



Aqua-Bric®

PERMEABLE PAVER

A uniquely designed permeable paver that allows water to infiltrate the pavement, reducing storm water runoff and recharging the ground water system.

- Meets EPA stormwater requirements with a superior solution
- Achieve significant savings through enhanced land planning
- Deliver maximum strength to handle vehicular traffic
- Produce remarkable curb appeal and convenient maintenance access
- Reduce Urban Heat Island Effect
- Aquabric is ADA compliant
- 50 year life cycle



Commercial Parking Lots



Residential Driveways

Aqua-Bric® Permeable Paver

Enhance your property... and the world around it.

How we choose to manage stormwater runoff today will affect the delicate ecosystems in our lakes, rivers, streams and bays for years to come. In an effort to preserve and replenish our precious resources, Belgard introduces our line of environmentally responsible pavers. With its unique design, Aqua-Bric can achieve ADA compliance while promoting groundwater recharge through infiltration. Permeable pavement design does not have to sacrifice aesthetics to provide a functional and environmentally friendly, pervious surface.

Benefits of PICP Systems

- Reduces storm water volume and peak flows via infiltration
- Filters total suspended solids, nutrients and metals from storm water runoff
- Reduces runoff temperature
- Imitates predevelopment conditions
- Reduces or eliminates retention/detention facilities
- Maintains dry weather stream flows
- Promotes ground water recharge
- Reduces downstream erosion and preserves existing systems
- Reduces Urban Heat Island Effect



BE PREPARED FOR COMPANY.™

AQUA-BRIC



*Aqua Bric Permeable ADA
Compliant (80mm)
Unit measure: SF
Specs: 5" x 10" x 3 1/8"*



*Belgard is a member of the
ICPI and NCMA and complies
with or surpasses the standards
of both organizations.*



BELGARD
— environmental —

1-877-BELGARD
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Atlanta, GA 30350
www.belgard.biz



Aqua-Bric

Section 32 14 13.19

PERMEABLE INTERLOCKING PRECAST CONCRETE UNIT PAVING

Note: This specification covers the general installation of a Permeable Interlocking Concrete Pavement System comprised of Concrete Pavers with Permeable Joint Material, a Bedding Course / Base Course / Sub-base Course each consisting of open graded aggregates, and an Edge Restraint consisting of cast-in-place concrete. An optional Geotextile, and/or a Membrane Liner, may be used directly above the subgrade, and Horizontal Drainage Piping installed at a set elevation, depending on the System design. Where alternate aggregate materials are specified to meet the project conditions and location, this specification will need to be modified accordingly.

This specification does not apply to roof pavers (Section 07 76 00), concrete overlays (Section 32 01 26.74), standard interlocking concrete pavements (Section 32 14 13.13), or precast concrete unit paving slabs (Section 32 14 13.16)

PART 1 – GENERAL SPECIFICATIONS

1.01 Section Includes

- A. Work consists of furnishing and construction of a Permeable Interlocking Concrete Pavement System in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the plans.
- B. Installation work includes:
 - 1. Verifying Subgrade is to the lines, grades, infiltration rate, and density shown on the construction drawings;
 - 2. Furnishing and installing Geotextile and/or Membrane Liner (where required), Horizontal Drainage Piping (where required), Sub-base Course, Base Course, Bedding Course, Edge Restraint, Concrete Pavers and Permeable Joint Material to the lines and grades shown on the construction drawings.

1.02 Related Sections

- A. Section 31 00 00 Earthwork
- B. Section 31 05 19.13 Geotextiles for Earthwork
- 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 References

- A. American Association of State Highway and Transportation Officials (AASHTO)
 - 1. GDPS-4-M Guide for Design of Pavement Structures

- B. American Society of Civil Engineers (ASCE)
 - 1. ASCE 58-10 Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways

