

1. General information

1.1 Summary

This work includes specifications for Pervious concrete at the location and to the dimensions shown on the plans, in accordance with the project manual. Intended for use with specific pervious concrete aggregates and mix designs, and applications.

1.2 Scope

This specification provides requirements for the construction of Pervious Concrete.

1.3 Referenced standards

1.3.1 Annual Book of ASTM Standards, American Society for Testing and Materials (ASTM) Standards, Material References.

1.3.1.1 ASTM C 29 “Test for Unit Weight and Voids in Aggregate”

1.3.1.2 ASTM C 150 “Specifications for Portland Cement” (Types I or II only).

1.3.1.3 ASTM C 172 “Sampling fresh concrete”

1.3.1.4 ASTM C 494 “Specification for Chemical Admixtures for Concrete”

1.3.1.5 ASTM C 595 “Specifications for Blended Hydraulic Cements” (Types IP or IS only).

1.3.1.6 ASTM C 1688 “Standard Test for Density and Voids Content of Freshly Mixed Pervious Concrete”

1.3.1.7 ASTM C-1701 “Standard Test Method for Infiltration Rate of In Place Pervious Concrete”

1.3.1.8 ASTM C 1692 “Clean Potable Water”

1.3.2 Maintenance and cleaning which meet the standards found in the BAPC Pervious Concrete Maintenance Manual, dated 2013 or newer.

1.3.3 ACI 306R “Cold Weather Concreting”

1.3.4 ACI 305 “Hot Weather Concreting”

1.4 Definition

1.4.1. Pervious Concrete

1.4.1.1 Pervious concrete contains little or no fines, creating an open matrix allowing water to pass through it. Properly installed and cured, pervious concrete is a strong and durable pavement or hardscape that can be used in any application in place of standard impervious concrete or asphalt.

1.5 Submittals

1.5.1 Bid Submittals— The following items must be submitted with the bid proposal. Proposals without the following submittals shall be rejected.

1.5.1.1 Certificates of Qualifications for Pervious Concrete Craftsman or Installers as discussed in Quality Control Section 1.6.1.1.A.

1.5.1.2 List of 5 reference jobs as discussed in Quality Control Section 1.6.1.1.C

1.5.2 Pre-Installation Submittals—The following items must be submitted no less than four (4) weeks before scheduled installation date.

1.5.2.1 Mix Design

1. Batch weights of all constituents.
2. Portland cement type and brand.
3. Non-Portland cement pozzolan type and source.
4. Admixture type and brand.
5. Aggregate source(s) and gradation(s).
6. Fresh density of the pervious concrete.

1.6 Quality Control

1.6.1 General—Test and inspect concrete materials and operations as work progresses as described in 1.6.2.1 Failure to detect defective work or material early will not prevent rejection if a defect is discovered later, nor shall it constitute final acceptance.

1.6.1.1 Contractor qualification—

A. The National Ready Mixed Concrete Association (NRMCA) provides three levels of certification; Craftsman, Installer, Technician.

B. The Contractor shall employ no less than one National Ready Mixed Concrete Association (NRMCA) certified pervious concrete **Craftsman**, who must be an employee of the Contractor, not a hired consultant, who shall oversee concrete placement, **or** the Contractor shall employ no less than five NRMCA certified Pervious Concrete **Installers**, who shall be on site working as members of each placement crew during all concrete placements. Employees certified at the lower NRMCA certified pervious concrete Technician level do not qualify.

C. For all projects where the total pervious concrete pavement area exceeds 10,000 square feet, at least one (1) NRMCA certified Pervious Concrete Craftsman who is a full-time employee of the installing company is required.

D. Contractor must provide documentation showing five or more successful pervious concrete projects in the last two years totaling more than 50,000 sq. ft. Documentation shall include name and address of project, photographs and contact information for project owner, architect or engineer.

1.6.2 Testing as required by project engineer

1.6.2.1 Fresh Density Test

Obtain a minimum 1 ft³ sample for acceptance tests in accordance with ASTM C172. Perform one density test in accordance with ASTM C1688 during each day's placement Fresh density shall be between +/-5 lb/ft³ of the specified fresh density.

