

Permeable Interlocking Concrete Pavements

This guide specification has been prepared by Oaks Concrete Products to assist design professionals in the preparation of a specification section covering Permeable Interlocking Concrete Pavement Systems (Section 32 14 13.19 of Constructions Specifications Canada). As there are different types of system designs (Full-, Partial- and No-Exfiltration), not all information may be applicable to a given installation.

PART 1—GENERAL

1.01 Summary

- A. Work shall consist of furnishing all materials, labour, equipment and supervision for construction of a Permeable Interlocking Concrete Pavement (PICP) System in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the drawings or as established by the Owner.

1.02 Related Sections

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| A. Section 31 00 00 | Earthwork |
| B. Section 31 32 19.23 | Geotextile Layer Separation |
| C. Section 31 05 19.16 | Geomembranes for Earthwork |
| D. Section 32 11 23 | Aggregate Base Courses |
| E. Section 32 16 13 | Curbs and Gutters |
| F. Section 32 17 00 | Paving Specialties (Bumpers, markings, snow melting) |
| G. Section 33 46 16.19 | Pipe Underdrains |

1.03 Reference Documents

- A. General: Where specifications and reference documents conflict, the Owner and design engineer will make the final determination of the applicable document.
- B. Design and Installation
 1. American Association of State Highway and Transportation Officials (AASHTO) GDPS-4-M - Guide for Design of Pavement Structures
 2. American Society of Civil Engineers (ASCE) 58-10 - Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways
 3. Interlocking Concrete Pavement Institute (ICPI) - Permeable Interlocking Concrete Pavement Design, Installation and Maintenance (latest edition)
 4. Interlocking Concrete Pavement Institute (ICPI) - Permeable Design Pro software
 5. Interlocking Concrete Pavement Institute (ICPI) Tech Spec Number 18 - Construction of Permeable Interlocking Concrete Pavement Systems.
- C. Concrete Pavers
 1. ASTM C-140 Test Method for Sampling and Testing Concrete Masonry Units and Related Units;
 2. ASTM C-936 Solid Concrete Interlocking Paving Units
 3. ASTM C-979 Pigments for Integrally Coloured Concrete

Permeable Interlocking Concrete Pavements

4. ASTM C-1645 Freeze-thaw and De-icing Salt Durability of Solid Interlocking Paving Units
5. ASTM C-1781 Surface Infiltration Rate of Permeable Unit Pavement Systems
6. CSA A23.1-FA1 Concrete Materials and Methods of Concrete Construction
7. CSA A231.2 Precast Concrete Pavers
8. CSA A283 Qualification Code for Concrete Testing Laboratories
- D. Edge Restraints
 1. ASTM C-94 Standard Specification for Ready Mixed Concrete
- E. Geosynthetics
 1. AASHTO M288 Geotextile Specification for Highway Applications;
 2. ASTM D-4873 Guide for Identification, Storage and Handling of Geotextiles;
- F. Aggregates and Soils
 1. ASTM C-29 Bulk Density ("Unit Weight") and Voids in Aggregate
 2. ASTM C-131 Resistance to Degradation of Small-Sized Course Aggregate by Abrasion and Impact in the Los Angeles Machine
 3. ASTM C-136 Sieve Analysis of Fine and Course Grained Aggregates
 4. ASTM D-448 Standard Classification for Sizes of Aggregate for Road and Bridge Construction;
 5. ASTM D-698 Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort;
 6. ASTM D-1557 Laboratory Compaction Characteristics of Soil Using Modified Effort
 7. ASTM D-1883 CBR (California Bearing Ratio) of Laboratory Compacted Soils
 8. ASTM D-2487 Test Method for Classification of Soils for Engineering Purposes (Unified Soil Classification System);
 9. ASTM D-2488 Description and Identification of Soils (Visual-Manual Procedure)
 10. ASTM D-6928 Resistance of Course Aggregates to Degradation by Abrasion in the Micro-Deval Apparatus
 11. ASTM E-2835 Measuring Deflections using a Portable Impulse Plate Load Test Device
 12. CSA A23.2 Sieve Analysis of Fine and Course Grained Aggregates
- G. Drainage Pipe
 1. ASTM D-3034 Standard Specification for Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings.
 2. ASTM D-3350 Standard Specifications for Polyethylene Plastic Pipe and Fittings Materials
- H. Where conflict exists between reference standards, the contractor shall obtain clarification from the engineer prior to proceeding with the work. Applicable CSA standards will prevail wherever ANSI or ASTM specifications conflict with CSA standards.

