Amendment to OPSS.MUNI 356 (November 2018) – Construction Specification for Pervious Concrete Pavement for Low-Volume Traffic Applications

This specification shall be read in conjunction with OPSS.MUNI 356 (Nov 2018). OPSS.MUNI 356 (Nov 2018) shall form a normative part of this specification as a completed document. All requirements of OPSS.MUNI 356 (Nov 2018) Appendix 356-A shall apply in this specification.

TS 859.02 References

Section 356.02 of OPSS.MUNI 356 is amended by the addition of the following standards, specifications or publications:

City of Toronto Standard Specifications

TS 2.10	Construction Specification for General Excavation
TS 501	Amendment to OPSS.MUNI 501 – Construction Specification for Compacting
TS 856	Construction Specification for Pipes in Green Infrastructure

City of Toronto Standard Details

T-850.131	Permeable Pavement – Pervious Concrete

Ontario Provincial Standard Specifications

OPSS.MUNI 180	General Specification for the Management of Excess Materials
OPSS.MUNI 356	Construction Specification for Pervious Concrete Pavement for Low-Volume Traffic Applications
OPSS.MUNI 1860	Material Specification for Geotextiles

CSA Standards

A23.1	Concrete Materials and Methods of Concrete Construction/ Methods of Test and Standard Practices for Concrete
A23.2-16A	Resistance to Degradation of Small-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
A23.2-17A	Resistance to Degradation of Large-size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine

Ready Mix Concrete Association of Ontario 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

ASTM Standards

D448	Standard Classification for Sizes of Aggregate for Road and Bridge Construction

D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil using Standard Effort
D2434	Standard Test Method for Permeability of Granular Soils (Constant Head)
D2937	Standard Test Method for Density of Soil in Place by the Drive-Cylinder Method
D3385	Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer

National Ready Mixed Concrete Association (NRMCA)
Pervious Concrete Contractor Certification Program

American Association of State Highway and Transportation Officials

M288	Standard Specification for Geosynthetic Specification for Highway Applications
T191	Standard Method of Test for Density of Soil In-Place By The Sand Cone Method
T310	In-Place Density and Moisture Content of Soil and Soil–Aggregate by Nuclear Methods (Shallow Depth)

TS 859.03 Definitions

Section 356.03 of OPSS.MUNI 356 is amended by the addition of the following definitions:

Granular Subbase means a layer of compacted aggregate that is placed above the subgrade.

Granular Base means a layer of compacted aggregate that is placed above the granular subbase.

TS 859.04 Design and Submission Requirements

Section 356.04 of OPSS.MUNI 356 is amended by the addition of the following subsections:

TS 859.04.02 Certification

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 pervious concrete. The supplier shall provide test data according to T-035 and T-040.

TS 859.04.03 Paving Plan

Prior to commencing the work, submit a detailed paving plan showing the edge constraints, schedule, sequence of work, equipment and workforce for Contract Administrator approval.

TS 859.04.04 Additional Submittals

The Contractor shall submit the test results for each source of the aggregate to be used for compliance with CSA A23.1, Table 12.

The Contractor shall submit all data on proposed concrete admixtures and proposed fibres.

TS 859.05 Materials

Section 356.05 of OPSS.MUNI 356 is amended by the addition of the following subsections:

TS 859.05.05 Granular Subbase (If Used)

The granular subbase material shall be open-graded crushed stone with 90% fractured faces and LA abrasion less than 40 according to CSA A23.2-16A or A23.2-17A. Rounded material or recycled concrete is not acceptable for vehicular applications. All materials shall be washed, with less than 2% passing the 0.075 mm sieve. Aggregate gradation for the granular subbase shall be according to CSA A23.1 Table 11, Group II, 80-40 mm as shown in Table 1. The ASTM D448 approximation is No. 2 Stone.

Table 1: 80-40 mm Granular subbase gradation

Sieve number	Percent passing
112 mm	100
80 mm	90-100
56 mm	25-60
40 mm	0-15
20 mm	0-5

TS 859.05.06 Granular Base

The granular base material shall be open-graded crushed stone with 90% fracture faces and LA abrasion less than 40 as per CSA A23.2-16A or A23.2-17A. Rounded material or recycled concrete is not acceptable for vehicular applications. All materials shall be washed, with less than 2% passing the 0.075 mm sieve. Aggregate gradation for the granular base shall be according to CSA A23.1 Table 11, Group II, 28-14 mm as shown in Table 2.. The ASTM D448 approximation is No. 57 Stone.

