SECTION 1
PERMEABLE INTERLOCKING CONCRETE PAVEMENT

Note: This guide specification for U.S. applications describes construction of permeable interlocking concrete pavers on a permeable, open-graded crushed stone bedding layer (typically ASTM No. 8 stone). This 2 in. (50 mm) layer is placed over an open-graded base (typically No. 57 stone no greater than 4 in. or 100 mm thick) and a sub-base (typically No. 2 stone or similar sized material such as No. 3 or 4 stone). The pavers and bedding layer are placed over an open-graded crushed stone base with exfiltration to the soil subgrade. In low infiltration soils or installations with impermeable liners, some or all drainage is directed to an outlet via perforated drain pipes in the subbase. While this guide specification does not cover excavation, liners and drain pipes, notes are provided on these aspects.

The text must be edited to suit specific project requirements. It should be reviewed by a qualified civil or geotechnical engineer, or landscape architect familiar with the site conditions. Edit this specification term as necessary to identify the design professional in the General Conditions of the Contract.

PART 1 GENERAL

1.01 SUMMARY

A. Section Includes

a. Permeable interlocking concrete pavers.
b. Crushed stone bedding material.
c. Open-graded subbase aggregate.
d. Open-graded base aggregate.
e. Bedding and joint/opening filler materials.
f. Edge restraints.
g. [Geotextiles].
h. Underdrainage pipe

B. Related Sections

1. Section 00455: Curbs and gutters
2. Section [_____]: [Stabilized] aggregate base.
3. Section 00430: Erosion control.
4. Section [_____]: Impermeable liner.
5. Section [_____]: Edge restraints.
6. Section 00475: Storm sewer
7. Section 00425: Earthworks/excavation/soil compaction.

1.02 REFERENCES

A. American Society for Testing and Materials (ASTM)

a. C 131, Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.
b. C 136, Method for Sieve Analysis for Fine and Coarse Aggregate.
c. C 140, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units.
d. D 448, Standard Classification for Sizes of Aggregate for Road and Bridge Construction.
e. C 936, Standard Specification for Solid Interlocking Concrete Pavers.
f. C 979, Specification for Pigments for Integrally Colored Concrete.
g. C 1781, Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems
h. D 698, Test Methods for Moisture Density Relations of Soil and Soil Aggregate Mixtures Using a 5.5-lb (2.49 kg) Rammer and 12 in. (305 mm) drop.
i. D 1557, Test Methods for Moisture Density Relations of Soil and Soil Aggregate

Mixtures Using a 10-lb (4.54 kg) Rammer and 18 in. (457 mm) drop.

j. D 2922 Standard Test Methods for Density of Soil and Soil-Aggregate In-Place by Nuclear Methods (Shallow Depth).
k. D 4254, Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
l. D 6758, Standard Test Method for Measuring Stiffness and Apparent Modulus of Soil and Soil-Aggregate In-Place by Electro-Mechanical Method
m. E 2835, Standard Test Method for Measuring Deflections using a Portable Impulse Plate Load Test Device

B. Interlocking Concrete Pavement Institute (ICPI)
   a. Permeable Interlocking Concrete Pavement manual.
   b. Permeable Design Pro software for hydrologic and structural design

1.03 SUBMITTALS

A. In accordance with Conditions of the Contract and Division 1 Submittal Procedures Section.
B. Paver manufacturer's/installation subcontractor's drawings and details: Indicate perimeter conditions, junction with other materials, expansion and control joints, paver [layout,] [patterns,] [color arrangement,] installation [and setting] details. Indicate layout, pattern and relationship of paving joints to fixtures, and project formed details.
C. Minimum 3 lb. (2 kg) samples of subbase, base and bedding aggregate materials.
D. Sieve analysis of aggregates for subbase, base and bedding materials per ASTM C 136.
E. Project specific or producer/manufacturer source test results for void ratio and bulk density of the base and subbase aggregates.
F. Soils report indicating density test reports, classification, and infiltration rate measured on-site under compacted conditions, and suitability for the intended project.
G. Erosion and sediment control plan.
H. Permeable concrete pavers:
   a. Paver manufacturer's catalog sheets with product specifications.
   b. [Four] representative full-size samples of each paver type, thickness, color, and finish. Submit samples indicating the range of color expected in the finished installation.
   c. Accepted samples become the standard of acceptance for the work of this Section.
   d. Laboratory test reports certifying compliance of the concrete pavers with ASTM C 936.
   e. Manufacturer's certification of concrete pavers by ICPI as having met applicable ASTM standards.
   f. Manufacturers' material safety data sheets for the safe handling of the specified paving materials and other products specified herein.
   g. Paver manufacturer's written quality control procedures including representative samples of production record keeping that ensure conformance of paving products to the product specifications.
I. Paver Installation Subcontractor:
   a. Demonstrate that job foremen on the project have a current certificate from the Interlocking Concrete Pavement Institute Concrete Paver Installer Certification program.
   b. Job references from projects of a similar size and complexity. Provide Owner/Client/General Contractor names, postal address, phone, fax, and email address.
   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.

