expectations.
   3. ASTM C1701 can be conducted on a pervious pavement at any time to establish level of functionality. Typically, a reduction of 25% triggers maintenance activities.
   4. ASTM C1701 can be done after curing to establish a baseline for future tests.
   5. ASTM C1701 is not a pass/fail test. It's a subjective test, but history has shown us to look for somewhere between 250 to 750 in/hr. with no value above 1,000 in./hr.

E. ASTM 1747 Method for Determining Potential Resistance to Degradation of Pervious Concrete by Impact and Abrasion.
   1. Generally pervious concrete with less than 40% mass loss has good performance in the field. This gives some indication of the pavements likeliness to delaminate or scale or not.
   2. Ready mixed producers are encouraged to use this test on their pervious mix designs, as an indicator to each mix's predisposition to surface degradation and general durability.

### 3.3 Site Acceptance Procedures and Remediation Strategies

The workability and consistency of pervious concrete may be determined for each ready mixed truck to ensure quality construction. Typically, workability is adjusted on-site for the first load and then readjusted during batching for all subsequent loads.

A. Check Batch Ticket: Upon arrival at the jobsite check for the correct mixture and appropriate delivery and mixing time.
B. Determine Consistency: Determine ASTM C1688 unit weight and compare against required values +/-3 pcf. In most situations, poor flow through the inverse slump cone will indicate potential for low unit weight values. Adjusting for workability will improve unit weight.
C. Check Workability: Perform an inverse slump check. If workability remediation is required first add 0.5 gallons of water per cubic yard, mix and retest. If additional workability remediation is required, add up to 50% of the original dosage of water reducer or the hydration stabilizer, mix and retest. If the mix is not acceptable a discussion between the inspector, ready mix and contractor should occur.
D. Adjust subsequent loads: Radio back to the batch personnel and relay water and/or admixture adjustments.

**3.4 Maintenance**

A. WARNING! Other traditional construction processes that normally follow pavement installment include using the parking lot or pavement for a staging area for landscape soils or mulch. Other arrangements will need to be planned for the staging area when utilizing pervious concrete pavements. Fines from the soils or mulch can clog the pervious pavement.
B. Vacuuming and/or Power Washing the pervious pavement are acceptable practices for occasional maintenance. As with all pavements, pervious pavements will occasionally need cleaning. Research and experience teach us that debris typically stay in the top inch of the pavement. Vacuuming tends to better evacuate the dirt, fines and organic material. Power-washing can be harmful if the psi adjustment is too intense. Power washing tends to push materials further down in the pavement. Combination cleaning machines that combine a wet spray and vacuum process have proven to work. Many pervious pavements have been maintained with street cleaners, walk behind vacuums, riding vacuums, etc. How often the pavement needs maintenance differs depending on the surrounding environment. Some projects have established a routine of vacuuming once a year just to be safe and keep the pavement in optimal condition. Others have only cleaned the pervious on an as-needed basis.
C. The General Contractor shall be responsible for making sure soil erosion (rain event, loss of silt fencing, landscaping staging errors, etc.) does not clog the pavement prior to turning the pavement over to the owner. The GC shall perform proper vacuuming/cleaning in this event.
D. Winter Maintenance
    1. Snow Removal. Back dragging with a skid bucket will damage the surface.
    2. Salt/Sand is generally not necessary. Salt may be required in certain ice or seasonal conditions. Sand will reduce permeability. Sanded pavements will require more routine vacuuming for maintenance.

**SECTION 4 – SPECIALTY PERVIOUS CONCRETE (Decorative)**

A. Integral colored pervious concrete can be attained by adding powered color or liquid color to the mix in the batching process in the ready mixed truck or central mix unit. Keep in mind this process needs to be tested and adjusted for each individual job. The water/cement ratio is very low in pervious concrete already. When adding powder color to the mix, it will use up more of the water in the mix. More water may be needed in the decorative pervious mix than in pervious without color.

B. Surface color can be applied to pervious concrete. There are coloring agents that can be applied to the surface. Color can then be sprayed on the surface in the curing stage and reapplied as needed for color intensity or maintenance.

C. Stamping pervious concrete can be done with metal/hard stamping tools. Stamping does leave the pavement open to the environment longer than the 3-5 minutes time limit for curing. An experienced crew would be needed to work quickly and curing attended to as soon as possible.

**SECTION 5 – PERFORMANCE SPECIFICATION FOR PERVIOUS CONCRETE**

As the industry moves forward, prescription specifications are diminishing and performance specification taking the lead. Pervious concrete can adapt to this change.

A. Pervious pavement 20-year design life.

B. Materials: Regionally attainable durable materials.

C. Portland cement Type I/II solely or in combination with other cementitious materials such as fly ash.

D. Mix design and concrete provided by Certified Pervious Ready Mix Supplier.

E. Contractor shall be a Certified Pervious Contractor, with the lead person certified on the job site the entire time pervious is placed.

F. Pervious Concrete section shall be minimum 6” thick for vehicular traffic applications.

G. Aggregate subbase shall be a minimum of 12”. The specifier may have additional aggregate subbase to accommodate the appropriate rain event.

H. Filter fabric shall be installed over soil subbase and up the sides of the pavement to the manufacturers recommended instructions.

I. Test panel to be completed a minimum of one week prior to the paving operation and accepted by the specifier. 80% of the crew used in the paving operation shall be present and participatory in the test panel placement.