Table 2: 28-14 mm Granular base gradation

Sieve number	Per cent passing
40 mm	100
28 mm	90-100
20 mm	30-65
14 mm	0-15
5 mm	0-5

TS 859.05.07 Geotextile Fabric

Geotextile fabric shall be non-woven needle punch, Class II according to AASHTO M288. For roadway applications use non-woven needle punch Class I according to AASHTO M288. Overlay of geotextile shall be according to AASHTO M288 or equivalent in OPSS.MUNI 1860.

TS 859.05.04 Pervious Concrete

The following text will continue the list in Subsection 356.05.04:

g) Delete “Slump requirements shall not apply” and replace with Slump at time and point of discharge: 20mm to 50mm.

l) Chemical admixtures shall be permitted to facilitate the production and placement of pervious concrete. In particular, the use of an air entraining admixture is required to provide protection from the cement paste from deterioration in freeze / thaw cycles. Air Entraining Mixture at 5% range according to TS 1350.05.01.04.

TS 859.07 Construction

Section 356.07 of OPSS.MUNI 356 is amended by adding the following subsections:

TS 859.07.13 Preparation

Prior to any work, the Contractor shall clean all surfaces of loose and foreign material.

TS 859.07.14 Excavation

Prior to any excavation, the Contractor shall have all utilities located and clearly marked, including an areaway locate to mark all underground walkways, rooms, coal chutes and so on.

The excavation shall be to the lines and grades shown on the Contract Drawings. All surplus or unsuitable material is to be disposed of, off the site, according to OPSS.MUNI 180.

The subgrade shall be prepared according to TS 2.10. Subgrade grading shall be as per the Contract Drawings.

The Contractor shall be required to make good all damage caused during the course of the construction to any part of the roadway, boulevard and private property and to restore the same, to as good or better condition as existed prior to commencement of work.

Care should be made to avoid compacting the subgrade during excavation. If compaction is required, estimate the infiltration rate according to ASTM D3385. Should compaction be required, compact to a minimum of 90% SPMDD according to ASTM D698. Contractor shall provide density results to the Contract Administrator.

Do not install in heavy rain, on frozen aggregates, or on frozen soil subgrade. Verify that the soil subgrade is free from standing water. Keep excavation area free from sediment during the entire construction duration. Any geotextile, base or subbase installed contaminated with sediment shall be removed and replaced with clean material.

The Contractor shall obtain written confirmation that the subgrade preparation is sufficient prior to further installation. Excavation elevations should be within +/- 3cm.

Subgrade shall be protected from over compaction or contamination by silty run-off or other contaminants. Provide physical barriers or direct traffic to eliminate unnecessary vehicular traffic on the subgrade during construction. Provide flow diversion and erosion and sediment control measures to protect the permeable pavement area from sedimentation until the upstream catchment area is thoroughly stabilized. Areas of subgrade contaminated by the accumulation of silty material following rains or other debris or contamination shall be removed and disposed at the Contractor's expense.

TS 859.07.15 Geotextile

Geotextile shall be placed on sides of soil subgrade, place on bottom only as directed by the Contract Administrator or as specified in the Contract Drawings. Geotextile shall be secured in place and overlaped a minimum of 0.3 m in the direction of drainage. Damaged geotextile shall be replaced according to the manufacturer's recommendations at no extra cost to the City.

TS 859.07.16 Edge Restraints

Install edge restraints as specified in the Contract Drawings. Edge restraint base shall be placed to a depth of 75 mm and shall be installed on a subgrade compacted to a minimum of 95% of maximum dry density according to TS 501.

TS 859.07.17 Underdrainage

If noted on the Contract Drawings, install underdrainage according to TS 856.

TS 859.07.18 Base, Subbase, and Bedding Layer

The Contractor shall notify the Contract Administrator a minimum of 24 hours prior to all base and sub-base work. The subbase/base shall be tested for infiltration by ASTM D3386 or approved alternate. The infiltration shall be no less than 63.5 mm/hr, 50% of the hydraulic conductivity (ASTM D2434) at 95% SPMDD. The density of subbase and base courses shall be determined by AASHTO T191, T310 or ASTM D2938 or as approved methods at the discretion of the Contract Administrator.