- C. American Society for Testing and Materials (ASTM)
 - 1. ASTM C-29 Bulk Density ("Unit Weight") and Voids in Aggregate
 - 2. ASTM C-94 Standard Specification for Ready Mixed Concrete
 - 3. ASTM C-131 Resistance to Degradation of Small-Sized Course Aggregate by Abrasion and Impact in the Los Angeles Machine
 - 4. ASTM C-136 Sieve Analysis of Fine and Course Grained Aggregates
 - 5. ASTM C-140 Sampling and Testing Concrete Masonry Units and Related Units
 - 6. ASTM C-936 Solid Concrete Interlocking Paving Units
 - 7. ASTM C-979 Pigments for Integrally Colored Concrete
 - 8. ASTM C-1645 Freeze-thaw and De-icing Salt Durability of Solid Interlocking Paving Units
 - 9. ASTM D-448 Standard Classification for Sizes of Aggregates for Road and Bridge Construction
 - 10. ASTM D-698 Laboratory Compaction Characteristics of Soil Using Standard Effort
 - 11. ASTM D-1557 Laboratory Compaction Characteristics of Soil Using Modified Effort
 - 12. ASTM D-1883 CBR (California Bearing Ratio) of Laboratory Compacted Soils
 - 13. ASTM D-2488 Description and Identification of Soils (Visual-Manual Procedure)
 - 14. ASTM D-3034 Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe and Fittings
 - 15. ASTM D-3350 Polyethylene Plastic Pipe and Fittings Materials
 - 16. ASTM D-4873 Identification, Storage and Handling of Geosynthetic Rolls and Samples
 - 17. ASTM D-6928 Resistance of Course Aggregates to Degradation by Abrasion in the Micro-Deval Apparatus

- D. Interlocking Concrete Pavement Institute (ICPI)
 - 1. Permeable Interlocking Concrete Pavement manual (latest edition)
 - 2. Permeable Design Pro software for hydrologic and structural design
 - 3. Tech Spec Technical Bulletins.

1.04 Submittals

- A. Contractor shall submit to the owner for approval, and retain for the balance of the project, a minimum of four full size samples of each Concrete Paver type/size/thickness/color/finish specified; the samples shall represent the range of shape, texture and color permitted for the respective type. Color(s) will be selected by Architect/Engineer/Landscape Architect/Owner from Manufacturer's standard colors.
- B. Prior to delivery of the associated material to the site, the Contractor shall submit the following product specific documentation for approval:
 - 1. Aggregates
 - 1.) Sieve analysis per ASTM C-136
 - 2.) Durability of aggregates using Micro Deval Degradation using ASTM D-6928.
 - 3.) Percentage of angular and sub-angular particles per ASTM D-2488.
 - 4.) Minimum 3 lb sample of each material for independent testing.
 - 5.) Source test results for void ratio and bulk density of the Base and Sub-base aggregates per ASTM C-29.
 - 2. Concrete Pavers:
 - 1.) Test results from an independent testing laboratory for compliance to ASTM C-936 or other applicable requirements.
 - 2.) Warranty documentation

- 3.) Close out Operations and Maintenance program
- 4.) Material Safety Data Sheets
- 3. Geosynthetics
 - 1.) One 18 inch x 18 inch panel of each geosynthetic (Geotextile or Membrane Liner) for inspection and testing. The sample panels shall be uniformly rolled and shall be wrapped in plastic to protect the material from moisture and damage during shipment. Samples shall be externally tagged for easy identification. External identification shall include: name of manufacturer; product type; product grade; lot number; and physical dimensions.
 - 2.) Material Safety Data Sheets
- 4. 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.

Note: For larger projects, the Method Statement will need to outline a method of measuring each layer (known as cluster) of pavers by the manufacturer and in the field, and a plan for dealing with the expected growth in size of each cluster. The focus is on maintaining the specified joint width and straight joint lines for the duration of the project.

1.05 Quality Assurance

- A. Contractor shall submit a list of five (5) previously constructed projects of similar size and magnitude prior to bid date to be qualified. Contact names and telephone numbers shall be listed for each project with date of completion.

Note: For mechanically installed projects, there should be verification that the Contractor has the necessary equipment, and is sufficiently familiar with its operation, to properly conduct the work. The manufacturer should also provide a description of the anticipated growth in size of each cluster, and a plan for managing the growth, so as to not interfere with placement by the paving machines. Reference ICPI Technical Specification 15 for more information.

- B. At a minimum, the Contractor's Site Foreman shall hold 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.
- C. Contractor shall conform to all local, state/provincial licensing and bonding requirements.
- D. Contractor will hold a mandatory pre-construction meeting with Design Engineer, Owner, and affected sub-trades accessing PICP work area to review method statement and quality control plan and communicate to all parties a work flow that is most desirable to meet the construction schedule as set forth by the General Contractor. Additional details of Pre-Construction meeting are outlined in Article 3.01.

1.06 Mock-Ups

- A. Install a 10 ft x 10 ft paver area following the installation practices described in Article 3.02.
- B. This area will be used to verify: surcharge of the Bedding Course; joint sizes; lines; laying pattern(s); 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.