1.04 Definitions

- A. Base Course –a medium sized (ASTM #57 Stone or similar) washed open graded free draining aggregate material of a designed thickness that provides both structural support over the Subgrade

Permeable Interlocking Concrete Pavements

- (in cooperation with the Subbase Course when used) and water storage capacity. When the Subbase Course is used, it also serves as a choking material between it and the Bedding Course.
- B. Bedding Course – a 50mm (2") thick loosely screeded layer of small sized (ASTM #8 Stone or similar) washed open graded free draining aggregate material used for bedding of the Concrete Pavers.
 - C. Concrete Pavers – solid individual paving units manufacturing from concrete that are either specifically designed for use in permeable applications or are laid in a pattern that creates large enough openings to facilitate the installation of the required Joint Material. Concrete Pavers are shipped in clusters called bundles or cubes, which consist of several layers of pavers strapped or wrapped together.
 - D. Drainage System – horizontal pipe(s) at or near the bottom of the PICP system that facilitate water drainage to a catchbasin, ditch or other receiving body. Raised elbows, weirs and orifice plates can be used as needed to control the water elevation within the PICP system before discharge occurs, and/or the discharge flow rate.
 - E. Edge Restraint – for commercial vehicular applications, a cast in place concrete curb (can be raised or flush), building or other stationary object that prevents the lateral movement of the Bedding Course and Concrete Pavers so they do not spread and loose interlock. Other Edge Restraints options that can be used in residential or commercial pedestrian application include plastic, steel or aluminum edging, cut stone, precast concrete and submerged concrete edge complete with mortared pavers.
 - F. Joint Material – a washed open graded free draining aggregate material (ASTM #8, #89 or #9 Stone or similar) used to fill the spaces between the Concrete Pavers to create interlock and maintain infiltration.
 - G. Laying Face – the working edge of the pavement where the laying of pavers is occurring.
 - H. Mechanical Installation - The use of specialized machines to lift whole layers of pavers from the bundles and place them on the prepared bedding course. These specialized machines are designed specifically for this application.
 - I. Membrane Liner – impermeable liner placed at the bottom and sides of a PICP system (where required), used to prevent the exfiltration/discharge of water other than through the Subsurface Drainage System. Usually includes a geotextile on top (possibly bottom) for protection from punctures.
 - J. Separation Geotextile - A geotextile filter fabric used to maintain separation between the Subbase Course and Subgrade.
 - K. Subbase Course – a large sized (ASTM #2 Stone or similar) open graded free draining aggregate material of a designed thickness that provides both structural support over the Subgrade in cooperation with the Base Course and water storage capacity.
 - L. Subgrade – the soil upon which the pavement structure and shoulders are constructed.

1.05 Submittals

- A. Product Data: At the time of bid, the General Contractor shall submit technical specifications and product data from the manufacturers for the following:
 - 1. Bedding Course
 - 2. Base Course
 - 3. Concrete Pavers
 - 4. Drainage System
 - 5. Joint Material