1.6.2.2 Infiltration Test

Surface infiltration shall be tested using ASTM C 1701. One test for every 10,000 sq ft, minimum 3 tests, results should be averaged. Test locations should be at least 15' from each other.

A. Must be tested on clean, level pervious pavement upon completion of the curing period but before acceptance and opening the pavement to traffic.

B. Permeability shall be at least 350 inches per hour, with no test below 100 inches per hour, on average as tested after curing period has ended.

C. If less than four (4) inches of open graded aggregate is used under the pavement the permeability rate will not be valid and the permeability rate shall not be used for criteria for acceptance or rejection of the pavement

1.6.2.3 Hardened density (optional for heavy duty applications)

If specifically required by the project engineer, after seven days curing, a minimum 3 cores should be taken from the test panels, in accordance with ASTM C 42, and measured for thickness and density in accordance with *ASTM C 1754*. These test results should be recorded as a reference for subsequent quality assurance and acceptance testing.

Cores taken from subsequent placements should also be tested in accordance with ASTM C 1754. The resulting measured density should be within plus or minus 5% of the average density of cores from the test panel.

1.6.2.4 Compressive strength testing is not used for pervious concrete.

1.6.3 Testing agencies—Agencies that perform testing services on concrete materials shall meet the requirements of ASTM C1077. Agencies inspecting the Work shall meet the requirements of ASTM E329. Testing agencies performing the testing shall be accepted by Architect/Engineer before performing any Work.

1.6.3.1 Field tests of concrete required in 1.6.2 shall be performed by an individual certified as both an NRMCA Certified Pervious Concrete Technician and an ACI Concrete Field Testing Technician—Grade 1 or equivalent.

1.6.4 Approved Mix Design - Once accepted by the Engineer, the mix design meeting the criteria specified in Section 1.5.2.1 shall become the approved mix design and shall not be modified in any way unless re-submitted and approved by the engineer. Modifications to the approved mix design not approved prior to being placed may be rejected. Admixture and water dosages may be modified as needed to maintain mix properties.

1.7 Field conditions

1.7.1 Protection of Existing Improvements

1.7.1.1 General contractor is responsible for preparing site for work – clearing area, protecting adjacent finished surfaces, materials and previously installed objects or furniture. General contractor shall provide

suitable protection where required before work commences and maintain protection throughout the course of the work.

1.7.1.2 To whatever extent possible, do not damage or disturb existing adjacent vegetation. Installer shall not be responsible for damaged vegetation within the work area. Remove all concrete stains from adjacent exposed surfaces of paving, structures, and grounds. Remove all waste and spillage.

1.7.2 Weather Limitations:

1.7.2.1 Do not place pervious concrete pavement when the ambient temperature is expected to fall below 35°F within 48 hours of placement, or is above 90°F, unless otherwise permitted in writing by the design professional of record. In the case of cold weather installation, surface efflorescence, as well as streaking, or tiger striping, which is a result of the curing membrane, may be significant.

1.7.2.2 Do not place pervious concrete pavement when the wind, heat or humidity does not allow enough time to place, properly joint, compact, edge, finish and cure before the surface dries to the point where it will result in raveling, i.e. loss of wet metallic sheen.

1.8 Acceptance

1.8.1 Reference Panel: If required, acceptance of the reference panel will be based on the criteria for acceptance of pavement per Section 1.8.2

1.8.2 Acceptance of pervious concrete pavement will be based on the following criteria:

- a. Appearance: Each lot of finished pervious concrete will be inspected for appearance by the Engineer. The pervious concrete shall have a consistent surface texture, shall have no more than five (5) percent of the surface area within each panel (joint to joint) clogged/sealed with cement paste or raveled, shall be free of ridges or other surface imperfections, shall have joints that are in the specified location and are constructed per specification, and shall be free of cracks wider than 3/32". Raveling is defined as: the contiguous dislodging of the surface layer(s) of aggregate.
- b. Smoothness: Pervious concrete pavement smoothness shall be checked with a eight-foot straight edge. The surface of the finished pavement shall be uniform to a degree such that no variations greater than 3/4-inch over eight (8) feet are present when tested with an 8-foot straight edge and checked in a direction perpendicular or parallel to the centerline and the pavement's planed surface.
- c. Grade: Pervious concrete shall be true to designed grades plus or minus 3/4" inch. Where abutting existing facilities such as sidewalks, walkways, curbs, driveways or other pavements, the pervious concrete shall be within 1/4 inch of that surface.