1.07 Delivery, Storage And Handling

- A. Comply with Manufacturer's ordering instructions and lead time requirements to avoid construction delays.
- B. Coordinate delivery and paving schedule to minimize interference with normal use of buildings adjacent to paving.
- C. Contractor shall check all materials upon delivery to assure that the proper materials have been received and are in good condition before signing off on the manufacturer's packing slip.
- D. Contractor shall protect all materials from damage or contamination due to jobsite conditions and in accordance with manufacturer's recommendations. Damaged or contaminated materials shall not be incorporated into the work.
- E. Deliver Concrete Pavers 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. Handle and transport aggregates to avoid segregation, contamination and degradation. Keep different materials sufficiently separated as to prevent mixing. Do not dump or store one material on top of another unless it is part of the installation process. Cover material with waterproof covering to prevent exposure to rainfall or removal by wind – secure the covering in place.
- G. Geosynthetics shall be delivered, stored and handled in accordance with ASTM D-4873.

1.08 Environmental Conditions

- A. Do not install during heavy rain, freezing conditions or snowfall.
- B. Do not install on frozen soil subgrade.
- C. Do not install frozen aggregates.

1.09 Maintenance Materials

- A. Provide _____ square feet additional paver material for use by Owner for maintenance and repair as attic stock.
- B. Pavers to be from the same production run as installed materials.
- C. Store paver materials in Owner designated location.

PART 2 – PRODUCTS

2.01 Definitions

- A. Base Course – within the context of this specification, a washed open graded free draining aggregate material (#57 Stone) of a designed thickness that provides both structural support over the Sub-base and water storage capacity (within the voids). It also serves as a choking material between the Bedding Course and Sub-base.
- B. Bedding Course – within the context of this specification, a two-inch thick layer of washed open graded free draining aggregate material (#8 Stone) loosely screeded smooth for bedding of the Concrete Pavers.
- C. Concrete Pavers – within the context of this specification, solid individual paving units manufacturing from concrete that are either specifically designed for use in permeable applications (include joints and voids) or are laid in a pattern that creates large enough openings to provide infiltration. Concrete Pavers are shipped in clusters called bundles or cubes, which consist of several layers of pavers strapped or wrapped together.
 - a. Voids – larger openings between the individual pavers that provide for infiltration.
 - b. Joints – smaller openings between the individual pavers that provide vertical and horizontal interlock between units.
- D. Edge Restraint – within this specification, a cast in place concrete curb, 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 include plastic, steel or aluminum edging, cut stone, precast concrete and submerged concrete edge complete with mortared pavers.

Note: for commercial applications, cast in place concrete Edge Restraints are recommended as they provide the greatest resistance to lateral movement. The other alternatives are listed for informational purposes only.

- E. Geotextile – Woven or non-woven fabrics made from plastic fibers used primarily for separation between Sub-base and Subgrade.
- F. Horizontal Drainage Piping – series of horizontal pipes within the sub-base that discharge to a catchbasin, ditch or other receiving body beyond the extent of the paved area. Piping is typically elevated in a Partial Exfiltration System, and at the bottom of the Sub-base in a No Exfiltration System.
- 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 No Exfiltration System, used to prevent the exfiltration/discharge of water other than through the Horizontal Drainage Piping. Usually includes a geotextile on top (possibly bottom) for protection.
- J. Permeable Joint Material – a washed open graded free draining aggregate material (typically #8, #89 or #9 Stone) used to fill the spaces (joints and voids) between Concrete Pavers to create interlock and still maintain infiltration.
- K. Permeable Interlocking Concrete Pavement System – a system of paving consisting of Concrete Pavers placed in an interlocking pattern with the joints and voids filled with Permeable Joint Material. The minimum rate of infiltration of the Concrete Pavers and Permeable Jointing Material is 10 inches per hour, or the design storm, whichever is greater. The Bedding Course, Base Course and Sub-base Courses provide structural support over the Subgrade and stores, exfiltrates (into the Subgrade) and/or drains the infiltrating water.

- L. Sub-base Course – within the context of this specification, an open graded free draining aggregate material (#2 Stone) of a designed thickness that provides both structural support over the Subgrade and water storage capacity (within the voids).
- M. Subgrade – the soil upon which the pavement structure and shoulders are constructed.