Permeable Interlocking Concrete Pavements

6. Membrane Liner
 7. Separation Geotextile
 8. Subbase Course
- B. Design Submittals:
1. If Owner furnishes construction drawings for the PICP system, no design submittal is required by the General Contractor.
 2. If the General Contractor is to furnish construction drawings for the PICP system, three (3) sets of drawings and design calculations shall be submitted to the Owner at least 45 days prior to construction for review and approval. The drawings and design calculations shall be prepared and stamped by a Professional Engineer registered in the province or state of construction that is experienced in PICP design (the Design Engineer), and shall include the following:
 - (a) Excavation Plan, which shows the proposed grading at the bottom of the Subgrade excavation, and the location of any discharge points for the Drainage System. Details on how to deal with the protection of utilities, footings and foundations within or adjacent to the excavation area shall also be included
 - (b) Site Plan, which shows the proposed final surface grading of the PICP system, colour and laying patterns for the Concrete Pavers, Edge Restraint and adjacent surface elevations, and details on any discharge point(s) for the Drainage System.
 - (c) Cross Section, which shows the design thickness for each of the Concrete Paver, Bedding Course, Base Course, and Subbase Course (when used), the elevation of the Drainage System, and the presence of the Separation Geotextile or Membrane Liner (when used). Dimensions of the Edge Restraint(s) can either be included in the Cross Section, or provided separately.
 - (d) Copies of any geotechnical investigation reports and/or soil testing data used in the design, including but not limited to an infiltration rate of the Subgrade Soil.
 - (e) A summary of the design criteria used for Structural and Hydraulic analysis of the system.
 - (f) Recommended gradations for the materials used for the Joint Material, Bedding Course, Base Course and Subbase Course.
- C. Samples:
1. A minimum of 30 days prior to construction, the General Contractor shall submit to the Owner for approval, and retain for the balance of the project:
 - (a) A minimum of four sample of each type and colour of Concrete Paver proposed in the project. The samples shall represent the range of finish, texture and color permitted. Pavers to be from the same production run as installed materials.
 - (b) For machine installation projects, stitching details to be used during product placement as supplied by the manufacturer.
 - (c) Written "*Method Statement and Quality Control Plan*" that describes material staging and flow, paving direction and installation procedures, including representative reporting forms that ensure conformance to the project specifications.

Permeable Interlocking Concrete Pavements

2. A minimum of 10 days prior to construction, the General Contractor shall submit to the Owner, for verification:
 - (a) Concrete Pavers – Test results from an independent testing laboratory for compliance to CSA A231.2 [ASTM C-936] or other applicable requirements
 - (b) Separation Geotextile – nominal 150mm by 250mm sample of each type required.
 - (c) Membrane Liner – nominal 150mm by 250mm sample of each liner and protection geotextile type required.
 - (d) Drainage System – nominal 150mm length of each type required.
 - (e) Test results from an independent testing laboratory of the initial infiltration rate of the proposed Concrete Paver and Joint Material combination in accordance with ASTM C1781.
 - (f) Joint Material and Bedding Layer
 - (i) 5 kg sample and source pile gradation analysis as tested in accordance with CSA A231.2 [ASTM C-136].
 - (ii) Durability of aggregates using Micro Deval Degradation per ASTM D-6928.
 - (iii) Percentage of angular and sub-angular particles per ASTM D-2488.
 - (g) Base Course and Subbase Course
 - (i) 5 kg sample and source pile gradation analysis as tested in accordance with CSA A231.2 [ASTM C-136].
 - (ii) Source test results for void ratio and bulk density of the Base and Sub-base aggregates per ASTM C-29.

1.06 Installer Qualifications

- A. Paver Installer shall submit:
 1. A list of five (5) previously constructed projects of similar size and magnitude. Project information to include:
 - (a) Project name and location.
 - (b) Date of construction.
 - (c) Contact information of Owner or General Contractor
 - (d) Type of Concrete Paver used.
 - (e) Surface area of the installation.
 - (f) Installation method (Manual or Mechanical Installation)
 2. Proof that the Installer's Site Foreman holds a PICP Technician Certificate from the Interlocking Concrete Pavement Institute (ICPI) contractor certification program. The Site Foreman is expected to be onsite for the entire installation
 3. Proof that the company conforms to all local, state/provincial licensing and bonding requirements
 4. Proof that the company is a Licensed Contractor in the province or state where the project is located.