- d. Line: Pervious concrete margins shall be true to designed lines plus or minus 1" inch at any point.
- e. Infiltration Rate: The average of all three (3) infiltration tests shall be greater than 350 inches per hour with no single test less than 100 inches per hour.
- f. Pressure wash testing: Before final acceptance the Engineer, may require a pressure wash test of the pervious concrete. Pressure washing shall be provided and completed by using portable washer equipment working at a minimum of 3000 psi at 2.4 gpm. The nozzle shall be a zero-degree nozzle and be held three (3) inches off the concrete surface and moved at a slow but steady rate. The Contractor shall pressure test a min three (3) locations per lot or as determined by the Engineer. Any sections of pervious concrete that breaks up, ravel, or does not infiltrate shall be removed and replaced with acceptable pervious concrete to the nearest joints. The Engineer may reject the concrete if the pressure washing dislodges more than a few individual aggregate particles in each panel. The Contractor shall decide, after placing the pervious concrete, when to perform the quality assurance pressure wash testing for the acceptance.

2. Products

2.1 Fabric

2.1.1 Non-woven geotech fabric, if required for separation, shall be Mirafi 140n or approved equal. If the designer determines geotech fabric is required for strength use, Mirafi FW402 or approved equal with similar flow rate and strength ratings.

2.2 Base

2.2.1 Base shall be composed of an open graded ¾" washed clean crushed rock, #57 stone, or Caltrans Class II Permeable rock maintaining a minimum of 35% void space. Recycled concrete aggregate shall not be used if using a geotechnical fabric.

2.2.2 For installations of more than 6" the section below the upper 3" may be a larger size to provide more stability so long as it meets 2.2.1.

2.3 Forms

2.3.1 Form materials must be durable enough to resist deformation during edge compaction and maintain grade.

2.3.2 Forms shall be clean and free of debris of any kind, rust, and hardened concrete.

2.4 Pervious Concrete

Comply with ASTM C94/C94M and the following requirements:

2.4.1 Aggregates

2.4.1.1. Aggregate shall have a minimum specific gravity of 2.60, a minimum rodded void content of 35% per ASTM C29, and a maximum absorption rate of 3%. Crushed aggregate or gravel shall be permitted.

2.4.1.2. Size of aggregate to be determined by engineer or owner based on locally available materials but in no case shall be larger than 1/2" nominal.

2.4.2 Admixtures

2.4.2.1 Hydration stabilizers are required for use to delay set time. Additional working time provided by hydration stabilizers can be several hours or more and is determined by dosage rate as recommended by manufacturer, and temperature.

2.4.2.2 Super absorbent polymers (SAP) are required to improve workability and curing and eliminate need for water reducers and viscosity modifiers. Use Pervious Enhancer Pro or approved equal.

2.4.2.3 Other admixtures may be used and must comply with ASTM C 494 and approved by the design professional of record.

2.4.3 Supplementary Cementitious Materials

2.4.3.1 SCMs such as fly ash, slag and silica fume are approved for use in pervious concrete. SCM mix proportions shall be included in the mix design.

2.4.3.2 Supplementary cementitious material shall be as specified herein:

- a. Fly Ash: Fly ash shall conform to the requirements of ASTM C618, Class F or C.
- b. Slag Cement: Slag cement shall meet the requirements of ASTM C989, Grade 100 or Grade 120.
- c. Silica Fume: Silica fume shall meet the requirements of ASTM C1240.

2.4.4 Reinforcing Materials

2.4.4.1 The use of Macro-fibers in pervious concrete mixtures increases durability and is permitted when required. Micro-fibers have minimal effect.