TS 859.07.19 Base

Aggregate base shall be placed in maximum lifts of 100 mm. For each lift, two passes of the vibratory mode shall be made, followed by two passes in the static mode with minimum 9 ton vibratory roller until there is no visible movement of the aggregate. Do not crush aggregate with the roller. Compact to level specified in Contract Drawings, to maximum of 95% SPMDD.

Use 60 kN (minimum) plate compactor for areas that cannot be reached by the roller.

The surface of the compacted subbase shall be such that when tested with a 3 m long straightedge, placed in any direction on the surface, the gap between the straightedge and the surface of the compacted base shall not be greater than 25 mm, at any point.

TS 859.07.20 Sub-Base

The Contractor shall notify the Contract Administrator a minimum of 24 hours prior to all base and sub-base work. Aggregate subbase shall be placed in maximum lifts of 200 mm. Protect geotextile during placement of aggregate subbase. For each lift, two passes of the vibratory mode shall be made, followed by two passes in the static mode with minimum 9 ton vibratory roller until there is no visible movement of the aggregate. Do not crush aggregate with the roller. Compact to level as specified in the Contract Drawings, to maximum of 95% SPMDD.

Use 60 kN (minimum) plate compactor for areas that cannot be reached by the roller.

The surface of the compacted base shall be such that when tested with a 3 m long straightedge, placed in any direction on the surface, the gap between the straightedge and the surface of the compacted subbase shall not be greater than 65 mm, at any point.

TS 859.07.07 Curing

Section 356.07.07 of OPSS.MUNI 356 is amended by adding the following paragraphs:

Curing shall occur at a minimum temperature of 10°C.

TS 859.07.09 Surface Tolerances

Section 356.07.09 of OPSS.MUNI 356 is amended by adding the following paragraphs:

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

TS 859.07.23 Hot and Cold Weather Construction

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 or drying weather or both conditions.

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. For additional cold weather curing information, see CSA A23.1 Clause 7.4.2.4.2.

TS 859.10 Basis of Payment

Section 356.10.01 of OPSS.MUNI 356 is amended by adding the following paragraphs:

…and Material to do the work, *including any underdrains, geotextile, granular base and subbase material supply and compaction*, subject to…

CONSTRUCTION SPECIFICATION FOR PERVIOUS CONCRETE PAVEMENT FOR LOW-VOLUME TRAFFIC APPLICATIONS

TABLE OF CONTENTS

356.01 SCOPE

This specification covers the requirements for the construction of pervious concrete pavement for low-volume traffic applications. This specification includes requirements for a trial section and special equipment and testing requirements.

356.01.01 Specification Significance and Use

This specification is written as a municipal-oriented specification. Municipal-oriented specifications are developed to reflect the administration, testing, and payment policies, procedures, and practices of many municipalities in Ontario.

Use of this specification or any other specification shall be as specified in the Contract Documents.

356.01.02 Appendices Significance and Use

Appendices are not for use in provincial contracts as they are developed for municipal use, and then, only when invoked by the Owner.

Appendices are developed for the Owner's use only.

Inclusion of an appendix as part of the Contract Documents is solely at the discretion of the Owner. Appendices are not a mandatory part of this specification and only become part of the Contract Documents as the Owner invokes them.

Invoking a particular appendix does not obligate an Owner to use all available appendices. Only invoked appendices form part of the Contract Documents.

The decision to use any appendix is determined by an Owner after considering their contract requirements and their administrative, payment, and testing procedures, policies, and practices. Depending on these considerations, an Owner may not wish to invoke some or any of the available appendices.

356.02 REFERENCES

When the Contract Documents indicate that municipal-oriented specifications are to be used and there is a municipal-oriented specification of the same number as those listed below, references within this specification to an OPSS shall be deemed to mean OPSS.MUNI, unless use of a provincial-oriented specification is specified in the Contract Documents. When there is not a corresponding municipal-oriented specification, the references below shall be considered to be the OPSS listed, unless use of a provincial-oriented specification is specified in the Contract Documents.