1.07 Quality Assurance

Permeable Interlocking Concrete Pavements

- A. The Owner shall appoint, at its cost, an Inspection Engineer who is a registered Professional Engineer and who is experienced with the construction of PICP Systems to perform inspections and testing.
- B. The Inspection Engineer shall perform the following:
 - 1. Inspect the construction of the PICP System for conformance with construction drawings and the requirements of this section;
 - 2. Inspect the Subgrade at bottom of excavation for any deleterious materials, groundwater seepage, standing water or soft spots;
 - 3. Verify Subgrade exhibits the bearing capability and infiltration capabilities specified in the design drawings – notify the Design Engineer of any inconsistencies;
 - 4. Inspect the final installation of the Separation Geotextile or Membrane Liner, paying particular attention to the side slopes and around appurtenances that protrude into the PICP area.
 - 5. Compare imported aggregates to the corresponding samples previously provided, and obtain (at the General Contractors expense) additional test results to verify compliance as required;
 - 6. Inspect and document aggregate thicknesses and compaction in accordance with these specifications;
 - 7. Test cast-in-place concrete used for the Edge Restraints to verify compliance (at the General Contractors expense).
 - 8. Notify the Paver Installer of improper installation practices or deficiencies, and provide the same with the opportunity to correct/repair;
 - 9. Test the infiltration rate of the completed PICP surface;
 - 10. Notify General Contractor and Owner of any deficiencies that has not been properly corrected; and,
 - 11. Document inspection results.
- C. Owner's quality assurance program does not relieve the General Contractor of responsibility for quality control and wall performance.

1.08 Delivery, Storage and Handling

- A. Comply with Manufacturer's ordering instructions and lead time requirements (for production and material testing) to avoid construction delays.
- B. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving
- C. General Contractor shall check all materials upon delivery to assure that the proper type, grade, color, and certification have been received.
- D. General Contractor shall store and handle all materials in accordance with manufacturer's recommendations, as specified herein, and in a manner that prevents deterioration or damage due to moisture, temperature change, contaminants, corrosion, breaking, chipping, UV exposure or other causes.

Permeable Interlocking Concrete Pavements

- E. Concrete Pavers to be delivered to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by fork lift or clamp lift. Unload and store Concrete Pavers at job site in such a manner that no damage occurs to the product.
- F. Keep Concrete Pavers and Drainage System piping off any unpaved surface using wood pallets or blocking.
- G. Stockpile aggregates on hard surfaces or geotextile to prevent contamination from site soils and sediment. Keep different materials sufficiently separated as to prevent mixing. Cover material with waterproof covering to prevent exposure to rainfall or removal by wind – secure the covering in place.
- H. Handle and transport aggregates to avoid segregation, contamination and degradation. Do not dump or store one material on top of another unless it is part of the installation process.
- I. General Contractor shall protect the materials from damage.
- J. Separation Geotextile and Membrane Liner shall be delivered, stored and handled in accordance with ASTM D-4873.
- K. Deteriorated, damaged or contaminated materials shall not be incorporated into the work.

1.09 Site Safety

- A. Occupational Health and Safety Regulations for Construction Projects are applicable to all site works.

PART 2 – PRODUCTS

2.01 Concrete Pavers

- A. Concrete Pavers shall be:
 - 1. Product – Enviro Midori - Herringbone, Enviro Midori – Random, Enviro Passagio, Hydr’eau Pave.
 - 2. Colour – Champagne; College Red; Golden Ash; Marble Grey; Milano; Onyx; Safari; Salem; Silversand.
- B. Provide _____ square metres (OR ____%) additional paver material for use by Owner for maintenance and repair as attic stock.
- C. Concrete Pavers shall conform to the requirements of CSA A231.2, including:
 - 1. Compressive Strength: Minimum average cube strength of 50MPa (7,200 psi), with no individual test result less than 45 MPa (6,500 psi), for laboratory cured specimens or minimum average cube strength of 40 MPa (5,800 psi) for unconditioned field samples;
 - 2. Freeze-Thaw Durability: Where freeze-thaw testing is required, the average mass loss of all specimens tested shall not be greater than (A) 225 g/m² when subject to 28 freeze thaw cycles, or (b) 500 g/m² when subject to 49 freeze thaw cycles. Testing shall be conducted using a 3% saline solution in according to ASTM C-1645.
 - 3. Dimensional tolerances: Measured length or width of test specimens shall not differ by more than -1.0mm (0.039”) to +2.0 mm (0.078”), while measured thickness shall not differ by more than +/- 3.0mm (0.118”).
 - 4. Appearance: All units shall be sound and free of defects that would interfere with the proper placing of the units or impair the strength or performance of the construction.

Permeable Interlocking Concrete Pavements

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 grounds for rejection. Efflorescence shall not be a cause for rejection.