J. Jointing is not recommended.

K. Cure for a minimum of 7 days.

L. Testing fresh unit weight concrete to check for in-situ consistency. Unit weight shall be ± 3 pcf of the established unit weight from the accepted test placement, per ASTM C1688.

M. The General Contractor shall be responsible for making sure no soil erosion (rain event, loss of silt fencing, landscaping staging errors, etc.) clogs the pavement prior to turning the pavement over to the owner at the completion of the job. The GC shall perform proper vacuuming/cleaning if this has occurred.

N. The Paving Contractor shall be responsible for turning over a pavement free of raveling and free draining.

**SECTION 6 – Pre-Construction Conference Checklist & Pervious Construction Checklist**

**Pre-Construction Conference Checklist**

The pre-construction conference checklist is to be used as a guide during the pre-construction conference. It is modified from the NRMCA's pre-construction conference checklist.

**Pervious Construction Checklist**

The pervious checklist is used to aid in organization and implementation.

Both checklists follow on the last two pages of this document.

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*Specifiers Guide for Pervious Concrete Pavement with Detention*
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Ohio Ready Mixed Concrete Association (www.OhioConcrete.org)
*Specifiers Guide for Pervious Concrete Pavement with Detention*
Portland Cement Association (www.cement.org)
The Carolinas Ready Mixed Concrete Association (www.crmca.com )
Georgia Concrete and Products Association (www.gaconcrete.org )
California Nevada Cement Promotion Council (www.cncpc.org )
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Nebraska Concrete & Aggregate Association (www.nebrconagg.com)

# Pervious Concrete
## Pre-Construction ✓ Checklist

| ✓ | | |
|---|---|---|
| | Submittals | Contractor Certified Technician, Installer or Craftsman Certified?<br>Ready Mix Certified Technician?<br>Are Internal Curing Options being used on this job?<br>Weight/Density from the Test Panel?<br>Isolation Joints?<br>Access for Concrete Trucks & Conveyor Truck? Any Site Restrictions?<br>Testing Lab Field Technician Pervious Certified?<br>Which tests will be performed? How often? Test Samples?<br>Erosion Control Plan? |
| | Site Work | Subgrade Thickness, Cut or Fill? Scarify or Compaction? Graded?<br>Additional Drainage?<br>Subbase Thickness?<br>Soak Base Prior to Pervious Placement?<br>Onsite Water Source?<br>Forms? Grade?<br>Block Outs?<br>Erosion Control Implemented? |
| | Weather | Weather Forecast?<br>Temperature Day of Placement? < 90 degrees? or > 40 degrees? For next 7 days?<br>Wind in Excess of 15 mph?<br>Humidity?<br>Curing Materials? Sprayers? Poly Sheeting being used? Pre-Rolled?<br>Curing Procedures? Timing?<br>Plenty of Anchors on Hand to Secure Poly?<br>Authority to Cancel and Reschedule Based on Weather/Temperature? |
| | Pre-Placement Confirmation | Pervious Concrete Mix Design Approved?<br>Test Panel Placement & Approval, What is the Field Established Unit Weight?<br>All Equipment & Tools on Hand? Water Source?<br>Proper Size Crew for the Job?<br>Conveyor Belt or Other Placement Type Required, Ordered, Fit on Site?<br>Block Outs for Drainage or Other Structures in Pavement?<br>Isolation joints at manholes, sign post, light posts, etc. |
| | Notes from meeting: | |

# Pervious Concrete Construction Checklist
## for Stormwater Mitigation in Kansas City

- ☐ 1. Use a Pervious Certified Technician, Installer or Craftsman Contractor and a Pervious Certified Technician Ready Mix Producer, Field Tester, & Inspector.
- ☐ 2. Approved Mix Design meeting the Specification.
- ☐ 3. Excavation deep enough to accommodate the designed depth of the Pervious Concrete System (the pervious layer and the base layer).
- ☐ 4. Geotextile filter fabric placed up the sides and over the base of the excavated area.
- ☐ 5. Stable clean rock base (< 1.5 inches) on top of the filter fabric to designed depth.
- ☐ 6. Durable rock, (¼" to 3/8") for the pervious concrete component, > 2.5 sp. gr., < 2.5 absorption.
- ☐ 7. Maximum 7% sand in the concrete matrix and fibers in the mix.
- ☐ 8. ASTM C1688 performed with every new truck ±3 lbs from the Test Panel unit weight.
- ☐ 9. Placed with a roller screed (roller filled with water or sand for weight)/or approved technique, encourage the pervious pan skip float behind the roller screed.
- ☐ 10. Joints are not recommended. If joints are used, pre-mark the locations.
- ☐ 11. Cure 5-10 minutes behind the screed. Spray on cure from both sides of the pavement
- ☐ 12. Cover with poly sheeting & securely anchored at sides and where necessary, as to not blow off in the wind or billow.
- ☐ 13. Pre-roll poly on tubes to roll over freshly placed pervious for efficiency and timing.
- ☐ 14. Cross-roll after screed (and over poly sheeting) for further consolidation and smoothing out ruts potentially left by screed.
- ☐ 15. Cure for a minimum of 7 days.
- ☐ 16. Forms removed after 7 days.
- ☐ 17. Backfill as needed next to concrete, being very careful to not contaminate pervious concrete with the soils.
- ☐ 18. Erosion control plan in place to protect the pavement until landscaping is ESTABLISHED.
- ☐ 19. Provide maintenance information to the owner.
- ☐ 20. ASTM C1754 and ASTM C1701 performed 3 for every 5,000 sf.