This specification refers to the following standards, specifications, or publications:

Ontario Provincial Standard Specifications, Construction

OPSS 919 Formwork and Falsework

Ontario Provincial Standard Specifications, Material

OPSS 1002 Aggregates - Concrete
OPSS 1004 Aggregates - Miscellaneous
OPSS 1305 Moisture Vapour Barriers
OPSS 1308 Joint Filler in Concrete
OPSS 1350 Concrete - Materials and Production

Ontario Ministry of Transportation Publications

MTO Laboratory Testing Manual:
LS-443 Method of Test for the Determination of the Void Content of Pervious Concrete Pavement Cores

CSA Standards

A23.2-3C Making and Curing Concrete Compression and Flexural Test Specimens *
A23.2-9C Compressive Strength of Cylindrical Concrete Specimens *
A23.2-14C Obtaining and Testing Drilled Cores for Compressive Strength Testing *
* [Part of A23.1-09/A23.2-09 - Concrete Materials and Methods of Concrete Construction/Methods of Test and Standard Practices for Concrete]

ASTM International

C 1116/C 1116M-09	Standard Specification for Fibre Reinforced Concrete
C 1688/C 1688M-08	Standard Test Method for Density and Void Content of Freshly Mixed Pervious Concrete

356.03 DEFINITIONS

For the purposes of this specification, the following definitions apply:

Cold Weather means those conditions when the air temperature is at or below 10 °C. It is also considered to exist when the air temperature is at or is likely to fall below 10 °C within 96 hours after pervious concrete placement. Temperature refers to shade temperature.

Construction Joint means the surface where two successive placements of pervious concrete meet or where new pervious concrete is placed against existing concrete across which it is desirable to achieve bond between the two concrete placements.

Control Joint means a joint that is created by scoring or sawcutting to prevent uncontrolled cracking due to drying or thermal shrinkage.

Isolation Joint means a joint that allows relative movement to take place between adjoining parts of a structure or pavement to prevent damage to the concrete.

Pervious Concrete Pavement means a rigid pavement structure that allows water flow into and through the pavement structure.

Surface Ravelling means the loss of coarse aggregate from the surface of the pervious concrete pavement.

356.04 DESIGN AND SUBMISSION REQUIREMENTS

356.04.01 Submission Requirements

356.04.01.01 Mix Design

The concrete mix design shall be submitted to the Contract Administrator according to OPSS 1350, with the following exceptions:

a) The mix design shall be submitted before the trial section is placed.

b) The air void system parameters of the hardened concrete shall not be required.

c) Pervious concrete mix shall meet the material requirements of this specification.

d) Strength results are not required with the mix design submission.

e) Mix design supporting documentation shall include a certificate from the National Ready Mixed Concrete Association (NRMCA) verifying that at least one member of the Contractor's team, who is responsible for the supervision of the placement of the pervious concrete, is certified by the NRMCA Pervious Concrete Contractor Certification program.

356.04.01.02 Trial Section

Three Business Days prior to the start of the trial section, the following information shall be submitted to the Contract Administrator:

a) Date, time, and location of the trial section.

b) Method and equipment to be used to place and compact the pervious concrete pavement.

c) Name of the NRMCA certified staff to be present and responsible for supervision of the placement.

356.05 MATERIALS

356.05.01 Forms

Forms, if used, shall be according to OPSS 919. Form materials shall extend the full depth of the pavement. Forms shall be of sufficient strength and stability to support mechanical equipment without deformation. Spacers, if used, shall be made of wood and shall be the same width as the formwork.

356.05.02 Isolation Joint Material

Isolation joint material shall be according to OPSS 1308.

356.05.03 Moisture Vapour Barrier

Moisture vapour barrier shall be according to OPSS 1305.

356.05.04 Pervious Concrete

The pervious concrete shall have a minimum 28-Day core compressive strength of 15 MPa, when tested according to CSA A23.2-9C and this specification.

Pervious concrete shall be according to OPSS 1350 with the following exceptions:

a) Pervious concrete plastic density shall be measured according to ASTM C 1688 and shall be within $\pm$ 80 kg/m^3 of the plastic density of the trial section.

b) The pervious concrete in the hardened state shall have a void content between 15 to 25%, when tested according to LS-443.

c) Coarse and fine aggregate are not required to meet the gradation requirements of OPSS 1002.

d) A viscosity modifying admixture (VMA) may be used. The trial section shall be used to observe and test the compatibility of the VMA with other admixtures and cementing materials.

e) Use of water reducer is not required.

f) Superplasticizer may be used.

g) Slump requirements shall not apply.

h) The testing requirements of OPSS 1350 for plastic and hardened air void testing shall not apply. The paste shall be adequately air entrained to provide freeze thaw resistance, with air entraining admixture dosage based on the dosage level typically used for mix designs with similar water to cement ratio.

i) The coarse aggregate shall have a maximum nominal aggregate size less than or equal to 13.2 mm.

j) Type III synthetic fibres according to ASTM C 1116 may be used. If used, synthetic fibres shall be added at the plant.

k) In addition, for municipal-oriented Contracts, the Material Sampling and Testing subsection requirements shall not apply, with the exception of the testing of water, admixtures, and cementing materials.