- D. Concrete Pavers shall conform to the requirements of ASTM C-936, including:
 - 1. Compressive Strength: Average of three units not less than 55 MPa (8,000 psi), with no individual unit less than 50 MPa (7,200 psi), when tested in accordance with ASTM C-140 as adjusted based on the paver thickness;
 - 2. Absorption: the average absorption of the test samples shall not be less than 5% with no individual unit greater than 7%, when tested in accordance with ASTM C-140.
 - 3. Freeze-Thaw Durability: Where freeze-thaw testing is required, the average mass loss of all specimens tested shall not be greater than (A) 225 g/m² when subject to 28 freeze thaw cycles, or (b) 500 g/m² when subject to 49 freeze thaw cycles. Testing shall be conducted using a 3% saline solution in according to ASTM C-1645.
 - 4. Dimensional tolerances: Measured length or width of test specimens shall not differ by more than +/- 1.6mm (0.063”), while measured thickness shall not differ by more than +/- 3.2mm (0.125”).
 - 5. Appearance: All units shall be sound and free of defects that would interfere with the proper placing of the units or impair the strength or performance 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 grounds for rejection. Efflorescence shall not be a cause for rejection.
- E. Pigment in Concrete Pavers shall conform to ASTM C-979.
- F. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.02 Joint Material and Bedding Course

- A. Clean, non-plastic aggregate, free from deleterious or foreign matter, manufactured from crushed rock.
- B. Where pavers are subject to vehicular traffic, Micro Deval Degradation of less than 8% as per ASTM D-6928.
- C. Percent of angular and sub-angular particles greater than 90%% as per ASTM D-2488. Do not use rounded river gravel.
- D. LA Abrasion <40 as per ASTM C-131, minimum CBR of 80% as per ASTM D-1883.
- E. Gradation of Joint Material and Bedding Course to conform to Table 1 as tested in accordance to CSA A23.2A [ASTM C136]. All aggregates shall have equal to or less than 2% passing the No. 200 (0.075 mm) sieve.

Table 1 – Joint Material and Bedding Course

	ASTM No. 8
12.5mm (1/2 in)	100
9.5mm (3/8 in)	85 to 100
4.75mm (No. 4)	10 to 30
2.36 mm (No. 8)	0 to 10

Permeable Interlocking Concrete Pavements

1.18 mm (No. 16)	0 to 5
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- F. Concrete Paver and Joint Material to have a minimum initial infiltration rate of 150 inches per hour per ASTM C1781, as verified by an independent testing laboratory
- G. General Contractor shall verify approval of submitted samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.03 Base and Subbase Courses

- A. Clean, non-plastic aggregate, free from deleterious or foreign matter, manufactured from crushed rock.
- B. Percent of angular and sub-angular particles greater than 90% as per ASTM D-2488. Do not use rounded river gravel.
- C. LA Abrasion <40 as per ASTM C-131, minimum CBR of 80% as per ASTM D-1883.
- D. Gradation of Base Course to conform to Table 2, while gradation of Subbase Course to conform to Table 3, as tested in accordance CSA A23.2A [ASTM C136]. All aggregates shall have equal to or less than 2% passing the No. 200 (0.075 mm) sieve.

Table 2 – Base Course

	ASTM No. 57
37.5mm (1½ in)	100
25.0mm (1 in)	95 to 100
12.5mm (1/2 in)	25 to 60
4.75mm (No. 4)	0 to 10
2.36 mm (No. 8)	0 to 5

Table 3 – Subbase Course

	ASTM No. 2
75mm (3 in)	100
63mm (2½ in)	90 to 100
50mm (2 in)	35 to 70
37.5mm (1½ in)	0 to 15
19 mm (3/4 in)	0 to 5

- E. General Contractor shall verify approval of submitted samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.04 Separation Geotextile

- A. Separation Geotextile shall be Mirafi FW404 woven geotextile (preferred) or 140N needlepunched nonwoven geotextile, unless otherwise specified in the drawings.
- B. Where an alternate material is specified in the drawings, the physical and hydraulic properties of geotextiles shall be specified in accordance with AASHTO M288-06.
- C. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

Permeable Interlocking Concrete Pavements

2.05 Membrane Liner

- A. Membrane Liner shall be a 30 mil PVC liner complete with 8 oz nonwoven protective geotextile, unless otherwise specified in the drawings.
- B. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.06 Drainage System

- A. The piping shall be perforated or slotted PVC pipe manufactured in accordance with ASTM D-3034, or corrugated HDPE pipe manufactured in accordance with ASTM D-3350.
- B. Perforations or slots shall be sized to prevent migration of Base Material into the pipe.
- C. All connectors and fittings shall match the piping material.
- D. General Contractor shall verify approval of submitted technical specifications, product data, samples and test results per Section 1.05 herein with the Owner prior to the installation.

