DESIGNER NOTE: The specifications below are based on the best available information. Designer should modify the specifications to satisfy project-specific constraints. The City uses the term “Permeable Unit Pavers” when infiltration achieved via aggregate filled joints (most common) and “Porous Unit Pavers” when infiltration is achieved through the paver material itself (less common).

DESIGNER NOTE: Green text corresponds to notes to the designer.

1. GENERAL
   1. SUMMARY
      1. This section Includes:
         1. Permeable/Porous Unit Pavers
         2. Joint Filter Aggregate
         3. Pavement Base
         4. Edge Restraints & Accessories
         5. Geotextile for Soil Separation
      2. Related Sections

DESIGNER NOTE: The designer should list any additional specification sections which relate to the permeable/porous unit paver work (i.e., temporary erosion control, utilities, earthwork, etc.)

* 1. STANDARDS AND CODES
     1. Reference Standards: This section incorporates by reference the latest version of the following documents. These references are a part of this section as specified and modified.

|  |  |
| --- | --- |
| Reference | Title |
| Caltrans | Standard Specifications |
| San Francisco DPW | Engineering Standard Specifications |
| ASTM C67 | Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units |
| ASTM C13 | Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine |
| ASTM C136 | Method for Sieve Analysis for Fine and Coarse Aggregate |
| ASTM C140 | Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units |
| ASTM D448 | Standard Classification for Sizes of Aggregate for Road and Bridge Construction |
| ASTM C936 | Standard Specification for Solid Interlocking Concrete Pavers |
| ASTM C979 | Specification for Pigments for Integrally Colored Concrete |
| ASTM C1781 | Standard Test Method for Surface Infiltration Rate of Permeable Unit Pavement Systems |
| ASTM E2835 | Standard Test Method for Measuring Deflections using a Portable Impulse Plate Load Test Device |

* 1. REFERENCES

DESIGNER NOTE: Designer to provide references to related industry manuals and guidance and all project specific documents (e.g., geotechnical report).

* + 1. Interlocking Concrete Pavement Institute (ICPI)
       1. Permeable Interlocking Concrete Pavement manual (Fifth Edition, or later).

DESIGNER NOTE: The designer should consider the use of the ICPI Permeable Design Pro software for structural design and determination of adequate depth for the pavement section.

* 1. SUBMITTALS
     1. Bid Submittals: The Contractor shall submit to the Owner the following as part of the bid proposal:
        1. Paver Installation Contractor/Subcontractor:
           1. A copy of Contractor/Subcontractor’s current certificate from the Interlocking Concrete Pavement Institute’s Concrete Paver Installer Certification program.
           2. A copy of Contractor/Subcontractor’s current certificate from the Interlocking Concrete Pavement Institute’s Permeable Interlocking Concrete Paver Installer (PICP) Specialist Course Certification program.
           3. Job references from three (3) projects of a similar size and complexity. Provide Owner/Client/General Contractor names, postal address, phone number, and email address.

DESIGNER NOTE: The designer should incorporate by reference these requirements in Division 00 of the Specifications.

* + 1. Pre-Installation Submittals: The Contractor shall submit to the Engineer the following a minimum of 20 calendar days prior to the construction of the permeable/porous unit pavers:
       1. Paver manufacturer’s/installation subcontractor’s drawings and details indicating perimeter conditions, junctions with other materials, expansion and control joints, paver layout/patterns, joint spacing and/or tabs, color arrangement, and installation [and setting] procedures. Drawings and details shall also indicate layout, pattern and relationship of paving joints to fixtures and project formed details.
       2. Source certificates, gradations, R-values, LA abrasion, and cleanness values of aggregates for base, reservoir course, and joint filler materials performed within one (1) month of product delivery to site.

DESIGNER NOTE: Consider revising acceptable age of sieve test depending on scale of project. On a larger project it may be appropriate to require testing by an independent lab with samples taken at the supplier’s yard from the stockpile to be used for the project.

* + - 1. Product data sheets for unit pavers and geotextiles.
      2. Laboratory test reports certifying compliance of the concrete pavers with ASTM C936.
      3. Manufacturer’s certification of concrete pavers by ICPI as having met applicable ASTM standards.

DESIGNER NOTE: Especially when using colored pavers, consider requiring submittal of full-size samples of each paver type, thickness, color, and finish. Require submittal of samples indicating the range of color expected in the finished installation. Accepted samples would become the standard of acceptance for the work of this Section.