1.04 QUALITY ASSURANCE

A. Paver Installation Subcontractor Qualifications:
   1. Utilize an installer having successfully completed a minimum of five concrete paver installation similar in design and material indicated on the project plan.

2. Utilize an installer with job foremen or site manager holding a record of completion of the North Carolina State University Stormwater BMP Inspection & Maintenance Certification Workshop.

C. Review the manufacturers' quality control plan, paver installation subcontractor's Method Statement and Quality Control Plan with a pre-construction meeting of representatives from the manufacturer, paver installation subcontractor, general contractor, engineer and/or owner's representative.

1.05 DELIVERY, STORAGE, AND HANDLING

A. General: Comply with Division 1 Product Requirement Section.
B. Comply with manufacturer's ordering instructions and lead-time requirements to avoid construction delays.
C. Delivery: Deliver materials in manufacturer's original, unopened, undamaged container packaging with identification tags intact on each paver bundle.
   1. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.
   2. Deliver concrete pavers to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by forklift or clamp lift.
   3. Unload pavers at job site in such a manner that no damage occurs to the product or existing construction
D Storage and Protection: Store materials in protected area such that they are kept free from mud, dirt, and other foreign materials.

1.06 ENVIRONMENTAL REQUIREMENTS

A. Do not install in rain or snow.
B. Do not install frozen bedding materials.

1.07 MAINTENANCE

A. Pavers shall be from the same production run as installed materials.

PART 2 PRODUCTS

2.01 PAVING UNITS

A. Manufacturer: Varies
B. Permeable Interlocking Concrete Paver Units:
   1. Paver Type:
      a. Material Standard: Comply with ASTM C 936.
      b. Color: Holland-Guilford blend
      c. Color Pigment Material Standard: Comply with ASTM C 979.
      d. Size: Length and width variable. 3 1/8 inches (80 mm) thick.
      e. Average compressive strength: 8000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa).
      f. Average water absorption (ASTM C 140): 5% with no unit greater than 7%
      g. Freeze/thaw testing requirements: Waved for applications not exposed to freezing conditions.

Note: Concrete pavers may have spacer bars on each unit. Spacer bars are recommended for mechanically installed pavers. Manually installed pavers may be installed with or without spacer bars. Verify with manufacturers that overall dimensions do not include spacer bars.

Note: When 3 1/8 in. thick pavers are specified, their compressive strength test results per ASTM C 140 should be adjusted by multiplying by 1.18 to equate the results to that from 2 3/8 in. (60 mm) thick pavers.

2.02 PRODUCT SUBSTITUTIONS

A. Substitutions: No substitutions permitted.

2.03 CRUSHED STONE FILLER, BEDDING, BASE AND SUBBASE

A. Crushed stone with 90% fractured faces, LA Abrasion < 40 per ASTM C 131, minimum CBR of 80% per ASTM D 1883.
B. Do not use rounded river gravel for vehicular applications.
C. All stone materials shall be washed with less than 1% passing the No. 200 sieve.
D. Joint/opening filler, bedding, base and subbase: conforming to ASTM D 448 gradation as shown in Tables 1, 2 and 3 below:

Note: No. 89 or No. 9 stone may be used to fill pavers with narrow joints.

Table 1
ASTM No. 8 Grading Requirements
Bedding and Joint/Opening Filler

Sieve Size	Percent Passing
12.5 mm (1/2 in.)	100
9.5 mm (3/8 in.)	85 to 100
4.75 mm (No. 4)	10 to 30
2.36 mm (No. 8)	0 to 10
1.16 mm (No. 16)	0 to 5

Table 2
ASTM No. 57 Base
Grading Requirements

Sieve Size	Percent Passing
37.5 mm (1 1/2 in.)	100
25 mm (1 in.)	95 to 100
12.5 mm (1/2 in.)	25 to 60
4.75 mm (No. 4)	0 to 10
2.36 mm (No. 8)	0 to 5

Note: ASTM No. 3 or No. 4 stone may be used as subbase material if ASTM No. 2 stone is unavailable.