2.07 Edge Restraints

- A. Edge restraints shall be cast in place concrete curbs constructed at a minimum to the dimensions of the municipal standards.

PART 3 – EXECUTION

3.01 Pre-Construction Meeting

- A. Prior to commencement of any work, the General Contractor shall conduct a pre-construction meeting with the Owner, Design Engineer, Inspection Engineer, Paver Installer, and any affected sub-trades. The General Contractor shall provide notification to all required attendees at least 14 days prior to the meeting.
- B. The pre-construction meeting agenda shall include:
 - 1. Design Engineer to explain all aspects of the PICP construction drawings.
 - 2. Design Engineer to convey the required CBR (bearing capacity) and infiltration capabilities of the Subgrade to the Inspection Engineer.
 - 3. Design Engineer to explain any measures that are required to coordinate the installation of utilities or other obstructions in the PICP system.
 - 4. General Contractor to verify the location of the Mock Up, and whether it will be part of the final construction or needs to be removed.
 - 5. General Contractor to verify the location of material storage areas, access routes and delivery truck unloading area, and when materials can start to be delivered to the site.
 - 6. Paver Installer to verify the expected start and completion dates of construction.
 - 7. An inspection of the site to verify that all site-specific conditions have been considered in the design. Design considerations include:
 - (a) Structures that are adjacent to, or in close proximity to, the PICP system.

Permeable Interlocking Concrete Pavements

- (b) Areas where surface water will discharge onto the PICP system, including adjacent paved or unpaved areas, rooftop gutters.
 - (c) Utilities that will be located near, or pass through/under, the PICP system.
 - (d) Location and condition of discharge point(s) of the Drainage System.
8. The Paver Installer will not proceed with the work until the Design Engineer has either confirmed the original design accounted for any unique design considerations identified during the inspection, or adjusts the design accordingly.

3.02 Mock up

- A. Install a 3m x 3m paver area for hand installation projects, or a 3m x 9m paver area for mechanical installation projects, following the installation practices described in Article 3.04 to 3.10.
- B. This area will be used to verify: surcharge of the Bedding Course; joint sizes; lines; laying pattern(s); stitching details (for mechanical installation); color(s); and, texture of the job.
- C. To provide a proper representation of color blend, a minimum of 3 cubes for manual installation, and 6 cubes for mechanical installation, will be pulled from.
- D. This area shall be the standard from which the work will be judged.
- E. Subject to approval by the Owner, the mock-up may be retained as part of the finished work. If mock-up is not retained, remove and dispose of mock-up at the completion of the project.

3.03 Excavation and Subgrade Preparation

- A. General Contractor shall excavate to the lines and grades shown on the construction drawings in accordance *Division 2, Section 02300 - Earthwork*.
- B. Inspection Engineer shall inspect the excavation and approve prior to proceeding.
 - 1. Where infiltration of water into the Subgrade is desired, the Inspection Engineer shall verify that the condition of the Subgrade, in particular the surface infiltration (where desired) has not been adversely impacted by the excavation work.
 - 2. Where compaction is desired, the Inspection Engineer shall verify that the compaction densities have been met. The General Contractor to proof roll Subgrade as directed to determine if remedial work is required.
 - 3. Subgrade shall be trimmed to within 0 and 13 mm (0-½") of the specified grades. The surface of the prepared Subgrade shall not deviate by more than 10mm (3/8") from the bottom edge of a 3 metre (10-foot) straight edge laid in any direction.
- C. Over excavation of unsuitable or adversely impacted Subgrade, and replacement with approved fill, will be compensated as agreed upon with the Owner.
- D. General Contractor shall protect the PICP area against:
 - 1. Contaminated surface water run-on at all times by using erosion control fences, berms, diversion ditches, temporary drains, and other measures necessary to prevent contaminated drainage to the PICP area.
 - 2. Traffic impacts (specifically the Subgrade if infiltration of water into the Subgrade is desired) by using fences, gates and barriers as required.
- E. Although the Owner may provide soil testing and quality assurance inspection during earthwork and Subgrade preparation, the Owner's quality assurance program does not

Permeable Interlocking Concrete Pavements

relieve the General Contractor of responsibility for quality control and system performance. General Contractor shall obtain any quality control testing or inspection not provided by the Owner that is necessary to satisfy the General Contractor with the condition of the Subgrade prior to commencement of the work.