2.4.4.2 No reinforcing bars, tie bars or dowels will be used in the installation of pervious concrete.

2.4.4.3. Keyways may be used if pavement is over six inches in thickness.

2.4.5 Pigments

Use pigments or color complying with ASTM C979 if specified in Contract Documents.

2.4.6 Water

Clean potable water shall be used per ASTM C 1692.

2.5 Mix Design

2.5.1 Mix Design Voids:

Mix design voids shall be in the range of 18-21%

2.5.2 Water Cement Ratio

Mix design water-cement ratio minimum shall be 32%

2.6 Cure Materials

2.6.1 Moisture-Retaining Cover:

A minimum of six mil Polyethylene film ASTM C 171 shall be used to cover the fresh pervious concrete.

2.6.2 Evaporation Control

Surface stabilizers and ASTM C309 compliant curing agents are allowed prior to polyethylene cover as long as they are applied in mist form and do not dilute the surface paste.

3. Execution

3.1 Reference Panel

3.1.1 If requested, reference panel requirement may be waived based on contractor experience, if approved by project engineer or owner.

3.1.2 Place reference panels on the project site, on a subgrade and base prepared as specified, using the material and construction requirements for pavement in this Specification. Test panel requirement may be waived based on contractor experience, if approved by project engineer or owner. Notify the Engineer at least three (3) Working Days before installing pervious concrete reference panel.

3.1.3 At a location, as approved by the contracting agency, the proposed contractor shall construct a sample reference panel on-site, using the same design requirements required for the substantial portion of the project. The sample reference panel should be a minimum of 100 sqft at the same thickness as specified for the application and should be installed using the same required tools and qualified personnel required for project installation as found in Section 1.6.1.1. The fresh concrete used in the reference panel shall be tested unit weight as per ASTM-C 1688.

3.1.4 The design professional of record shall approve a site cast sample of the specified pavement before paving begins. The following criteria for the sample shall be used:

3.1.4.1 The surface appearance of the sample must be approved for texture, finish as described in Acceptance section 1.8.2. The finished product must be a reasonable facsimile of the approved sample.

3.1.5.2 Permeability shall be tested using ASTM C 170.

A) Permeability shall be at least 350 inches per hour, with no test below 100 inches per hour, on average, as tested after the initial curing period.

B) If less than 4 inches of specified base rock is installed the ASTM C 1701 permeability test shall not be criteria for acceptance.

3.1.5 Accepted reference panels, in like new condition, may be used in the contract work. Retain and maintain approved reference panels during construction in an undisturbed condition as a standard for judging completed portions of the final installations.

3.1.5 Rejected panels shall be removed at contractor's expense.

3.2 Pre-installation meeting

3.2.1 If required, a pre-paving meeting shall be scheduled at prior to the installation. The following individuals are required to attend:

3.2.1.1 General contractor

3.2.1.2 Pervious concrete installation

3.2.1.3 Site work contractor

3.2.1.4 Project engineer

3.3 Subgrade prep

3.3.1 Contractor shall ensure the subgrade is prepared in accordance with Contract Documents.

3.3.2 Contractor shall ensure that the required pavement thickness is obtained in all locations by verifying subgrade elevation.

3.3.3 Compact subgrade to 90 percent (+/- 2 %, 92% max) of the maximum dry density per standard Proctor test (ASTM D698). Determination of in-place density shall be made using a nuclear gauge per ASTM D6939.

3.3.4 Areas of the subgrade which are over-compacted, as determined by the Geotechnical Engineer, shall be ripped/tilled to a depth of 6 inches (minimum) or as directed by the Geotechnical Engineer and shall be recompact.

Contractor shall locate all utilities within pavement footprint prior to ripping and re-compacting subgrade

3.3.5 Construct subgrade to +/- 3/4 inch of the grades and slopes specified on the Plans.

3.3.6 General contractor shall keep all traffic off the subgrade during construction to the maximum extent practical. Re-grade and re-compact subgrade disturbed or over-compacted by construction traffic, as needed. Compact the material added to obtain final subgrade elevation.

3.4 Base Installation

3.4.0 Construct base to +/- ½ inch of the grades and slopes specified on the Plans.

3.4.1 Prior to installation of base, geotech fabric (if required) must extend to the edge of the base area, or per the design documents, whichever is greater unless otherwise specified by the design professional.