* 1. QUALITY CONTROL AND QUALITY ASSURANCE
     1. General: Test and inspect permeable/porous unit paver materials and operations as Work progresses as described in this section. Failure to detect defective Work or materials at any time will not prevent rejection if a defect is discovered later, nor shall it constitute final acceptance.
        1. Paver Installation Subcontractor Qualifications:
        2. Installer shall provide documentation showing three (3) successful permeable/porous unit paver installations completed in the last three (3) years, collectively totaling more than 10,000 square feet. Documentation shall include name and address of project, and contact information for project owner.
        3. Installer shall utilize job foremen holding a record of completion from the Interlocking Concrete Pavement Institute PICP Installer Technician Course.

DESIGNER NOTE: Consider changing these requirements to match scale and complexity of project including a minimum total amount of pavers placed.

* + 1. Responsibilities of Contractor
       1. Pre-Placement Conference: A mandatory pre-placement conference will take place, including at a minimum the Engineer, the Owner, general Contractor, and paver installer, to review the manufacturers’ quality control plan, personnel qualifications, and the paver installers’ Method Statement and Quality Control Plan.
       2. Reference Panel: Place reference panels on the project site, on a subgrade and base prepared as specified, using the material and construction requirements for pavement in this Specification. Each panel must have a surface area of at least 100 square feet (sf), and a width and thickness as specified for the pavement in the Contract Documents. The Engineer shall observe and accept each element of the paver construction prior to the placement of additional pavement. Failure to install acceptable reference panels of permeable/porous unit pavers will indicate an unqualified installer. Construction and evaluation of the reference panel(s) will occur as follows:
          1. Notify the Engineer at least ten (10) Working Days before installing paver reference panel.
          2. Coordinate the location of the reference panel with the Engineer.
          3. Notify the Engineer when each element of the reference panel is ready for inspection.
          4. Remove, replace, and dispose of any unsatisfactory portions of reference panel as determined by the Engineer and at no additional cost to the Owner.
          5. Retain and maintain approved reference panel during construction in an undisturbed condition as a standard for judging completed portions of the final installations.

Approved reference panels may remain as final installations of the Work at the discretion of the Engineer. If not retained, the reference panel shall be removed and disposed at no additional cost to the Owner.

DESIGNER NOTE: Mechanized installations may require a larger mock up area. Consult with the paver installation (Sub) Contractor on the size of the reference panel.

DESIGNER NOTE: Use this panel to determine expected settlement (surcharge) of the leveling course, joint sizes, and lines, laying pattern, color, and texture of the job.

DESIGNER NOTE: The designer should consider requiring verification of subgrade infiltration rate and provision to increase reservoir course depth based on results.

* + - 1. Infiltration Testing: Perform surface infiltration tests per ASTM C1781 as described below.
         1. Three (3) test locations per 10,000 square feet of permeable/porous unit pavers, in place
         2. One (1) additional test location per 5,000 square feet of permeable/porous unit pavers, or fraction thereof, in place

DESIGNER NOTE: Designer to specify the number and location(s) of required post construction infiltration tests.

* + 1. Acceptance
       1. The surface elevation of pavers shall be 1/8 to 1/4 inch (3 to 6 mm) above adjacent drainage inlets, concrete collars or channels.
       2. Lippage: No greater than 1/8 inch (3 mm) difference in height between adjacent pavers.
       3. Bond lines for paver courses shall be within ½ inch (± 15 mm) over a 50‑foot (15 m) string line.
       4. The final surface tolerance of compacted pavers shall not deviate more than ± 3/8 inch (10 mm) under a 10‑foot (3 m) long straightedge.
       5. Infiltration Rate: The average of all tests shall be greater than 50 inches per hour with no single test less than 25 inches per hour.

DESIGNER NOTE: The designer should adjust infiltration rates to reflect project specific conditions such as anticipated sediment loading based on pavement use (e.g., vehicular, pedestrian) and design run-on from adjacent surfaces. The recommended criteria are as follows:

* For permeable/porous unit pavers that will accept run-on from adjacent impervious and/or pervious surfaces OR pavement that will be subject to vehicular traffic:
  + The average of all surface infiltration tests shall be greater than 100 inches per hour with no single test less than 50 inches per hour
* For permeable pavement not subject to run-on OR vehicular traffic:
  + The average of all surface infiltration tests shall be greater than 50 inches per hour with no single test less than 25 inches per hour

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

* 1. DELIVERY, STORAGE, AND HANDLING
     1. General: Comply with Division 1 Product Requirement Section.
     2. Comply with manufacturer’s ordering instructions and lead-time requirements to avoid construction delays.
     3. 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.
     4. Unload pavers at job site in such a manner that no damage occurs to the product or existing construction.
     5. Storage and Protection: Store materials in a protected area such that they are kept free from mud, dirt, and other foreign materials.
  2. MAINTENANCE

DESIGNER NOTE: Consider requiring the provision of additional pavers to be retained and stored by the Owner for future maintenance.

