



PERVIOUS CONCRETE SPECIFIER'S GUIDELINES

This sample guideline provides suggested wording for the construction of pervious concrete pavements including: materials, preparation, forming, placing, finishing, jointing, curing, and quality control. It also provides guidelines for testing, evaluation, and acceptance of pervious concrete pavement systems.



FOREWORD

Stormwater runoff occurs when rain falls in urban areas. This runoff causes increased pollution in rivers and streams, flash floods and loss of rainwater that could otherwise replenish water tables and aquifers. Pervious concrete has a 15–25% void structure in the hardened concrete. Typically, flow rates of 200 litres of water per minute pass through each square metre of pervious pavement, however flow rates can be substantially higher. This is far more water than is normally generated during most rain storms.

Stormwater runoff can send as much as 90% of pollutants, such as oil and other hydrocarbon liquids found on the surface of traditional parking lots, directly into rivers and streams. By capturing rainfall and allowing it to percolate into the ground, soil chemistry and biology can treat the polluted water naturally. Pervious concrete puts rainwater back in the ground where it belongs. Also, owners that use pervious will spend fewer dollars on the labour, construction, and maintenance of detention ponds, skimmers, pumps, drainage pipes, and other stormwater management systems.

Expensive irrigation systems can also be downsized or eliminated. In reducing runoff from paved areas, pervious concrete reduces the need for separate stormwater retention ponds and allows the use of smaller capacity storm sewers. This allows property owners to develop a larger area of available property at a lower cost.

MESSAGE TO SPECIFIER

This sample pervious concrete guideline document is intended solely for use by professional personnel who are competent to evaluate the significance and limitations of the information provided in this document and who will accept full responsibility for the application of this information. The Ready Mixed Concrete Association of Ontario (RMCAO) disclaims any and all responsibility and liability for the accuracy and application of the information included in this guideline document to the fullest extent permitted by law. Please note that each project will have different circumstances that the owner or consultant must assess due to factors such as geographical area, soil conditions, water table and available local aggregates.

Pervious Concrete Systems

The design of a pervious concrete system primarily consists of the following components:

- **Pervious Concrete Pavement** – This is the top layer of the pervious concrete system that consists of ready mixed concrete with interconnected voids that allow surface water to pass through the pavement to the underlying layers of the system. The minimum typical thickness is 150 mm, however the concrete thickness will be dictated by the loading that the pavement will be exposed to during its service life.
- **Granular Stormwater Storage Layer** – The aggregate base material that is used to temporarily store the rainwater and surface water runoff that impacts the pervious concrete pavement. This layer typically consists of 19 mm clear stone or OPSS Granular “O” material with the thickness of the layer determined by the various site specific conditions (local rainfall amounts, permeability of the subgrade, adjacent surface water runoff, water table height, etc.). For the severe, hard wet freeze thaw conditions that exist in Ontario, the National Ready Mixed Concrete Association

(NRMCA) recommends typical granular thickness of 200–600 mm. This is a critical design element that must be considered in preparing a pervious concrete design.

- **Subgrade Soils** – Since the basic design of the pervious concrete system is to temporarily store the water in granular stormwater storage layer while gradually discharging the water into the native soil, the engineering and hydrogeological properties of the subgrade materials are critical to the overall design of the system. Key components of the initial pervious concrete design are therefore determining the infiltration rate of the subgrade material and the height of the existing water table in this material. Infiltration testing must be performed by a qualified testing laboratory and if the soil conditions do not allow for adequate drainage of the stormwater, then the system must be designed to allow for positive drainage of the water from the granular stormwater storage layer (piping, daylighted aggregate drain, etc.).

DESIGN

The design of a pervious concrete system requires that the Architect/Engineer understand both the structural and hydrological requirements of the pavement system and the advantages and limitations of the proposed construction site.

One of the tools that can be used to assist in the design process is the “[Pervious Concrete Hydrological Design and Resources](#)” CD that is produced by the Portland Cement Association (PCA) and the NRMCA. This resource CD contains a design calculator that models the performance of pervious concrete systems to ensure that they operate appropriately.