356.06 EQUIPMENT

356.06.01 General

Equipment made of aluminium material shall not come in contact with the plastic pervious concrete.

356.06.02 Placing Equipment

Equipment used for placing the pervious concrete shall be one of the following:

a) A slipform paver.

b) A laser screed.

c) A razorback steel truss screed, with vibratory or Clary screed.

d) A vibratory steel screed, or steel roller screed with integral internal vibration.

356.06.03 Compaction Equipment

356.06.03.01 Roller Compaction Equipment

Rolling compaction shall be achieved using a steel pipe roller that spans the width of the section to be placed and exerts sufficient pressure to provide the necessary compaction.

356.06.03.02 Hand Tampers

Hand compaction equipment shall have a maximum width of 300 mm.

356.06.04 Edging Tools

Edging tools shall have a 6 mm radius.

356.06.05 Straight Edges

Straight edges shall be 3 m in length and made of metal.

356.07 CONSTRUCTION

356.07.01 General

The Contract Administrator shall be notified in writing of the intent to place the pervious concrete pavement 3 Business Days prior to the start of the placing operation.

356.07.02 Operational Constraints

Placement of pervious concrete during cold weather is not permitted.

Pervious concrete shall not be placed in the rain. All necessary precautions shall be taken to protect placed plastic pervious concrete from rainfall.

Pervious concrete shall not be placed when the ambient air temperature is above 28 °C or likely to rise above 28 °C, throughout the duration of the placing operation.

Pervious concrete shall not be placed against any material that is at a temperature above 35 °C, or against any material that is at a temperature below 5 °C.

Traffic, other than foot traffic, shall not be permitted on the pervious concrete pavement until the pervious concrete has attained a core compressive strength of 15 MPa.

The pervious concrete pavement shall be protected from damage to its surface when steel-tracked equipment is used.

Construction equipment and trucks heavier than 20,000 kg shall not be permitted on the pervious concrete pavement at any time.

When a drainage system is part of the design, it shall be operational prior to the placement of the pervious concrete.

356.07.03 Trial Section

The trial section shall be constructed, in the presence of the Contract Administrator, to demonstrate the Contractor's ability to successfully produce, place, and finish pervious concrete pavement. The trial section shall be placed a minimum of 4 weeks prior to pervious concrete being placed in the work. The Contract Administrator shall be notified of the trial placement date 3 Business Days in advance.

The trial slab 10 metres long shall be constructed, at the paving thickness specified in the Contract Documents. The width of the trial slab shall be the width of the widest section that is intended to be placed at one time. The location of the trial section shall be proposed to the Contract Administrator for approval. To simulate the effect of travel time, the trial section location shall not be farther from a ready mix plant than the job site. In the event that the trial section location is closer to the plant than the job site, the discharge from the ready mix truck shall be delayed sufficiently to match the estimated travel time.

The trial section shall be constructed with pervious concrete of the same materials and mix design; supplied by the same ready mix plant; and placed, consolidated, and cured using the materials, equipment, and personnel, including NRMCA-certified supervisors that the Contractor intends to use in the work.

All Aspects of coring and conducting tests shall be undertaken on pervious concrete pavement to determine thickness, compressive strength, and void content.

Plastic density and void content shall be determined according to ASTM C 1688 and the test results shall be submitted to the Contract Administrator.

Thickness, compressive strength, and hardened density and void content, shall be determined by dividing the trial section into 6 sections of equal size and shape, removing one 100 mm diameter full-depth core from each of the 6 sections according to CSA A23.2-14C, and testing the cores as follows:

a) All cores shall be tested for thickness according to the Acceptance of Thickness subsection.

b) Three cores shall be tested for hardened density and void content according to LS-443.

c) The remaining three cores shall be tested for 28-Day compressive strength according to CSA A23.2-9C and this specification.

Test results shall be submitted to the Contract Administrator to determine acceptability of the trial section according to the Table 1. Once acceptability of the trial section is confirmed in writing by the Contract Administrator, placement of pervious concrete may commence. If the trial section is not accepted, another trial section shall be constructed. Unacceptable trial sections in the work shall be removed.