* Extra materials: Provide [Specify area] [Specify percentage] additional material for use by Owner for maintenance and repair.
* Extra pavers shall be from the same production run as installed materials.

1. PRODUCTS

DESIGNER NOTE: Some projects may include permeable/porous and solid unit pavers. Specify each product, as required.

* 1. PERMEABLE/POROUS UNIT PAVERS
     1. Manufacturer: [Specify manufacturer name.].
        1. Contact: [Specify ICPI member manufacturer contact information.].
     2. Permeable/Porous Unit Paver Type:
        1. Paver: [Specify name of product group, family, series, etc.].
        2. Material Standard: Comply with ASTM C 936.
        3. Color [and finish]: [Specify color], [Specify finish].
        4. Color Pigment Material Standard: Comply with ASTM C979.
        5. Size: [Specify] inches ([Specify] mm) x [Specify] inches ([Specify] mm) x [Specify] inches ([Specify] mm).
        6. Joint Gap Size: [Specify] inches ([Specify] mm).
        7. Joint Gap Mechanism: [Specify if integral pre-cast interlocking spacer, or other structural paver spacer] type.
        8. Bevel Size: [Specify] inches, [Specify] type.

DESIGNER NOTE: Permeable unit pavers with 3/8 inch (10 mm) or 1/2 inch (12 mm) gaps shall be permeable interlocking concrete pavers with integral precast interlocking spacer per San Francisco Public Works Order No: 200369 Attachment B Section 2(e). Permeable unit pavers with any gap size installed in areas of vehicular loading shall also have integral spacers. Permeable unit pavers with 1/4 inch (6-8 mm) gaps that are installed in areas of pedestrian loading may specify integral spacers or separate spacers that are full-depth (e.g., structural paver spacers); SFPUC to review and approve specified spacers. Tile spacers are not allowed.

* 1. JOINT FILLER AGGREGATE
     1. Crushed Particles: 90 percent (minimum) tested in accordance with California Test 205.
     2. LA Abrasion: Less than 40 tested in accordance with ASTM C131.
     3. Cleanness Value: 75 (minimum) tested in accordance with California Test 227 at least once per 500 cubic yards of base material.
     4. Rounded river gravel may not be used.
     5. Permeable Unit Paver: The following aggregate shall be used to fill joints unless manufacturer recommends otherwise. Aggregate gradations shall be per Section 2.03.C.1. If manufacturer recommendation is different from the gradations shown below the Contractor shall be notified at least 48 hours prior to placement of the joint filler.

DESIGNER NOTE: Designer to strikethrough non-proposed aggregate.

|  |  |  |
| --- | --- | --- |
| Gap Width | | Joint Filler Aggregate Gradation |
| (Inch) | (mm) |
| 3/8 or 1/2 | 10 or 12 | ASTM No. 8 or 89 |
| 1/4 | 6-8 | ASTM No. 9 |

* + 1. Porous Unit Pavers: Joint filler shall be per manufacturer’s recommendation.
  1. PAVEMENT BASE
     1. Pavement Base Material shall consist of clean, mechanically crushed stone, substantially free from adherent coatings. Materials shall be washed thoroughly to remove clay, organic matter, extraneous debris, or objectionable materials. Recycled materials or rounded river gravel are not permitted. Material shall be obtained only from a source(s) approved by the Engineer. Written requests for source approval shall be submitted to the Engineer not less than ten (10) Working Days prior to the intended use of the Material. Should the proposed source be one that the Engineer has no history of Material performance with, the Engineer reserves the right to take preliminary samples at the proposed source, and make preliminary tests, to first determine acceptability of the new source and then perform the applicable Material approval testing. Continued approval of a source is contingent upon the Materials from that source continuing to meet Contract requirements. Materials shall meet the Standard Specifications for grading and quality for use in the Work; however, allowable exceptions may be specified in the Contract. The Engineer shall reserve the right to sample and test Material at any time including at the source.
     2. Pavement Base shall consist of up to three (3) layers as specified on the Plans and included herein:
        1. “Leveling Course” shall be ASTM No. 8 (modified) stone per Section 2.03.C.

DESIGNER NOTE: This layer of the pavement base is intended to provide a smooth, level surface for placement of pavers.

* + - 1. “Base Course” shall be ASTM No. 57 (modified) stone per Section 2.03.C.

DESIGNER NOTE: This layer of the pavement base is intended to provide structural (load bearing) capacity to the pavement.

* + - 1. “Reservoir Course” shall be ASTM No. 2 (modified), ASTM No. 3 (modified), or ASTM No. 57 (modified) stone per Section 2.03.C.

DESIGNER NOTE: This layer of the pavement base is intended to provide water storage and drainage of the pavement, structural support, and a capillary break. The materials specified should be crushed, clean, washed rock to provide the desired structural capacity, maintain good drainage, function as a capillary barrier, and minimize clogging of the subgrade due to export of fines.