- F. Where deficiencies or inconsistencies are identified, the Inspection Engineer shall notify the Design Engineer in writing. The Paver Installer will not proceed with the work until the Design Engineer has verified that the deficiencies or inconsistencies have been addressed.

3.04 Membrane Liner (where required)

- A. Install Membrane Liner in accordance with the manufacturer's recommendations and following the Panel Installation Drawings.
- B. The Membrane Liner is applied to the bottom and sides of the excavation. Allow for enough Membrane Liner to exceed the final elevation of the surface.
- C. Protrusions through the Membrane Liner shall be properly booted.
- D. Install Protection Geotextiles as required in accordance with the manufacturer's recommendations.
- E. The Geotextile is applied to the bottom and sides of the excavation with overlapping joints a minimum of 300mm (12"). Overlaps to follow down slope.
- F. Geotextile to be pulled taught and secured using sandbags.
- G. Allow for enough geotextile to exceed the final elevation of the surface.
- H. After completion of the surface, the excess liner and geotextile should be cut flush with the finished grade.

3.05 Separation Geotextile (where required)

- A. Install Separation Geotextiles as required in accordance with the specifications and drawings.
- B. The Geotextile is applied to the bottom and sides of the excavation with overlapping joints a minimum of 300mm (12"). Overlaps to follow down slope.
- C. Geotextile to be pulled taught and secured using stakes.
- D. Allow for enough geotextile to exceed the final elevation of the surface.
- E. After completion of the surface, the excess geotextile should be cut flush with the finished grade.

3.06 Drainage System

- A. At the specified location(s), install the Drainage System pipes in accordance with the manufacturer's recommendations. Ensure the pipes are properly sloped to provide proper drainage to the outlet locations.
- B. Pipes shall be surrounded by a minimum of 100mm (4") of Base Course material to prevent damage from the Subbase material.
- C. Care must be taken not to damage the Drainage System during subsequent aggregate installation.

Permeable Interlocking Concrete Pavements

3.07 Subbase and Base Course

- A. Keep PICP area free from sediment during the entire job. Any aggregate contaminated with sediment shall be removed and replaced with clean aggregate.
- B. Install the Sub-base Course and Base Course at the thicknesses, compaction rates, surface tolerances, and elevations outlined in the specifications.
 1. Place and spread the first layer of Base/Subbase without displacing or damaging the Separation Geotextile or Membrane Liner (if used). To prevent damage, tracked vehicles must not be used to spread the initial Base/Subbase layer.
 2. The aggregate should be spread, moistened and compacted in uniform layers not exceeding 150mm (6") loose thickness. Compaction is performed using either a 10 T (10 ton) vibratory roller or a minimum 13,500 lbf centrifugal force reversible vibratory plate compactor. For each lift, make at least two passes in the vibratory mode and at least two passes in the static mode – continue compaction until there is no visible movement in the materials.
 3. Verify compaction of the Base and Subbase using a Lightweight Deflectometer per ASTM E2835.
- C. Final surface tolerance of the Base Course should be plus or minus 10mm (3/8") over a 3m (10 foot) straight edge laid in any direction.
- D. Attention will be paid to providing proper compaction near curbs, grade beams, concrete collars around utility structures, lights standards, tree wells, building edges and other protrusions as applicable to the project. In areas not accessible to large compaction equipment, compact to specified density with mechanical tampers (jumping jacks).
- E. Before commencing the placing of the Bedding Course, the base shall be inspected by the Inspection Engineer.

