Construction Specification for Concrete Unit Pavers

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TS 3.80.01 SCOPE

This specification covers the requirements for the installation of concrete unit pavers.

TS 3.80.02 REFERENCES

This specification refers to 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 1003	Amendment to OPSS 1003 – Material Specification for Aggregates – Hot Mixed, Hot Laid, Asphaltic Concrete
TS 1010	Amendment to OPSS 1010.MUNI – Material Specification for Aggregates – Base, Subbase, Select Subgrade and Backfill Material
TS 1350	Amendment to OPSS 1350.MUNI – Material Specification for Concrete – Material and Production

City of Toronto Standard Drawings

T-310.020-2	Sidewalk Paved with Unit Paver Band at Curb
T-310.050-2	Vehicular Crossing of Sidewalk with Unit Paver Installation
T-561.030-1	Unit Pavers on Concrete Base Non-Vehicular Locations
T-561.030-2	Unit Pavers on Granular Base Non-Vehicular Locations

Ontario Provincial Standard Specifications

OPSS 180	General Specification for the Management of Excess Materials
OPSS.MUN1004	Material Specification for Aggregates – Miscellaneous

Canadian Standards Association

A23.1-FA1	Concrete Material and Methods of Concrete Construction, Table 4 Grading Limits for Fine Aggregate
A23.2-11C	Water Absorption of Concrete
A179	Mortar and Grout for Unit Masonry
A231.2	Precast Concrete Pavers

American Association of State Highway and Transportation Officials Standards

M-288	Standard Specification for Geotextile Specification for Highway Application

American Society for Testing and Materials

C144	Standard Specification for Aggregate for Masonry Mortar
C979	Standard Specification for Pigments for Integrally Coloured Concrete
D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedures)

Interlocking Concrete Pavement Institute

Tech Spec 2	Construction of Interlocking Concrete Pavements
Tech Spec 3	Edge Restraints for Interlocking Concrete Pavements
Tech Spec 4	Structural Design of Interlocking Concrete Pavement for Roads and Parking Lots

Tech Spec 17 Bedding Sand Selection for Interlocking Concrete Pavements in Vehicular Applications
Tech Spec 22 Geosynthetics for Segmental Concrete Pavements

TS 3.80.03 DEFINITIONS

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

Aspect Ratio means the overall length of a paver divided by its thickness. Example: A 100 mm wide by 200 mm long by 80 mm thick paver has an aspect ratio of 2.5. Compare to Plan Ratio.

Bedding Sand means a layer of uncompacted sand that is screeded smooth prior to placement of the pavers.

Concrete Paver means a precast concrete paving product according to CSA A231.2.

Edge Paver means a precast concrete unit made or field cut with a straight side for placement flush with a concrete curb or other edge restraint.

Edge Restraint means a curb, edging, building or other appurtenance that is intended to confine the bedding sand and concrete pavers so that the pavers do not spread and lose interlock.

Laying Face means the exposed vertical face of a row of pavers on the bedding sand.

Plan Ratio means the overall length of a paver divided by its width. Example: A 100 mm wide by 200 mm long by 80 mm thick paver has an aspect ratio of 2.0. Compare to Aspect Ratio.

TS 3.80.04 DESIGN AND SUBMISSION REQUIREMENTS

TS 3.80.04.01 Bedding and Joint Sand

Submit sieve analysis for the bedding and joint sand according to CSA A23.2A. Bedding material should be a minimum of 60 per cent sub-angular and sub-rounded according to ASTM D2488.

TS 3.80.04.02 Concrete Pavers

Submit five labelled representative full-size samples of each paver type, thickness, colour and finish expected in the finished installation. The Contract Administrator shall inspect the pavers for conformance. The City may require concrete pavers to be tested according to CSA A231.2 for dimensional tolerance, compressive strength and freeze thaw durability by an independent testing laboratory. Testing shall be at no extra cost to the City.

TS 3.80.04.03 Manufacturers Materials

Provide manufacturer's certification of concrete pavers having met all applicable CSA standards. Provide manufacturer's catalog product data, installation instructions and material safety data sheets for the safe handling of the specified materials and products.

TS 3.80.05 MATERIALS

TS 3.80.05.01 Granular Subbase

The granular subbase material shall be Granular A according to TS 1010.

TS 3.80.05.02 Concrete Base

The materials for and the production of concrete base shall be according to TS 1350 and the following:

1)	Cement type	Normal Portland GU / Portland limestone GUL
2)	Minimum 28 day cylinder compressive strength	32 MPa
3)	Class of exposure	C-2
4)	Nominal maximum size of coarse aggregate	19 mm
5)	Slump at point of discharge (formed concrete)	80 ± 30 mm
6)	Total air content	6.5 ± 1.5%
7)	Maximum water/cementing materials ratio	0.45

TS 3.80.05.03 Granular Base

The granular base material shall be Granular A according to TS 1010.