The design program allows the user to input the following items:

- Area of the pervious concrete pavement
- Typical rainfall amounts for the 10 year design storm
- Area of adjacent surface that may drain onto the pervious concrete pavement
- Infiltration rate of the natural soil
- Thickness and permeability values of both the pervious concrete and granular stormwater storage layers

The program then determines the maximum water level rise within the granular stormwater storage layer and the draw down time necessary for complete drainage of the granular layer to take place. This valuable design tool can be ordered directly from either the PCA or NRMCA websites.

Final Note:

If you have any questions regarding the content of this document, please contact:

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1. GENERAL PROVISION

1.1 GENERAL DESCRIPTION

The work of this specification includes materials, preparation, forming, placing, finishing, jointing, curing, and quality control of Pervious Concrete Pavement System.

1.2 SCOPE OF WORK

This specification contains guidelines that are to be followed when constructing pervious concrete pavements.

1.3 DEFINITIONS *(referenced from ACI 522.1-08)*

Architect/Engineer—the architect, engineer, architectural firm, or engineering firm issuing Contract Documents or administering the work under contract documents, or both.

Contract documents—a set of documents supplied by the owner to the contractor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

Contractor—the person, firm, or entity under contract for construction of the work.

Early-entry dry-cut saw—a tool designed to produce joints in concrete commencing 1 to 4 hours after finishing and without ravelling the cut edges.

Exposure condition, severe—an environment, normally in cold climate regions, in which concrete may be saturated or in almost continuous contact with moisture before freezing, and where deicing agents are used.

Joint, construction—the surface where two successive placements of concrete meet, across which it may be desirable to achieve bond, and where the first has undergone final set before the next placement.

Joint, contraction—formed, sawed, or tooled groove in a concrete structure to create a weakened plane to regulate the location of cracking resulting from the dimensional change of different parts of the structure.

Joint, isolation—a normally vertical interface allowing relative movement without transferring sufficient tension, compression, or traction forces to negatively affect the performance of a structure or pavement.

Owner—the corporation, association, partnership, individual, public body, or authority for whom the Work is constructed.

Panel—a concrete element that is relatively thin with respect to other dimensions and is bordered by joints or edges.

Pavement, pervious—a pavement comprising material with sufficient continuous voids to allow water to pass from the surface to the underlying layers.

Permitted—accepted or acceptable to the Architect/Engineer, usually pertaining to a request by the contractor, or when specified in contract documents.

Project Drawings—graphic presentation of project requirements.

Project Specification—the written document that details requirements for the work in accordance with service parameters and other specific criteria.

Reference Standards—standardized mandatory language documents of a technical society, organization, or association, including the building codes of local or provincial authorities, which are referenced in the contract documents.

Subbase—a layer in a pavement system between the subgrade and the base course, or between the subgrade and a pervious concrete pavement.

Subgrade—the soil prepared and compacted to support a structure or a pavement system.

Submittal—document or material provided to the Architect/Engineer for review or acceptance.

Work—the entire construction or separately identifiable parts thereof required to be furnished under contract documents.

1.4 REFERENCED STANDARDS

ACI Standards

- ACI 522.1-08 Specification for Pervious Concrete Pavement

ASTM Standards

- ASTM C 979 Standard Specification for Pigments for Integrally Coloured Concrete
- ASTM C1688 Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete
- ASTM D 994 Standard Specification for Preformed Expansion Joint Filler for Concrete (Bituminous Type)
- ASTM D1751 Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
- ASTM D1752 Standard Specification for Preformed Sponge Rubber Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving and Structural Construction
- ASTM D3385 Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer

CSA Standards

- CAN/CSA A23.1-04 Concrete Materials and Methods of Concrete Construction/
CAN/CSA A23.2-04 Methods of Test and Standard Practices for Concrete
- CAN/CSA A283-06 Qualification Code for Concrete Testing Laboratories
- CAN/CSA A3000-08 Cementitious Materials Compendium

RMCAO Technical Bulletins

- [T-035](#) Standard Test Method for Determining Pervious Concrete Plastic Density
- [T-040](#) Test Method for Porosity Measurements of Portland Cement Pervious Concrete

Ontario Building Code (OBC)

- 2006 Ontario Building Code The work shall conform to the requirements of the 2006 Ontario Building Code, and any applicable acts of any authority having jurisdiction over the work.