2.02 Concrete Pavers

- A. Supplied by: **Belgard Hardscapes**

Georgia Masonry Supply

1443 Battle Creek Road,
Jonesboro, GA 30236
800-621-5222
770-471-2128 Fax

- B. Concrete Paver product required:

Product Type: **Aqua-Bric**

Product Size: 5" X 10"

Product Thickness: 3 1/8"

Product Color: _____

Product Finish: Standard

NOTE: For specific product availability, contact your regional Belgard representative or visit our web site at BelgardCommercial.com.

NOTE: The pattern in which pavers are installed is very important in vehicular applications. Avoid patterns with long continuous lines; these may be subject to failure under vehicular traffic.

NOTE: There are recommended minimum thicknesses, and maximum aspect ratios, of pavers used in different applications (eg: pedestrian, light vehicular, heavy vehicular). To verify what is applicable to the given project, contact your regional Belgard representative or visit our web site at BelgardCommercial.com.

- C. Concrete Pavers shall conform to the following requirements set forth in ASTM C-936:
 1. Measured length or width of test specimens shall not differ by more than +/- 0.063 in, while measured thickness shall not differ by more than +/- 0.125 in.
 2. Average compressive strength of 8,000 psi (55 MPa) with no individual unit under 7,200 psi (50 MPa) when tested in accordance with ASTM C-140.

Note: The listed compressive strength results are based on testing protocols for a 2.63 inch (60 mm) thick unit. If thicker pavers are tested, then the resulting compressive strength test results should be multiplying by the applicable adjustment factor. Please refer to ICPI Tech Spec 9 for the adjustment factors.

3. Average absorption of 5% with no unit greater than 7% when tested in accordance with ASTM C-140.
4. 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.

D.

Efflorescence shall not be a cause for rejection.

Note: Efflorescence is a whitish powder-like deposit that sometimes appears on concrete products. Calcium hydroxide and other water-soluble materials form or are present during the hydration of Portland cement. Pore water becomes saturated with these materials, and diffuses to the surface of the concrete. When this water evaporates, the soluble materials remain as a whitish deposit on the concrete surface. The calcium hydroxide is converted to calcium carbonate during a reaction with carbon dioxide from the atmosphere. The calcium carbonate is difficult to remove with water. However, the efflorescence will wear off with time, and it is advisable to wait a few months before attempting to remove any efflorescence. Commercially available cleaners can be used, provided directions are carefully followed. Some cleaners contain acids that may alter the color of the pavers.

E. Pigment in Concrete Pavers shall conform to ASTM C-979.

2.03 Bedding Course

- A. Clean, non-plastic aggregate, free from deleterious or foreign matter, manufactured from crushed rock.
- B. Micro Deval Degradation of less than 8% as per ASTM D-6938.
- C. Percent of angular and sub-angular particles greater than 90%. 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 to conform to Table 1 as tested in accordance to ASTM C-136. All aggregates shall have equal to or less than 2% passing the No. 200 (0.075 mm) sieve.

Table 1
Grading Requirements for Bedding Course (ASTM No. 8 Stone per ASTM D-448)

Sieve Size	Percent Passing
1/2 in. (12.5 mm)	100
3/8 in. (9.5 mm)	85 to 100
No. 4 (4.75 mm)	10 to 30
No. 8 (2.36 mm)	0 to 10
No. 16 (1.18 mm)	0 to 5

2.04 Permeable Joint Material

- A. Where joints are greater than or equal to 1/4 inch, use ASTM No. 8 Stone as specified for the Bedding Course.
- B. Where joints are less than 1/4 inch, use pre-bagged Permeable Joint Material as supplied by Belgard.

2.04 Base and Sub-base

- A. Clean, non-plastic aggregate, free from deleterious or foreign matter, manufactured from crushed rock.
- B. Micro Deval Degradation of less than 8% as per ASTM D-6938.
- C. Percent of angular and sub-angular particles greater than 90%. 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 Base Course to conform to Table 2 as tested in accordance to ASTM C-136. Gradation of Sub-base Course to conform to Table 3 as tested in accordance to ASTM C-136. All aggregates shall have equal to or less than 2% passing the No. 200 (0.075 mm) sieve.

Table 2
Grading Requirements for Base Course (ASTM No. 57 Stone per ASTM D-448)

Sieve Size	Percent Passing
1-½ in. (37.5 mm)	100
1 in. (25 mm)	95 to 100
½ in. (12.5 mm)	25 to 60
¾ in. (9.5 mm)	0 to 10
No. 4 (4.75 mm)	0 to 5

Table 3
Grading Requirements for Sub-base Course (ASTM No. 2 Stone per ASTM D-448)

Sieve Size	Percent Passing
3 in. (75 mm)	100
2- ½ in. (63 mm)	90 to 100
2 in. (50 mm)	35 to 70
1-½ in. (37.5 mm)	0 to 15
¾ in. (19 mm)	0 to 5

2.06 Edge Restraints

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

2.07 Geosynthetics

- A. Where required, Geotextile and/or Membrane Liner materials shall be selected by the Design Engineer based on the intended use.