TS 3.80.05.04 Bedding Sand

Bedding sand shall be according to CSA A23.1 (FA1) gradation for concrete sands.

Table 1: Bedding sand gradation

Sieve number	Per cent passing
10 mm	100
5 mm	95-100
2.5 mm	80-100
1.25 mm	50-80
630 µm	25-65
315 µm	10-35
160 µm	2-10
80 µm	0-2

Where concrete pavers are subject to vehicular traffic, utilize sands that are as hard as practically available.

Limestone screenings or stone dust shall not be used. Mason sand or sand according to CSA A179 shall not be used for bedding sand.

TS 3.80.05.05 Joint Sand

Joint sand shall be according to CSA A179 gradation for joint sand.

Table 2: Joint sand gradation

Sieve number	Per cent passing
5.0 mm	100
2.5 mm	90-100
1.25 mm	85-100
630 µm	65-95
315 µm	15-80
160 µm	0-35
80 µm	0-10

TS 3.80.05.06 Polymeric Sand – High Strength

Polymeric sand shall be blended native sands according to ASTM C144 sand mixed with synthetic polymers for pavement joint stabilization. The use of polymeric sand shall be as specified in the Contract Documents.

TS 3.80.05.07 Concrete Pavers

Concrete pavers shall be according to CSA A231.2. Concrete pavers shall have the following material characteristics:

(a) Minimum average cube or core compressive strength of 50 MPa for laboratory cured specimens or 40 MPa for unconditioned field samples.

(b) Resistance to 28 freeze-thaw cycles while immersed in a 3 per cent solution with no greater mass lost than 225 g/m² if surface area after 28 cycles, or 500 g/m² after 49 cycles.

(c) Concrete pavers shall be uniform in size and texture.

The concrete pavers shall not differ in length or width by −1.0 to +2.0 mm and in height by more than ± 3.0 mm.

Failure to meet any of the requirements (a) through (c) shall result in the rejection of all of the concrete pavers represented by the failed set. All rejected pavers shall be replaced, with all associated costs, including the testing of the replacement set, at no extra cost to the City.

All units shall be free of defects that would interfere with the proper placing of the units or impair the strength or permanence of the construction. Minor cracks incidental to the usual methods of manufacture, or minor chipping resulting from customary methods of handling in shipment and delivery, shall not be deemed grounds for rejection of the lot. Individual concrete pavers having visually significant imperfections, chipped edges or cracks shall not be used and shall be rejected.

TS 3.80.05.07.01 ***Concrete Paver Types***

The type, size, colour, joint width and radius chamfer and finish shall be specified in the Contract Documents. City standard paver types shall meet the following specifications.

Type 1 – Interlocking Precast Concrete Paver	
Sizes	100 mm x 200 mm x 80 mm
	200 mm x 200 mm x 80 mm
	200 mm x 300 mm x 80 mm
Colours	Medium Grey
	Light Grey
	Dark Grey
	Dark Red
	Light Red
Joint Width and Top Radius/Chamfer	2 – 3 mm joint width with spacer
	2 mm top radius/chamfer width

Type 2 – 3D Locking Precast Concrete Road Paver	
Locking Requirements	Robust, 3d/dual-direction locking suitable for public roadways with heavy automobile usage
Ratio	Ratio between 2:1 or 3:1. Size as recommended by proponent (no smaller than 100 mm x 200 mm)
Depth	100 mm
Colours	Medium Grey
	Light Grey
	Dark Grey
	Dark Red
	Light Red
Finish	Tumbled or as specified
Joint Width and Top Radius/Chamfer	Maximum 5 mm joint width with spacer
	2 mm maximum top radius/chamfer width

TS 3.80.05.07.02 *Colour and Finish*

City standard concrete pavers shall have a high albedo for colours medium grey and light grey having a Solar Reflex Index (SRI) greater than 29. All colours shall be integral to the concrete paver not surface finish referred to as face-mix. Pigment shall be according to ASTM C979. No surface sealers allowed.

TS 3.80.05.08 19 mm Type II Clear Stone

Clear stone shall be 19 mm Type II, according to OPSS.MUNI 1004 and meet the following physical properties.

Table 3: Clear Stone – 19 mm Type II

Laboratory test	MTO test number	Clear Stone 19 mm Type II
loss by washing, pass 75μm sieve, % maximum	LS-601	2.0
percent crushed particles, % minimum	LS-607	60
micro-deval abrasion Loss, % maximum	LS-618	25

Clear stone shall be 19 mm Type II, according to OPSS.MUNI 1004 and meet the following gradation requirements.