National Ready Mixed Concrete Association (NRMCA)

- Pervious Concrete Contractor Certification Program

1.5 STANDARDS - PRODUCING ORGANIZAITONS

- **Canadian Standards Association (CSA)**

5060 Spectrum Way, Suite 100
Mississauga, Ontario, Canada L4W 5N6
www.csagroup.org

- **American Concrete Institute (ACI)**

38800 Country Club Drive
Farmington Hills, MI 48331 U.S.A
www.concrete.org

1.6 SUBMITTALS

1.6.1 Contractor shall submit drawings and documentation as required in this specification for acceptance by the Architect/Engineer.

1.6.2 Obtain written acceptance of submittals before using the materials or methods requiring acceptance.

1.6.3 Prior to the start of construction the contractor shall submit and/or demonstrate to the Architect/Engineer the following:

1. Certification demonstrating that at least one member of the contractor's construction team in a supervisory role has obtained the NRMCA Pervious Concrete Contractor Certification as offered by the Ready Mixed Concrete Association of Ontario.
2. Certification from the concrete producer that they have a currently valid "Certificate of Ready Mixed Concrete Production Facilities" or "Certificate of Mobile Mix Concrete Production Facilities" as issued by the Ready Mixed Concrete Association of Ontario (RMCAO) for the plant or mobile equipment being used to supply the concrete.
3. When required by the Architect/Engineer and if available, in-place pavement test results from previous work, completed within the last 12 months, including design void content and plastic density.
4. One test panel, as described in 1.6.5, placed, jointed, and cured; a minimum of 20 m² and having the required thickness defined by the contract documents. Test panels will be the full width of the equipment being used to place the pervious concrete. The target density and void content from this test panel shall be submitted to the Architect/Engineer for review and acceptance.

1.6.4 Performance based concrete mix design submissions shall be submitted to the Architect/Engineer prior to conducting their trial placement or the actual pervious concrete placement. The mix design submission shall follow the RMCAO Mix Design Submission Process.

1.6.5 PERVIOUS CONCRETE TEST PANEL

Prior to construction, test panel(s) shall be placed and approved by the Architect/Engineer. The test panel(s) shall:

1. Be constructed in accordance with the plans and specifications. The contractor shall place a test panel of at least 20 m² and the proposed construction placement width at the required project thickness, consolidated, jointed and cured using the materials, equipment and personnel proposed for the project. The purpose of the test panel is to demonstrate to the satisfaction of the Architect/Engineer that the in-place porosity can be achieved and a satisfactory pavement can be installed using the proposed materials and equipment.
2. Test panel cost and removal, if necessary, shall be the responsibility of the contractor. Test panels may be placed at any of the specified pervious concrete pavement locations on the project or at another site.
3. Test panels shall have an acceptable surface finish, joint detail, thickness, porosity and curing procedure as defined in this specification.
4. Satisfactory performance of the test panels shall be determined by:
 - a. The concrete producer determining their target plastic density of pervious concrete. This value shall be used as the target value for all placements.
 - b. Verifying that the thickness of the concrete pavement conforms to the project specifications.
 - c. Determining the average void content of three cores extracted from the pavement and tested using the test method identified in RMCAO [T-040](#) – “*Test Method for Porosity Measurements of Portland Cement Pervious Concrete*”. The average porosity shall be between 15 – 25%.

1.6.7 A pre-paving conference will be held prior to placing pervious concrete on the project. The placing contractor, concrete supplier and concrete testing firm shall all attend the conference and will review the results of the trial placement and document the contractors approved placement method and the testing verification system that will be used for the acceptance of the pervious concrete placement.

2. MATERIALS

2.1 GENERAL

Locally available materials conforming to CSA A23.1 shall be used.

2.2 SUBBASE MATERIAL

Subbase material shall meet the size and grading requirements indicated in the contract documents.