3.4.3 Compact pavement base, in six (6) inch (maximum) lifts, by making a minimum of two passes over the pavement base material with a minimum 5,000 lb. vibratory plate compactor. When installing a two layer base using a larger rock on the bottom, use a minimum ten (10) ton vibratory roller.

Acceptance of the pavement base will be based on Engineer's observation of aggregate movement during final compaction pass.

3.4.4 Contractor shall inspect the in-place open graded base aggregate to:

3.4.3.1 Ensure compliance to the plans and specifications.

3.4.3.2 Verify the base rock is free-draining. If not, do not proceed.

3.4.3.3 Ensure that the required pavement thickness is obtained in all locations by verifying base elevation.

3.4.3.4 Base extends at least three inches beyond edge of slab.

3.5 Setting formwork

3.5.1 Set, align, and brace forms so that the hardened pavement meets the tolerances specified in 3.6. Install forms to allow continuous progress of work. Assemble formwork to permit easy stripping and dismantling without damage to concrete.

3.5.2 The vertical face of previously placed concrete may be used as a form ensuring that the pavement is protected from damage.

3.5.3 Forms shall remain in place and undisturbed throughout the curing period.

3.5.4 Forms may be wood or metal.

3.6 Tolerances

3.6.1 Top of Forms: Not more than 1/2" inch variance from specified elevation.

3.7 Batching & Mixing

3.7.1 Mix Proportions

3.7.1.1 Total cementitious material should be sufficient to result in a design void content of 18-21%.

3.7.1.2 Concrete shall be batched at a minimum of 0.32, after adjusting for aggregate moisture.

3.7.2 Batch and mix in compliance with ASTM C94/C94M

3.7.3 Discharge shall be completed as long as the mix is workable.

3.7.4 Hydration stabilizer can significantly increase working time based on dosage. Installer should be well versed in the use of hydration stabilizer.

3.7.5 Job site water addition at or above the design water cement ratio to maintain proper cement paste consistency and wet metallic sheen on the paste is permitted as long as the additional water does not thin the cement paste to the point where it drains down.

3.8 Delivery

3.8.1 Delivery of materials must be carefully scheduled to minimize trucks waiting for excessive periods of time on job. Pervious concrete that has been in the truck for excessive periods of time and is no longer workable should be rejected. Hydration stabilizer can significantly increase working time based on dosage.

3.8.2 Standard Ready Mix Concrete trucks

3.8.2.1 Standard Ready Mix Concrete trucks can be used for pervious concrete mixes.

3.8.3 Volumetric trucks also known as 'Truck Mounted Mobile Mixers'

3.8.3.1 Volumetric trucks can be used for delivery and mixing of pervious concrete as well.

3.9 Pervious Concrete Placement

3.9.1 Inspection

3.9.1.1 Before placing concrete, inspect and complete formwork installation.

3.9.2 Prior to placement

3.9.2.1 In hot and or dry conditions, prior to placement of pervious concrete, moisten sub-base aggregate to provide a uniform dampened condition at the time concrete is placed. If initial application of water is quickly absorbed apply a second application of water just before installing pervious concrete.

3.9.3 Placement

3.9.3.1 Deposit concrete either directly from the transporting equipment onto the subgrade or sub-base, unless otherwise specified.

3.9.3.2 Do not place concrete on frozen subgrade or sub-base.

3.9.3.3 Finish the pavement to the elevations and thickness specified in Contract Documents and meet the requirements of 3.6.

3.9.4 Edging

3.9.4.1 Edge top surface to a radius of not less than 1.5x the nominal size of the aggregate.

3.9.5 Finishing

3.9.5.1 Compact fresh concrete to stay within the requirement tolerances.

3.9.5.2 Compact pervious concrete to a dense, pervious surface.

3.9.5.3 Tools

- A. Spinning “Roller” screed – A spinning/motorized roller screed is the preferable method of strike off and initial compaction.
- B. Hand Operated Straight Edge -- A hand operated straight edge may be used to place the pervious concrete where the spinning roller screed is not feasible.
- C. Cross roller or motorized float pan should be used to provide secondary compaction and improve surface flatness and texture.
- D. Finishing Tools – Hand floats/trowels and other tools typical to concrete finishing may be used but only if they do not seal the surface.
- E. Asphalt rollers, vibrating truss screeds or plate compactors shall not be used.