Table 4: Clear Stone – 19 mm Type II

Sieve sizes	Nominal maximum size
63 mm	-
53 mm	-
26.5 mm	100
19.0 mm	90-100
16.0 mm	65-90
13.2 mm	-
9.5 mm	20-55
6.7 mm	-
4.75 mm	0-10
75 μm	0-2.0

TS 3.80.05.09 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.

TS 3.80.05.10 Edge Restraints

Where not otherwise retained, provide edge restraints installed around the perimeter of all interlocking concrete paving unit areas. Timber shall not be used as an edge restraint. Edge restraints shall be as specified on the Contract Drawing.

TS 3.80.06 EQUIPMENT

Concrete pavers shall be set into the bedding sand using a high frequency, low amplitude, mechanical flat plate vibratory compactor. The plate compactor shall transmit an effective force of not less than 22 kN. The frequency of vibration shall be within the range of 75 to 100 Hz to vibrate the pavers into the sand.

TS 3.80.07 CONSTRUCTION

TS 3.80.07.01 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 180.

The subgrade shall be prepared according to TS 2.10.

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.

TS 3.80.07.02 Base

The concrete pavers shall be placed using a granular or a concrete base, as specified in the Contract Documents. The slope of the base shall match the final slope of the concrete pavers.

TS 3.80.07.02.01 *Granular Base*

Granular base shall be placed at a minimum depth of 150 mm for walkways and boulevards, and 200 mm, for driveways. It shall be compacted to a minimum of 100% of maximum dry density according to TS 501.

The surface of the compacted granular 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 granular base shall not be greater than 10 mm, at any point..

TS 3.80.07.02.02 *Concrete Base*

Prior to the placement of the concrete base, the Contractor shall construct a granular subbase. The subbase shall be placed to a depth of 75 mm and shall be compacted to a minimum of 95% of maximum dry density according to TS 501.

The concrete base shall be poured to a minimum depth of 100 mm. At the outer limits of the concrete pavers, the concrete depth shall be increased to form a 200 mm wide edge restraint, level with the proposed surface of the pavers. The 200 mm wide edge restraint shall be omitted when the pavers are placed adjacent to a concrete curb or other permanent structure.

The surface of the concrete 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 concrete base shall not be greater than 10 mm, at any point.

At all maintenance holes, valve boxes, handwells and so forth, the surrounding concrete shall be increased to the proposed surface of the pavers. The concrete shall be squared off and the outer edge of the appurtenance shall be encased by a minimum of 50 mm of concrete. The size and location of the raised concrete shall be governed by the alignment of the concrete pavers. No concrete paver shall be cut or trimmed to less than one-third of its original area. For 100 x 200 x 80 mm size concrete pavers, they shall be cut or trimmed to no less than 50 mm in length.

Plastic drain pipes (50 mm diameter) shall be placed at the low side of the base, spaced at every 3 m along the length of the concrete base. The drain shall be a minimum of 400 mm long and shall be flush with the top of the base. A drainage pocket shall be constructed at every drain. The pocket shall consist of 19 mm Type II clear stone placed 200 mm wide x 200 mm long x 300 mm deep from the bottom of the concrete base. It shall be situated to drain into the granular material at the back of the curb. If the drain cannot be discharged into a well-draining granular material, the drainage pocket shall be increased to 300 mm wide x 300 mm long. Prior to placing the bedding sand, the drain shall be covered by centering a 200 mm x 200 mm piece of geotextile fabric over the opening.

TS 3.80.07.02.03 *Concrete Paver for Walkways, Sidewalks and Boulevards*

Concrete pavers for walkways, curb edges and boulevards shall be Type 1 – Interlocking Precast Concrete Paver and shall have an aspect ratio of 4:1 or less.

Concrete pavers on sidewalks and boulevards shall be installed in either a running bond pattern according to T-310.02-2 or 90 degree herringbone pattern.

Concrete pavers along the curb edge shall be installed as a double row in a stack bond pattern.

TS 3.80.07.02.04 *Concrete Paver for Roads*

Concrete pavers for roads shall be Type 2 – 3D Locking Precast Concrete Road Paver. Concrete paver for roads shall have an aspect ratio of 3:1 or less. Portland cement concrete base thickness under Type 2 concrete paver shall be according to the Contract Documents.

TS 3.80.07.02.05 *Concrete Paver for Parking Lots*

Concrete pavers for parking lots shall be the following as specified in the Contract Documents

1) Type I – Interlocking Precast Concrete Paver 100 mm x 200 mm x 80 mm in applications designed for up to 5 million ESAL installed in a running bond or 90 degree herringbone pattern, or

2) Type 2 – 3D Locking Precast Concrete Road Paver installed according to the manufacturers recommend pattern Portland cement concrete base thickness under Type 2 concrete paver shall be according to the Contract Documents.