Table 3
Grading Requirement for ASTM No. 2 Subbase

Sieve Size	Percent Passing
75 mm (3 in.)	100
63 mm (2 1/2 in.)	90 to 100
50 mm (2 in.)	35 to 70
37.5 mm (1 1/2 in.)	0 to 15
19 mm (3/4 in.)	0 to 5

2.04 ACCESSORIES

A. Provide accessory materials as follows:

Note: Curbs will typically be cast-in-place concrete. Concrete curbs may be specified in Section 00455. Do not use plastic edging with steel spikes to restrain the paving units for vehicular applications.

1. Edge Restraints
   a. Manufacturer: Varies
   b. Material: Concrete.
   c. Material Standard: 3000 psi (21 MPa)

2. Geotextile:

a. Material Type and Description: woven
b. Material Standard: apparent opening size of 0.300 to 0.600 mm in minimum of 12-inch wide (305 mm)
c. Manufacturer: varies

3. Underdrain piping
   a. Manufacturer: Varies
   b. Material: schedule 40 Polyvinyl chloride (PVC), rigid polyvinyl chloride compound, Type 1 Grade 1 with a Cell Classification of 12454 as defined in ASTM D 1784 trade name designation H707 PVC, being white or gray in color as specified.
   c. Material standard: All sizes shall be manufactured in strict accordance to the requirements of ASTM D1785 for physical dimensions and tolerances. It shall also meet the requirement of ASTM D2665 standard specification for PVC plastic drain, waste and vent (DWV) pipe and shall be dual marked as such.

PART 3 EXECUTION

3.01 ACCEPTABLE INSTALLERS

A. See Paver Installation Subcontractor Qualifications in Section 1.04 (Quality Assurance)

3.02 EXAMINATION

Note: The elevations and surface tolerance of the soil subgrade determine the final surface elevations of concrete pavers. The paver installation contractor cannot correct deficiencies excavation and grading of the soil subgrade with additional bedding materials. Therefore, the surface elevations of the soil subgrade should be checked and accepted by the General Contractor or designated party, with written certification presented to the paver installation subcontractor prior to starting work.

A. Acceptance of Site Verification of Conditions:
   1. General Contractor shall inspect, accept and certify in writing to the paver installation subcontractor that site conditions meet specifications for the following items prior to installation of interlocking concrete pavers.

Note: Compaction of the soil subgrade is optional and should be determined by the project engineer. If the soil subgrade requires compaction, compact to a minimum of 95% standard Proctor density per ASTM C 698. Compacted soil density and moisture should be checked in the field with a nuclear density gauge or other test methods for compliance to specifications. Stabilization of the soil and/or base material may be necessary with weak or continually saturated soils, or when subject to high wheel loads. Compaction will reduce the permeability of soils. If soil compaction is necessary, reduced infiltration may require drain pipes within the open-graded subbase to conform to local storm drainage requirements.

   a. Verify that subgrade preparation, compacted density and elevations conform to specified requirements.
   b. Provide written density test results for soil subgrade to the Owner, General Contractor and paver installation subcontractor.
   c. Verify location, type, and elevations of edge restraints, [concrete collars around] utility structures, and drainage pipes and inlets.
   2. Do not proceed with installation of bedding and interlocking concrete pavers until subgrade soil conditions are corrected by the General Contractor or designated subcontractor.

3.03 PREPARATION

A. Verify that the soil subgrade is free from standing water.
B. Stockpile joint/opening filler, base and subbase materials such that they are free from standing water, uniformly graded, free of any organic material or sediment, debris, and ready for placement.
C. Edge Restraint Preparation:
    1. Install edge restraints per the drawings at the indicated elevations (Sheet 25 of 30).

3.04 INSTALLATION

Note: The minimum slope of the soil subgrade is 0%. Actual slope of soil subgrade will depend on the drainage design and exfiltration type. All drain pipes, observation wells, overflow pipes, and (if applicable) geotextiles, berms, baffles and impermeable liner should be in place per the drawings prior to or during placement of the subbase and base, depending on their location. Care must be taken not to damage drainpipes during compaction and paving. No mud or sediment can be left on the base or bedding aggregates. If they are contaminated, they must be removed and replaced with clean materials.

A. General
    1. Any excess thickness of soil applied over the excavated soil subgrade to trap sediment from adjacent construction activities shall be removed before application of the subbase materials.
    2. Keep area where pavement is to be constructed free from sediment during entire job. Base and bedding materials contaminated with sediment shall be removed and replaced with clean materials.
    3. Do not damage drainpipes, overflow pipes, observation wells, or any inlets and other drainage appurtenances during installation. Report any damage immediately to the project engineer.
B. Geotextiles
    1. Place on sides of soil subgrade/curbing base as indicating in the cross sections of the plan. Secure in place to prevent wrinkling from vehicle tires and tracks.
    2. Overlap a minimum of 0.3 m (12 in.) in the direction of drainage.
C. Open-graded subbase and base

Note: Compaction of areas or sites that cannot accommodate a roller vibratory compactor may use a minimum 13,500 lbf (60 kN) vibratory plate compactor with a compaction indicator. At least three passes should be made over each lift of the subbase and base aggregates.