2.08 Horizontal Drainage Piping

- A. The Horizontal Drainage 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.

PART 3 – EXECUTION

3.01 Inspection

Note: Construction drawings and design calculations for the Permeable Interlocking Concrete Pavement System are typically prepared and stamped by a Professional Engineer registered in the state of the project. The engineering designs, techniques, and material evaluations should be completed in accordance with the ICPI Permeable Paver Design Manual, and/or State/County/City Stormwater Regulations (whichever is applicable to designer). However, the Contractor still has an obligation to the Owner to provide a quality product; it is for this reason that the Contractor, being the one most familiar with the site, is required to conduct a Pre-Construction Inspection to ensure that nothing is overlooked.

- A. Prior to commencement of any work, the Contractor shall conduct a pre-construction meeting with the Owner, Design Engineer and affected sub-trades. The pre-construction meeting should, at a minimum, verify:
- a. The location of the Mock Up, and whether it will be part of the final construction or need to be removed.
 - b. The site layout conforms to the Site Plan. In particular, the location and elevation of discharge points (if any) of the Horizontal Drainage Pipes.
 - c. The excavation work conforms to the specified lines and elevations. Subgrade shall be trimmed to within 0 and 1/2 in of the specified grades. The surface of the prepared Subgrade shall not deviate by more than 3/8 in from the bottom edge of a 10-foot straight edge laid in any direction.
 - d. The condition of the subgrade, in particular that the surface infiltration (where desired) has not been adversely impacted by the excavation work. Where compaction is desired, that the compaction densities have been met.

Note: Compaction of the soil subgrade may be necessary to achieve stability under vehicle load. Compaction, however, will reduce the permeability of soils. In such cases, laboratory and on-site testing for density and soil permeability should be conducted. These can help establish a relationship between compacted density and anticipated design permeability after compaction. An experienced civil or geotechnical engineer familiar with local soil conditions should be consulted for determining project standards for the percentage of soil Proctor density and test methods for permeability. When soil compaction is required, standard Proctor density per ASTM D-698 for pedestrian areas and residential driveways is recommended. Modified Proctor density per ASTM D-1557 is recommended for areas subject to heavy vehicular traffic. Density and moisture should be checked in the field with a nuclear density gauge or other test methods for compliance to specifications.

- e. Locations of curbs, grade beams, utility structures, light standards, tree wells or any other protrusions as applicable to the project.
 - f. The details of the site's 'Erosion and Sediment Control Plan'.
 - g. Panel Installation Drawings for the Geosynthetics, in particular the location of any protrusions through the Membrane Liner where boots are required.
- B. Although the Owner may provide soil testing and quality assurance inspection during earthwork and Subgrade preparation, the Owner's quality assurance program does not relieve the Contractor of responsibility for quality control and system performance. Contractor shall obtain any quality control testing or inspection not provided by the Owner that is necessary to satisfy the Contractor with the condition of the Subgrade prior to commencement of the work. This may include:
- a. Proof rolling of the subgrade to determine presence of soft spots or localized pockets of objectionable materials.
 - b. Infiltration testing to verify the subgrade has not been adversely impacted.
 - c. Compaction testing.

- C. Where deficiencies or inconsistencies are identified, the Contractor shall notify the Design Engineer in writing. The Contractor will not proceed with the work until the Design Engineer has verified that the deficiencies or inconsistencies have been addressed.
- D. Beginning of Installation means acceptance of Subgrade.

3.02 Installation Base Course

- A. Keep area where pavement is to be constructed free from sediment during the entire job. Any materials contaminated with sediment shall be removed and replaced with clean material.
- B. Install Membrane Liner in accordance with the manufacturer's recommendations. 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. After completion of the surface, the excess liner should be cut flush with the finished grade,

Note: Where required, the Membrane Liner is placed on the prepared soil subgrade as a containment (impermeable) material. Sections are welded together, and boots are installed around all protrusions.