2.3 PERVIOUS CONCRETE

Concrete materials shall comply with CSA A23.1/.2 and the following requirements:

2.3.1 The concrete mix design shall meet the following performance requirements:

- *Maximum w/cm ratio of 0.40*
- *Maximum nominal aggregate size of 14 mm**

**Depending on the use of the pervious concrete, the size of the aggregate will vary. Larger sized aggregates may be suitable in some cases, but will need to be approved by the Architect/Engineer prior to use.*

2.3.2 Chemical admixtures shall be permitted to facilitate the production and placement of pervious concrete.

- The use of an air entraining admixture is required in order to provide additional protection to the cement paste from deterioration due to freeze thaw cycles. *

**Since the plastic air content test method cannot be used to determine the actual air content of the pervious concrete, the concrete producer shall base the air entraining admixture dosage on the dosage levels typically used for their mix designs with similar w/cm ratios. Air content testing will not be used for material acceptance and rejection purposes.*

2.3.3 The concrete mix design may contain fine aggregate.

2.3.4 The use of fibres shall be permitted in pervious concrete.

2.3.5 The use of supplementary cementing materials (SCM) is permitted in pervious concrete. The SCM shall be ground granulated blast furnace slag, fly ash, or silica fume or any combination of two or all of the materials. HVSCM 1 concrete shall only be used with prior written approval of the Architect/Engineer.

2.3.6 If integral colour is specified as part of the project, the pigments shall comply with ASTM C979.

2.4 ISOLATION JOINT MATERIAL

Isolation joint material shall comply with ASTM D994, D1751, or D1752 when specified in the contract documents.

3. CONSTRUCTION PROCESS

3.1 SUBGRADE PREPARATION AND FORMWORK

3.1.1 SUBGRADE PREPARATION

1. Subgrade shall be prepared as specified in the contract documents.
2. Subgrade shall be prepared to ensure that required pavement thickness is obtained in all locations.
3. Traffic must be kept off the subgrade during construction to the maximum extent practical. If disruption is created by concrete delivery vehicles or other construction traffic, the subgrade must be regraded and recompact prior to concrete placement.
4. The material added shall be compacted to obtain final subgrade elevation.
5. Subgrade permeability shall be determined in accordance with ASTM D3385 and confirm that it meets the requirements of contract documents prior to concrete placement. Do not proceed with the pervious concrete pavement placement until the Architect/Engineer has confirmed that the permeability value complies with their initial design.

3.1.2 FORMWORK

1. Forms may be of wood, steel or other material of sufficient strength and stability to support mechanical equipment without deformation of plan profiles following spreading, strike-off and compaction operations.
2. Forms shall be set, aligned, and braced to meet tolerances specified in section 3.2.6.
3. Forms shall be clean and free from debris, rust, and hardened concrete.
4. Form release agent must be applied to the form face, which will be in contact with the concrete, immediately before placing concrete.
5. The vertical face of previously placed concrete may be used as a form. Form release agent must not be applied to previously placed concrete. Previously placed concrete must be protected from damage.

3.2 MIXING, DISCHARGE AND PLACING

3.2.1 MIXING AND DISCHARGE

Batch and mix in compliance with CSA A23.1/2 and RMCAO's plant certification requirements except that the discharge shall be completed within 60 minutes of the introduction of mix water to the cement. The discharge time can be increased to 90 minutes when the concrete producer utilizes an extended set control admixture. Water addition is permitted at the point of discharge throughout the unloading process in order to maintain the necessary material consistency.

3.2.2 PLACING

1. Placement width shall be completed as specified in contract documents, and shall not exceed 6 m unless otherwise specified.
2. Place concrete either directly from hauling equipment, or by conveyor onto the prewetted subgrade or subbase, unless otherwise specified. Concrete pump cannot be used to place pervious concrete.
3. Concrete shall not be placed onto frozen subgrade or subbase.
4. Concrete shall be placed within forms to an approximately uniform height.
5. Concrete shall be spread using a come-along, or a square-ended shovel.
6. No traffic shall be permitted on the fresh concrete.
7. Strike-off shall be completed between forms using a form-riding paving machine or vibrating screed. Other strike-off devices may be used when accepted.
8. No steel trowels or power finishing equipment shall be used.
9. Concrete shall be finished to the elevations and thickness specified in contract documents and meet requirements in 3.2.6.