    1. Moisten, spread and compact the No. 2 subbase in 4 to 6 in. (100 to 150 mm) lifts.
    2. For each lift, make at least three passes in the vibratory mode then at least two in the static mode with a minimum 10 t (8 T) vibratory roller until there is no visible movement of the No. 2 stone. Do not crush aggregate with the roller.
    3. The surface tolerance of the compacted No. 2 subbase shall be ±2 1/2 in. (± 65mm) over a 10 ft (3 m) straightedge.
    4. Moisten, spread and compact the No. 57 base layer in one 4 in. (100 mm) thick lift.
        i. On this layer, make at least two passes in the vibratory mode then at least two in the static mode with a minimum 10 t (8 T) vibratory roller until there is no visible movement of the No. 57 stone. Do not crush aggregate with the roller.
        ii. The surface tolerance the compacted No. 57 base should not deviate more than. ±1 in. (25 mm) over a 10 ft (3 m) straightedge.

E. Bedding layer
    1. Moisten, spread and screed the No. 8 stone bedding material.
    2. Fill voids left by removed screed rails with No. 8 stone.

3. The surface tolerance of the screeded No. 8 bedding layer shall be ±3/8 in (10 mm) over a 10 ft (3 m) straightedge.
4. Do not subject screeded bedding material to any pedestrian or vehicular traffic before paving unit installation begins.

F. Permeable interlocking concrete pavers and joint/opening fill material

1. Lay the paving units in the pattern(s) and joint widths shown on the drawings. Maintain straight pattern lines.
2. Fill gaps at the edges of the paved area with cut units. Cut pavers subject to tire traffic shall be no smaller than 1/3 of a whole unit.
3. Cut pavers and place along the edges with a double-bladed splitter or masonry saw.
4. Fill the openings and joints with No. 8 stone.
5. Remove excess aggregate on the surface by sweeping pavers clean.
6 Compact and seat the pavers into the bedding material using a low-amplitude, 75-90 Hz plate compactor capable of at least 5,000 lbf (22 kN). This will require at least two passes with the plate compactor.
7. Do not compact within 6 ft (2 m) of the unrestrained edges of the paving units.
8. Apply additional aggregate to the openings and joints if needed, filling them completely. Remove excess aggregate by sweeping then compact the pavers. This will require at least two passes with the plate compactor.
9. All pavers within 6 ft (2 m) of the laying face must be left fully compacted at the completion of each day.
10. The final surface tolerance of compacted pavers shall not deviate more than ±3/8 (10 mm) under a 10 ft (3 m) long straightedge.
11. The surface elevation of pavers shall be 1/8 to 1/4 in. (3 to 6 mm) above adjacent drainage inlets, concrete collars or channels.

G. PVC Underdrain pipe

1. Only install PVC underdrains in the applicable PICP systems—not all installation on the project have underdrains.
2. Attach a utility trace wire to all PVC for future utility locate ease.
3. The underdrain should be manually perforated by a drill, with circular perforations being 3/8-inch in diameter. They should be spaced every 4-inches on center, and every 90-degrees radially around the pipe.
4. Any PVC not located directly in the permeable pavement aggregate shall be solid, and not perforated. Attach and hydraulically seal perforated sections, solid sections, and any adapters (elbows, tees, wyes, etc.).

3.05 FIELD QUALITY CONTROL

A. After sweeping the surface clean, check final elevations for conformance to the drawings.
B. Lippage: No greater than 1/8 in. (3 mm) difference in height between adjacent pavers.

Note: The surface of the pavers may be 1/8 to 1/4 in. (3 to 6 mm) above the final elevations after compaction. This helps compensate for possible minor settling normal to pavements.

C. The surface elevation of pavers shall be 1/8 to 1/4 in. (3 to 6 mm) above adjacent drainage inlets, concrete collars or channels.
D. Bond lines for paver courses: ±½ in. (±15 mm) over a 50 ft (15 m) string line.
E. Verify the surface infiltration at a minimum of 100 in./hour using test method C 1781.

3.06 PROTECTION

A. After work in this section is complete, the General Contractor shall be responsible for protecting work from sediment deposition and damage due to subsequent construction activity on the site.

B. PICP installation contractor shall return to site after 6 months from the completion of the work and provide the following as required: fill paver joints with stones, replace broken or cracked pavers, and re-level settled pavers to initial elevations. Any additional work shall be considered part of original bid price and with no additional compensation.

END OF SECTION