3.10 Jointing

- 3.10.1 Pervious concrete is placed in lanes so joint placement is more restrictive than traditional concrete. Joint placement is at the discretion of the installer unless noted in the design documents in which case the designer or engineer shall consult with installer on joint location.
- 3.10.2 When joint placement is not indicated on the Project Drawings, installer shall submit drawings describing proposed jointing.
- 3.10.3 Spacing between contraction joints shall not exceed 34 times the depth of the pavement. The larger horizontal dimension of the slab panel shall not exceed 150% of the smaller dimension.
- 3.10.4 Tool contraction joints to the specified depth and location in fresh concrete immediately after the concrete is compacted.
 - 3.10.4.1 Contraction joint depth shall be a minimum of one fifth the pavement thickness.
- 3.10.5 Saw cut concrete joints may be placed after concrete has hardened sufficiently to prevent aggregate from being dislodged and soon enough to prevent pavement cracking.
- 3.10.6 If saw cuts are performed before the curing period has ended, the slabs shall be kept fully saturated with water while uncovered, and immediately recovered after cutting is completed.

3.11 Concrete curing

- 3.11.1 Proper moisture level is indicated by cement paste with a wet metallic sheen. Loss of surface moisture, as indicated by a loss of wet metallic sheen, results in insufficient curing and raveling. Begin the curing as soon as possible after discharge of material and before excessive loss of surface moisture occurs.
 - 3.11.1.1 Polyethylene Moisture-Retaining Cover:
 - A. Completely cover the pavement surface with a minimum 6 mil thick polyethylene sheet. Cut sheeting to a minimum of a full placement width plus 12” on both sides.

- B. Cover all exposed edges of pavement with polyethylene sheet. Overlap sheet edges by a minimum of 12”.
- C. Secure curing cover material in such a manner as to ensure curing sheet will remain securely in place throughout the duration of the curing period.
- D. Evaporation Control: Water, surface stabilizers and ASTM C309 compliant curing agents are allowed as long as they are applied in mist form and do not excessively dilute the surface paste.

3.11.2 Cure pavement for a **minimum** of 7 uninterrupted days, unless otherwise specified. Mixes with 20% or more SEMs shall be cured a **minimum** of 10 days.

3.11.3 All curing times are based on temperatures at or above 55°F during the curing time. Each day temperatures are lower than 55°F does not count as a curing day. The added time required is to be determined by the design professional of record.

3.12 Concrete protection

3.12.1 Pavement Protection during Construction

3.12.1.1 Pervious concrete pavements shall not be used for staging areas of construction materials or equipment, nor shall any trades dump materials such as dirt, debris, or bark on the pervious concrete.

3.12.1.2 After completion of installation and curing period, General contractor shall protect the pavement surface from abrasion, discoloration, or sediments until completion of any construction or landscaping activity that may expose the pavement to hazards.

3.12.1.3 General contractor shall be responsible to clean, repair and touch-up, or replace when directed, pavement which has been soiled, discolored, or damaged by other trades outside the installer’s control prior to substantial completion.

3.13 Cleaning

3.13.1 Pressure washing or vacuuming or a combination of both may be used as required. Pressure washers are approved for use after 14 days. Pressure washing no higher the 3500 psi with a 20 degree or greater nozzle.

3.14 Maintenance/Cleaning

3.14.1 After completion of installation General Contractor is responsible for protecting and cleaning.

3.14.2 Owner is responsible for all maintenance after project work acceptance.

3.14.3 The contractor must supply the owner with a copy of a Pervious Concrete Maintenance Manual.

3.15 Opening to traffic

3.15.1 The pavement must have cured for at **minimum** 7 uninterrupted days before light vehicle traffic is permitted, 28 days cure for heavy vehicles. The Architect/Engineer must accept the pavement before being opened up to traffic.