3.2.3 SLIPFORM PAVEMENT

1. Slipform equipment shall be permitted.
2. Follow placement procedure as outlined in 3.2.2 with the exception of 3.2.2.4, 3.2.2.5 and 3.2.2.7.

3.2.4 SURFACE TEXTURE

1. Compaction shall be completed to stay within the requirements of 3.2.6.
2. Compaction of the concrete along the slab edges shall be completed with hand tools.
3. Compaction of the concrete shall provide a dense, pervious surface.

3.2.5 EDGING

Edge top surface to a radius of not less than 6 mm.

3.2.6 TOLERANCES

1. Pavement shall be constructed to comply with the following tolerances:

- Elevation: + 19 mm, - 0 mm
- Thickness: + 38 mm, - 6 mm
- Contraction Joint Depth: + 6 mm, - 0 mm

2. Prior to testing for compliance to tolerances, pavement surface must be mechanically swept.

4. COMPACTION, CURING and JOINTING

4.1 COMPACTION

Pervious concrete placement requires special equipment for compaction and jointing (if jointing is specified). The concrete shall be jointed and compacted using the methods listed or by alternatives demonstrated by the Contractor during the trial placement and accepted by the Architect/Engineer.

4.1.1 Rolling compaction shall be achieved by a pipe of sufficient weight that spans the width of the section being placed and provides the necessary surface compaction. The pipe may be hydraulically rotated during the compaction process.

4.1.2 Plate compaction (for small areas) shall be achieved using a walk behind soil plate compactor provided that the concrete is covered with plywood. Ideally the plywood will span from edge form to edge form to prevent compaction below the required surface elevation of the pavement.

4.2 CURING

4.2.1 Curing to begin within 20 minutes of concrete discharge unless longer working time is accepted by the Architect/Engineer, and within 2-4 m of finishing operation.

4.2.2 Pavement surface is to be completely covered with a minimum 0.15 mm thick polyethylene sheet. Sheets shall be cut to a minimum of a full placement width prior to concrete placement.

4.2.3 All pavement edges shall be covered with a polyethylene sheet.

4.2.4 Secure curing cover material without using dirt, sand or gravel.

4.2.5 Cure pavements for minimum of 7 days uninterrupted at a minimum temperature of 10 °C, unless otherwise specified.

4.3 JOINTING

- 4.3.1 Pervious concrete will generate cracking similar to conventional concrete pavements. Due to the porous surface of pervious concrete, cracking is not as readily noticeable as with conventional concrete. For this reason, jointing is considered optional.
- 4.3.2 If it is deemed desirable to specify joints, they shall be constructed at the locations, depths, and with horizontal dimensions indicated in the contract documents.
- 4.3.3 If it is deemed desirable to specify joints, and the requirements are not indicated on the project drawings, submit drawings describing proposed jointing in accordance with the requirements of this specification and the requirements of 4.2.3.1 through 4.2.3.8. Work shall not proceed until the jointing requirements have been accepted by the Architect/Engineer.
1. Designate the position for contraction joints, construction joints, and isolation joints.
 2. The larger horizontal dimension of a slab panel shall not exceed 125% of the smaller dimension.
 3. The angle between two intersecting joints shall be between 80 – 100 degrees, as specified in the contract documents.
 4. Joints shall intersect the pavement free edges at 90 degree angles and shall extend straight for a minimum of 0.5 m from the pavement edge where possible.
 5. Joints from adjacent pavement panels shall be aligned.
 6. Joints in attached or adjacent curbs shall be aligned within 6 mm of joints in pavement.
 7. Contraction joint depth shall be 1/4 to 1/3 of the pavement thickness. When using an early-entry dry-cut saw, the depth shall be at least 25 mm. The spacing between contraction joints shall not exceed 6 m, unless otherwise specified. The minimum joint width for saw cutting is 3 mm.
 8. Isolation joints shall be used where pavement abuts fixed objects and shall extend the full depth of the pavement. The joint shall be filled with isolation joint material.
- 4.3.4 Contraction joints may be constructed using either of the following methods, when joints are specified:
1. Saw cut concrete after it has hardened sufficiently to prevent aggregate from being extricated and soon enough to control random pavement cracking. Only remove curing materials as needed to minimize drying.
 2. Tooled to the specified depth and width in fresh concrete immediately after the concrete is compacted.