Placement in the work can proceed early if all requirements are met, including meeting the specified core compressive strength.

356.07.04 Placing

A person certified according to the NRMCA Pervious Concrete Contractor Certification program shall be responsible for the supervision of the placement of the pervious concrete.

Before placing pervious concrete on granular base, the granular immediately ahead of the pervious concrete paving operation shall be wetted down thoroughly without leaving standing water.

The granular base material shall not be disturbed or displaced by any equipment used for the placing operations.

During placement, pervious concrete shall be uniform in consistency with no visible signs of segregation and free of lumps.

Placement shall be continuous.

Pervious concrete shall be deposited within 1.5 m of its final position.

Sufficient material shall be in front of the placement equipment to ensure there are no low spots.

Discharge of individual loads of pervious concrete shall be completed within 90 minutes of the introduction of mix water to the cement. If there is an interruption in placement, the pervious concrete shall be covered with a moisture vapour barrier. When an interruption of more than 20 minutes occurs, a construction joint shall be made.

356.07.05 Compaction

Following placement and strike-off, pervious concrete shall be compacted. This compaction process may be done with or without the use of spacers. Spacers, if used, shall be removed after strike-off and before compaction.

The concrete shall be compacted to the level of the top of the forms or to the final elevation, depending on the equipment used for placement, using a steel roller. Longitudinal rolling shall be required, followed immediately by rolling in the transverse direction, if required to remove surface indentation or other surface irregularities. Care shall be taken during compaction that sufficient compactive force is applied, without excessively working or consolidating the concrete surface such that the void structure of the pervious concrete is closed.

Hand tampers shall be used to compact the concrete along the slab edges immediately adjacent to the forms. After placement and compaction, no further finishing shall be performed on the concrete and no material shall be applied to the concrete.

Finishing and edging shall begin as soon as the pervious concrete is discharged from the truck.

356.07.06 Joints

Control joints shall not be required.

A construction joint should be installed at the end of the day's production or when an interruption of more than 20 minutes occurs in the concrete paving operation.

Isolation joints shall be used when abutting appurtenances and fixed vertical structures, including light pole bases and building foundations. Isolation joint material shall be according to this specification.

Edging and additional compaction with hand tamping tools shall be performed along all form lines and along all isolation joints and construction joints to reduce potential for ravelling under traffic.

356.07.07 Curing

A moisture vapour barrier shall be placed on the surface of the pervious concrete immediately after compacting the pervious concrete surface, within 2 to 4 m of the compacting operation. Air flow in the space between the moisture vapour barrier and the concrete surface shall be prevented. The moisture vapour barrier strips shall overlap 150 mm and shall be held in place at the edges and laps to prevent displacement, without marring the surface of the concrete. Curing shall continue for a minimum period of 7 Days.

356.07.08 Surface Appearance

The finished pervious concrete pavement surface shall have a uniform open texture and shall, over a 100 m^2 section, be free of:

a) a single surface appearance deficiency exceeding 1 m^2, or

b) the combined area of multiple surface appearance deficiencies exceeding 2 m^2.

Surface appearance deficiencies include, but are not limited to, the following:

a) Tears.

b) Plastic shrinkage cracking.

c) Streaking.

d) Accumulation of paste.

e) Contamination by tracking, spilling, or placing of mud or other contaminants onto the pavement.

f) Presence of closed surface.

Surface appearance shall be assessed by a visual survey.

356.07.09 Surface Tolerance

Except across the crown or drainage gutters, the surface of the pervious concrete pavement shall be such that when tested with a 3 m long straight edge placed in any location and direction, including the edge of pavement and joints, there shall not be a gap greater than 10 mm between the bottom of the straight edge and the surface profile of the pervious concrete pavement.

356.07.10 Surface Ravelling

The surface of the pervious concrete pavement shall not exhibit any surface ravelling based on a visual review.

356.07.11 Sampling and Testing

356.07.11.01 Plastic Pervious Concrete

Carry out all aspects of sampling and testing of the plastic pervious concrete.

Quality control testing shall consist of plastic density and void content testing. Plastic density and void content shall be measured according to ASTM C 1688. The plastic density shall be within 80 kg/m^3 of the plastic density of the trial section. Quality control testing shall be performed on each load of pervious concrete.