Concrete paver for parking lots shall have an aspect ratio of 3:1 or less.

TS 3.80.07.02.06 *Geotextile*

Place geotextile strips, a minimum of 300 mm wide, to cover areas where bedding sand loss may occur such as at cuts for joints in curbs, around drainage structures and other appurtenances.

TS 3.80.07.03 Bedding Sand

Spread bedding sand evenly over the base course and screed to a nominal 25 mm thickness. Spread bedding sand evenly over the base course and screed rails, using the rails or edge restraints or both to produce a 25 mm un-compacted thickness.

Do not disturb screeded sand. Screeded area shall not substantially exceed that which is covered by pavers in a one day. Do not use bedding sand to fill depressions in the base surface. Concrete pavers shall be placed only on loose, moist bedding sand.

TS 3.80.07.04 Concrete Paver Placement

Concrete pavers shall be placed uniformly and hand tight, such that all joints are correctly aligned. Provide joints between pavers between 2 and 3 mm wide. No more than 5 percent of the joints shall exceed 5 mm wide to achieve straight bond lines. Joint or bond lines shall not deviate more than 15 mm over 15 m from string lines.

Where concrete pavers require trimming, they shall be cut with a dry diamond blade with vacuum abatement measures, wet cut or a guillotine, to give a straight edge. Fill gaps at the edges of the paved area with cut pavers or edge units. All cut pavers exposed to vehicular tires shall be no smaller than one-third of a whole paver.

Simultaneously spread, sweep and compact dry joint sand into joints continuously until full. At least four passes with a plate compactor shall applied to the surface while simultaneously spreading the sand into the joints. All joints should be filled to the bottom of the edge radius/chamfer. Do not compact within 2 m of unrestrained edged of paving units. Remove excess joint sand from the surface when installation is complete. Surface shall be broom clean after removal of excess joint sand.

TS 3.80.08 QUALITY ASSURANCE

TS 3.80.08.01 Surface Tolerance

The surface of the concrete pavers 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 pavers shall not be greater than 10 mm, at any point.

The surface elevation of pavers shall be 3 to 10 mm above adjacent drainage inlets, concrete collars or channels at the completion of construction, in anticipation of post construction consolidation of the base and bedding materials.

Lippage: No greater than 3 mm difference in height between adjacent pavers.

TS 3.80.08.02 Acceptance

If any pavers are loose, chipped or unevenly cut, these concrete paver units shall be rejected. Areas failing to meet the requirement for surface tolerance shall be rejected.

Any rejected concrete pavers or areas shall be removed and either reinstalled or replaced by the Contractor. All costs associated with the removal, reinstallation and replacement of rejected concrete pavers shall be at no extra cost to the City.

TS 3.80.09 MEASUREMENT FOR PAYMENT

TS 3.80.09.01 Unit Pavers

Measurement of unit pavers shall be of the surface area, including any edge restraint, in square metres (m^2). No deduction will be made for poles or utility frames and covers.

TS 3.80.10 BASIS OF PAYMENT

TS 3.80.10.01 Unit Pavers – 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. Payment shall include all excavation, the supply, placing, levelling and compacting of all granular, the supply and placement of concrete base and edge restraints, the supply and placement of drains, the supply and placement of concrete pavers and bedding sand, and the filling of all joints.

Appendix 3.80-A, April 2018
For Use While Designing and Administrating City Contracts

Note: This is a non-mandatory commentary appendix intended to provide information to a designer and contract administrator during the design and construction stage of a contract on the use of this TS specification in a City 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.

Notes to Designer:

The designer should specify the following in the Contract Documents:

- type, size, colour, joint width and top radius chamfer and finish of the concrete pavers (3.80.05.07.01)

- calculate granular base thickness based on soil subgrade strength and ESAL's for walkways, sidewalks and parking lots. To calculate granular base thicknesses for different load requirements, see ICPI Tech Spec #4 or ASCE 58-16. (3.80.07.02.03 or 3.80.07.02.05)

- material type such as plastic, concrete, aluminum, steel, pre-cast stone, cut stone or concrete based on the application. To select and edge restraint, see ICPI Tech spec #3 (3.80.05.10)

- calculate the Portland cement concrete base thickness based on soil subgrade strength and ESAL's for roads and parking lots. To calculate concrete base thicknesses for different load requirements, see ICPI Tech Spec #4 or ASCE 58-16. (3.80.07.02.04 or 3.80.07.02.05)