4.4 HOT AND COLD WEATHER CONSTRUCTION

- 4.4.1 When the ambient air temperature is at or above 27 °C, or when there is a probability of its rising to 27 °C during the placing period (as forecast by the nearest official meteorological office), facilities shall be provided for the protection of the concrete in place from the effects of hot and/or drying weather conditions (see CSA A32.1 Clause 7.4.4.2. for additional information).

- 4.4.2 When the air temperature is at or below 5 °C, or when there is a probability of its falling to 5 °C within 24 hours of placing (as forecast by the nearest official meteorological office), all materials and equipment needed for adequate protection and curing shall be on hand and ready for use before concrete placement is started.

5. TESTING, INSPECTION and ACCEPTANCE

5.1 GENERAL

- 5.1.1 Test and inspect concrete materials and operations as work progresses as described in 5.5. Failure to detect defective work or material early will not prevent rejection if a defect is discovered later, nor shall it constitute final acceptance.
- 5.1.2 The contractor shall employ no less than one NRMCA certified Pervious Concrete Technicians, who shall be on site working in a supervisory capacity during all concrete placement unless otherwise specified. The concrete producer shall employ no less than one NRMCA certified Pervious Concrete Technician, who shall be on site working in a supervisory capacity during all concrete placement unless otherwise specified.

5.2 TEST PANELS

- 5.2.1 Test panels shall be placed using the mix designs, materials, and equipment as proposed for the project and as identified in 1.6.5.

5.3 TESTING AGENCIES

- 5.3.1 Agencies that perform laboratory testing services on concrete materials shall conform to the requirements of CSA A283 and be certified by CSA. Testing agencies performing the testing shall be accepted by the Architect/Engineer before performing any Work.
- 5.3.2 All field testing of concrete required for the project shall be performed by a NRMCA certified Pervious Concrete Technician who also holds either of the following certifications: CSA Certified Concrete Testing Technician, Concrete Testing and Sampling Certificate; or ACI Concrete Field Testing Technician-Grade 1.

5.4 TESTING RESPONSIBILITIES OF CONTRACTOR

- 5.4.1 Advise the Architect/Engineer at least 48 hours before concrete placement.

5.5 TESTING

- 5.5.1 Obtain a minimum 30 L sample for acceptance tests in accordance with CSA A23.1/.2. Measure a minimum of one density test during each day's placement or every 50 m³ (whichever is greater) in accordance with ASTM C1688 and as identified in RMCAO Technical Bulletin [T-035](#) "Standard Test Method for Determining Pervious Concrete Plastic Density".

- Fresh density shall be within $\pm 80 \text{ kg/m}^3$ of the specified fresh density. The fresh density test method is used for jobsite acceptance and rejection of individual loads of pervious concrete only.

5.5.2 Remove three cores from each lot of 500 m^2 in accordance with CSA A23.1/.2, not less than 7 days after placement of the pervious concrete. Cores shall be a minimum nominal 100 mm diameter and selected randomly from the lot. Measure the cores for thickness and determine the average thickness. After thickness determination, trim the core as identified in RMCAO Technical Bulletin [T-040](#) “*Test Method for Porosity Measurements of Portland Cement Pervious Concrete*”.

1. Tolerance for thickness and density reported as the average of three cores of each lot shall be as follows:
2. The compacted thickness shall not be more than 6 mm less than the specified thickness, with no single core exceeding 13 mm less than the specified thickness; nor shall the average compacted thickness be more than 38 mm more than the specified thickness.
3. Porosity shall be between 15 to 25%.
4. Core holes shall be filled with pervious concrete or conventional concrete as directed by the Architect/Engineer.

5.6 OPENING TO TRAFFIC

5.6.1 The pavement shall not be opened to vehicular traffic until the concrete has been continuously cured for a minimum of 7 days at a temperature of at least 10°C and until it has been accepted by the Architect/Engineer.