356.07.11.02 Hardened Pervious Concrete

356.07.11.02.01 General

After a minimum of 8 Days and a maximum of 10 Days, two sets of three 100 mm diameter cores per sublot shall be taken. The locations for the two sets of cores shall be randomly selected by the Contract Administrator. Each set shall be taken within a 1 m^2 area in each location. No core shall be taken within 250 mm of any joint or edge of slab. Cores shall be drilled through the complete depth of pervious concrete pavement perpendicular to the surface of the slab. Cores shall be drilled according CSA A23.2-14C.

The cores shall be delivered to the quality assurance (QA) laboratory designated by the Owner in the Contract Documents for testing. The cores shall be stored at a temperature of 23 °C $\pm$ 2 °C in a moist condition, according to the laboratory curing requirements of CSA A23.2-3C, until time of testing.

The cores shall be tested for:

a) Thickness according to the Acceptance of Thickness clause.

b) Hardened void content and density according to LS-443.

c) Compressive strength according to CSA A23.2-9C except that the load shall be applied until complete failure of the specimen.

356.07.11.02.02 Lot Size

A lot shall consist of the total quantity of pervious concrete pavement of the same specified thickness on the Contract. Each lot shall be divided into 500 m^2 sublots or a minimum of three sublots. If the quantity of pervious concrete placed on one day is less than 500 m^2, it shall be considered a sublot.

356.07.11.02.03 Filling of Core Holes

Each core hole shall be filled immediately after coring with pervious concrete. When pervious concrete is not available, 13.2 mm clear stone may be used to meet the requirements of OPSS 1004 to fill the core hole to 35 mm from the concrete pavement surface and cover with hydraulic cement based concrete patching material. The patching material shall be mixed, handled, and cured according to the manufacturer's instructions. Immediately before filling, the inside surface of each core shall be cleaned by nylon brushing. The patch shall be finished flush with the surface of the surrounding pervious concrete pavement. All excess material shall be removed from the surface of the pervious concrete pavement.

356.07.11.02.04 Identification of Cores

Each core shall be legibly labelled immediately after its removal from the slab. The core shall be placed into a sample bag and sealed with a tag provided by the Contract Administrator. The core identification numbers shall be specified by the Contract Administrator.

356.07.11.02.05 Transportation of Cores

Transport cores in a safe manner that avoids damage to the cores. The cores shall be delivered to the laboratory designated by the Owner. The cores shall be delivered on the same day they are obtained. The cores shall be kept at a temperature above 5 °C and protected from moisture loss during transportation.

356.07.12 Management of Excess Material

Management of excess material shall be according to the Contract Documents.

356.08 QUALITY ASSURANCE

356.08.01 General

Acceptance shall be based on a visual inspection and QA testing of the completed work as outlined below. Pervious concrete pavement deemed unacceptable shall be repaired according to Table 2.

356.08.02 Acceptance Based on Visual Inspection

A visual inspection of the pervious concrete pavement surface shall be conducted by the Contract Administrator to determine if any of the following defects are present:

a) Surface appearance not meeting the requirements of the Surface Appearance subsection.

b) Surface tolerance not meeting the requirement of the Surface Tolerance subsection.

c) Slight, moderate, or severe surface ravelling.

   Slight surface ravelling is defined as the loss of the top layer of coarse aggregate in less than 1% of the surface area of the lot. Moderate surface ravelling is defined as the loss of the top layer of coarse aggregate in 1 to 10% of the surface area of the lot. Severe surface ravelling is defined as the loss of the top layer of coarse aggregate in more than 10% of the surface area of the lot or the loss of more than one layer of coarse aggregate, exceeding a depth of 26 mm, in any area of the lot.

Visual inspection for ravelling shall be carried out prior to opening to traffic, at the completion of the Contract and at the Warranty Period inspection.

Pervious concrete pavement not meeting surface appearance or surface tolerance requirements shall be deemed unacceptable.

Pervious concrete pavement sublots with slight ravelling shall be accepted. Pervious concrete pavement sublots with moderate surface ravelling or severe surface ravelling shall be deemed unacceptable.

356.08.03 Acceptance for Thickness

All cores shall be measured for thickness. Untrimmed hardened core samples shall be used to determine placement thickness. For each core, 4 length measurements shall be taken, rounded to the nearest millimetre. The measurements shall be taken at the ends of perpendicular diameters. The thickness of each sublot shall be based on the average length of all cores within the sublot.

Sublots with an average core thickness of more than 6 mm less than the specified thickness or with an individual core thickness of more than 13 mm less than the specified thickness shall be deemed unacceptable.