- C. Install Geotextiles as required in accordance with the specifications and drawings. The Geotextile is applied to the bottom and sides of the excavation with overlapping joints a minimum of 12 inches. Overlaps to follow down slope. Allow for enough geotextile to exceed the final elevation of the surface. After completion of the surface, the excess geotextile should be cut flush with the finished grade,

Note: Where required, Geotextile is placed on the prepared soil subgrade as a separation material. Overlap is a function of CBR: 12 to 18 inches for CBR of 3 and above; 24 to 36 inches for CBR of 1.0 to 3.0; or, sewn for CBR less than 1.0. Please consult manufacturers' specifications and the Geotechnical Engineer.

- D. 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 Sub-base without displacing or damaging the geosynthetics (if used). To prevent damage, tracked vehicles must not be used to spread the initial Sub-base layer.
 - 2. The aggregate should be spread and compacted in uniform layers not exceeding 6 inch 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 visible movement in the materials.
 - 3. At the specified elevation(s), install the Horizontal Drain Pipes in accordance with the manufacturer's recommendations. Ensure the Pipes are properly sloped to provide proper drainage to the outlets Pipes shall be surrounded by a minimum of 4 inches of Base Course material to prevent damage from the Sub-base material. Care must be taken not to damage Horizontal Drain Pipes during subsequent aggregate installation.

Note: the Horizontal Drain Pipes are surrounded by the #57 stone (Base Material) as the larger sized pieces within the #2 Stone Sub-base Material) can perforate the plastic pipe.

4. Final surface tolerance should be plus or minus 1 inch over a 10 foot straight edge laid in any direction.
 5. 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 Owner or the Consultant

3.03 Installation 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 not less than 6 inch 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.

3.04 Installation Bedding Course, Concrete Pavers and Permeable Joint Material

- A. Spread the Bedding Course evenly over the Base Course and screed to a nominal 2 in. 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. Moisten and lightly compact the Bedding Course using a Plate Compactor. Surface tolerances shall be 3/8 inch over a 10-foot straight edge.
- D. Loose screed the bedding course.
- E. 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 replaced. Initiation of Concrete Paver placement shall be deemed to represent acceptance of the pavers.
- F. Lay the Concrete Pavers in the pattern(s) as shown on the drawings. Maintain straight pattern lines.
- G. Paving units shall be installed from a minimum of 3 bundles for hand installations, 6 bundles for mechanical installations, simultaneously to ensure color blending.

Note: Color variation occurs with all concrete products. This phenomenon is influenced by a variety of factors, e.g. moisture content, curing conditions, different aggregates and, most commonly, from different production runs. By installing from a minimum of three bundles simultaneously, variation in color is dispersed and blended throughout the project.

- H. Joints between the individual Concrete Pavers shall be maintained according to the spacer bars.
- I. 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.
- J. 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.

- K. 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.
- L. 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 Permeable Joint Material.
- M. Any units that are structurally damaged during compaction shall be immediately removed and replaced.
- N. Apply a dressing of Permeable Joint Material to the surface and sweep into the joints and voids. Fill joints and voids, 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.
- O. Do not compact within 6 feet of the unrestrained edges of the paving units.
- P. All work to within 3 ft (1 m) 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.
- Q. Sweep off excess aggregate when the job is complete.

3.05 Quality Assurance/Quality Control

- A. Quality Assurance - The Owner may engage inspection and testing services, including independent laboratories, to provide quality assurance and testing services during construction. This does not relieve the Contractor from securing the necessary construction quality control testing.
- B. Quality assurance should include as a minimum verification with the Design Engineer that the Contractor's quality control plan and testing are adequate. Quality assurance shall also include observation of construction for general compliance with design drawings and project specifications.
- C. Quality Control – The Contractor shall engage inspection and testing services to perform the minimum quality control testing described in the design plans and specifications. Only qualified and experienced technicians and engineers shall perform testing and inspection services.
- D. Quality control testing shall include backfill testing to verify soil types and compaction, and verification that the system is being constructed in accordance with the design plans and project specifications.

3.06 As-built Construction Tolerances

- A. Final inspection shall be conducted to verify conformance to the drawings after removal of excess aggregate. All pavements shall be finished to lines and levels to ensure positive drainage at all drainage outlets and channels.
- B. The final surface elevations shall not deviate more than +/- 3/8 inch under a 10 ft long straight edge.

Note: For installation on a compacted aggregate base and soil subgrade, the specifier should be aware that the top surface of the pavers may be 1 /8 to 1 /4 in. (3 to 6 mm) above the final elevations after compaction. This difference in initial and final elevation is to compensate for possible minor settling.

END OF SECTION