3.08 Edge Restraints

- A. Adequate Edge Restraint shall be provided along the perimeter of all paving as specified. The face of the Edge Restraint, where it abuts pavers, shall be vertical.
- B. All concrete Edge Restraints shall be constructed to dimensions and level specified and shall be supported on a compacted Base/Subbase not less than 150mm (6") thick.
- C. Concrete used for the construction of Edge Restraints shall be air-entrained and have a compressive strength as specified. All concrete shall be in accordance with ASTM C94 requirements.

3.09 Bedding Course, Concrete Pavers and Joint Material

- A. Moisten, spread and screed the Bedding Course evenly over the Base Course to a nominal 50mm (2") thickness. Do not use the bedding material to fill depressions in the Base Course surface.
- B. The Contractor shall screed the Bedding Course using either an approved mechanical spreader (e.g.: an asphalt paver) or by the use of screed rails and boards.
- C. Surface tolerances shall be 10mm (3/8") over a 3m (10-foot) straight edge.
- D. Ensure that Concrete Pavers are free of foreign material before installation. Concrete Pavers shall be inspected for color distribution and all chipped, damaged or discolored Concrete Pavers shall be

Permeable Interlocking Concrete Pavements

replaced. Initiation of Concrete Paver placement shall be deemed to represent acceptance of the pavers.

- E. Lay the Concrete Pavers in the pattern(s) as shown on the drawings. Maintain straight pattern lines. For mechanical installations, follow the stitching details submittal as verified during the Mock Up.
- F. Concrete Pavers shall be installed from a minimum of 3 bundles for hand installations, 6 bundles for mechanical installations, simultaneously to ensure colour blending.
- G. Joints between the Concrete Pavers shall be maintained according to the spacer bars.
- H. Fill gaps at the edges of the paved area with cut pavers or edge units. Do not install cut pavers smaller than one-third of a whole paver along edges subject to vehicular traffic – trim two pavers to fit.
- I. Cut pavers using a masonry saw. Upon completion of cutting, the area must be swept clean of all debris to facilitate inspection and to ensure the Concrete Pavers are not damaged during compaction.
- J. Using a low amplitude plate compactor capable of at least 5,000 lbs. (22 kN) compaction at a frequency of 75 hz –100 hz, compact and seat the Concrete Pavers into the Bedding Course.
- K. The pavers shall be compacted to achieve consolidation of the Bedding Course and brought to level and profile by not less than three passes. Initial compaction should proceed as closely as possible following the installation of the paving units and prior to the acceptance of any traffic or application of Joint Material.
- L. Any units that are structurally damaged during compaction shall be immediately removed and replaced.
- M. Apply a dressing of Joint Material to the surface and sweep into the joints. Fill joints, then sweep off excess material before vibrating the material down into the joints using a plate compactor. This will require at least two or three passes with the compactor.
- N. Do not compact within 2 m (6 feet) of the unrestrained edges of the paving units.
- O. All work to within 2 m (6 feet) of the Laying Face must be left fully compacted at the end of each day. Cover the Laying Face with plastic sheets overnight if not closed with cut and compacted pavers.
- P. Sweep off excess aggregate when the job is complete.
- Q. Once the Paver Installer's work is complete, and the area approved by the Inspection Engineer, the General Contractor shall be responsible for protecting the work from sediment deposition and damage due to subsequent construction activity on the site.

3.10 As-built Construction Tolerances

- A. Final inspection shall be conducted to verify conformance to the drawings and compliance to the conditions of the Mock Up.
- B. All pavements shall be finished to lines and levels to ensure positive drainage at all drainage outlets and channels.
- C. The final surface elevations shall not deviate more than +/- 10mm (3/8") under a 3m (10 ft) long straight edge.
- D. Concrete Pavers to be 3 to 6mm (1/8 to ¼") above curbs, inlets, concrete collars and channels.
- E. Lippage shall be no greater than 3mm (1/8") difference in height between adjacent pavers.
- F. Bond lines for the pavers shall be +/- 12.5mm (½") over a 15m (50 foot) string line.

Permeable Interlocking Concrete Pavements

- G. Check filling of joints with a putty knife. Maximum 6mm (1/4") below chamfer edge at completion.
- H. Infiltration rate of the PICP surface to exceed 150 inches per hour as determined using ASTM C-1781,

END OF SECTION