356.08.04 Acceptance for Void Content and Density

For each sublot, one set of three 100 mm diameter cores shall be measured for void content and density according to LS-443.

Sublots with an average void content less than 15% or more than 25% and any individual void content in excess of 35% shall be deemed unacceptable.

356.08.05 Acceptance for Core Compressive Strength

For each sublot, the second set of three 100 mm diameter cores shall be measured for core compressive strength according to CSA A23.2-9C and this specification.

Sublots with an average core compressive strength less than 15 MPa at 28 Days or an individual core compressive strength less than 11 MPa at 28 Days shall be deemed unacceptable.

356.09 MEASUREMENT FOR PAYMENT

356.09.01 Actual Measurement

356.09.01.01 Pervious Concrete Pavement

Measurement of pervious concrete pavement shall be by surface area in square metres to the nearest 0.1 m^2 of pervious concrete pavement placed.

356.10 BASIS OF PAYMENT

356.10.01 Pervious Concrete Pavement - Item

Payment at the Contract price for the above tender item shall be full compensation for all labour, Equipment, and Material to do the work, subject to the payment adjustment specified in Table 2.

The following shall be carried out at no extra cost to the Owner:

a) Additional trial sections.

b) Repairs to pervious concrete pavement deemed unacceptable.

TABLE 1
Pervious Concrete Pavement Trial Section Acceptance Requirements

Criteria	Acceptance Requirement
Surface Appearance, m^2 per 100 m^2	No single irregularity $\geq$ 1
	No combined multiple irregularities $\geq$ 2
Surface Tolerance, mm gap	$\leq$ 10
Surface Ravelling Severity (Note 1)	None or Slight
Thickness, mm less than specified thickness	Single core not more than 13
	Average of 3 cores not more than 6
Thickness, mm more than specified thickness	Single core < 20
28-Day Core Compressive Strength, MPa	$\geq$ 15
Void Content, %	20 $\pm$ 5

Note:

1. Surface ravelling severity definitions according to the Acceptance Based on Visual Inspection subsection.

TABLE 2
Repairs to Unacceptable Pervious Concrete Pavement

Criteria	Repair Requirement	Repair
Surface Tolerance, mm gap	> 10	Submit a proposal for remedial work to the Contract Administrator for approval or remove pervious concrete pavement to full depth as directed by the Contract Administrator and replace with acceptable pervious concrete pavement.
Surface Ravelling Severity (Note 1)	Slight	None.
	Moderate	Sublot represented shall be assessed a payment reduction of 10%.
	Severe	Remove pervious concrete pavement to full depth in the sublot represented and replace with acceptable pervious concrete.
Surface Appearance, m^2 per 100 m^2	Single irregularity ≥ 1 Combined multiple irregularities ≥ 2	Remove pervious concrete pavement to full depth in the sublot represented and replace with acceptable pervious concrete.
Thickness, mm less than specified thickness	Single core > 13 Sublot > 6	
28-Day Core Compressive Strength, MPa	Single core < 11 Sublot < 15	
Void Content, %	Single core > 35 Sublot < 15 or > 25	

Note:

1. Surface ravelling severity definitions according to the Acceptance Based on Visual Inspection subsection.

Appendix 356-A, November 2018
FOR USE WHILE DESIGNING MUNICIPAL CONTRACTS

Note: This is a non-mandatory Commentary Appendix intended to provide information to a designer, during the design stage of a contract, on the use of the OPS specification in a municipal contract. This appendix does not form part of the standard specification. Actions and considerations discussed in this appendix are for information purposes only and do not supersede an Owner's design decisions and methodology.

Designer Action/Considerations

Pervious concrete pavement is suitable for low-traffic applications, including parking lots, boulevards, and walkways.

The designer should specify the following in the Contract Documents:

- Thickness of pervious concrete pavement. (356.07.03)

- QA laboratory. (356.07.11.02.05)

Pervious concrete pavement is a part of a site-specific stormwater management system. Pervious concrete pavement can reduce the impact of stormwater by reducing runoff volumes and decreasing and delaying peak flows.

The pavement structure design should follow the guidelines of the StreetPave software distributed by the American Concrete Pavement Association or equivalent.

The designer should be aware pervious concrete pavement requires enhanced maintenance processes to ensure long-term performance.

The designer should ensure that the General Conditions of Contract and the 100 Series General Specifications are included in the Contract Documents.

Related Ontario Provincial Standard Drawings

No information provided here.