DESIGNER NOTE: ASTM No. 2 stone is preferred.

DESIGNER NOTE: If the designer chooses to specify materials that differ from those provided herein, the designer should check their filter criteria to evaluate the likelihood of finer-graded material migration into underlying courser graded materials or reduction in permeability relative to the underlying material. Refer to SFPUC aggregate filter criteria guidance document for information on selecting appropriate alternate materials.

* + 1. Pavement Base Material shall meet the following specifications for grading and quality.

DESIGNER NOTE: Designer to strikethrough non-proposed aggregate.

DESIGNER NOTE: If the designer chooses to specify materials per the procedure above, provide the required gradation the in the table below.

* + - 1. Aggregate Gradation tested in accordance with ASTM C136 at least once per 500 cubic yards of base material.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Sieve1 | Percent Passing by Weight | | | | | |
| ASTM No. 9 (modified)3 | ASTM No. 89 (modified) | ASTM No. 8 (modified) | ASTM No. 57 (modified) | ASTM No. 3 (modified) | ASTM No. 2 (modified) |
| 3 inch | – | – | – | – | – | 100 |
| 2 1/2 inch | – | – | – | – | 100 | 90 to 100 |
| 2 inch | – | – | – | – | 90 to 100 | 35 to 70 |
| 1 1/2 inch | – | – | – | 100 | 35 to 70 | 0 to 15 |
| 1 inch | – | – | – | 95 to 100 | 0 to 15 | – |
| 3/4 inch | – | – | – | – | – | 0 to 5 |
| 1/2 inch | 100 | 100 | 100 | 25 to 60 | 0 to 5 | – |
| 3/8 inch | 100 | 90 to 100 | 85 to 100 | – | – | – |
| No. 4 | 85 to 100 | 20 to 55 | 10 to 30 | 0 to 10 | – | – |
| No. 8 | 10 to 40 | 5 to 30 | 0 to 10 | 0 to 5 | – | – |
| No. 16 | 0 to 10 | 0 to 10 | 0 to 5 | – | – | – |
| No. 30 | – | – | – | – | – | – |
| No. 50 | – | 0 to 5 | – | – | – | – |
| No. 1002 | – | – | 0 to 2 | 0 to 2 | 0 to 2 | 0 to 2 |
| No. 2002 | 0 to 2 | 0 to 2 | – | – | – | – |

1 Sieve provided in nominal size square openings or United States Standard Sieve Series sizes.

2 Gradation modified from ASTM for portion passing the No. 100 and 200 sieve, as shown.

3 Materials likely to meet this specification are available locally as Graniterock 1/4” premium screenings (Wilson 1/4" x #10 Premium Screenings) or equivalent.

* + - 1. L.A. Abrasion: 30 percent (maximum) tested in accordance with ASTM C131.
      2. Cleanness Value: 75 (minimum) tested in accordance with California Test 227 at least once per 500 cubic yards of base material.
      3. Crushed Particles: 90 percent (minimum) with two (2) or more fractured faces tested in accordance with California Test 205.
      4. The combined portion of Material retained on the U.S. No. 4 sieve shall not contain more than 0.1 percent wood waste by weight. The portion of Material passing a U.S. No. 10 sieve shall not have wood waste that results in more than 250 parts per million of organic matter by calorimetric tests when tested. The color shall be measured after the sample has been in the test solution for 1 hour.
  1. EDGE RESTRAINTS & ACCESSORIES
     1. Provide accessory materials as follows: Edge Restraints
        1. Manufacturer: [Specify manufacturer.].
        2. Material(s): [Pre-cast concrete] [Cut stone] [steel].
        3. Material Standard: [Specify material standard.].
        4. Configuration: [Specify geometry, manufacturer’s model number, stakes or spikes, paver spacers, coatings, color, etc.]

DESIGNER NOTE: Curbs will typically be cast-in-place concrete or precast set in concrete haunches. Cast in place concrete curbs should be specified in another Section. Do not use plastic edging with steel spikes to restrain unit pavers for vehicular applications. Metal edge restraints shall be sized and specified with a product depth 1/2” maximum below top of pavers.

* 1. GEOTEXTILE FOR SOIL SEPARATION

DESIGNER NOTE: See ICPI publication, Permeable Interlocking Concrete Pavements for guidance on geotextile selection. Geotextile is not typically required under permeable pavement applications unless recommended by a geotechnical engineer. Geotextile can be placed vertically for material separation between side walls of reservoir course and native soil.

* + 1. Geotextile shall be woven, consisting only of long chain polymeric fibers or yarns formed into a stable network such that the fibers or yarns retain their position relative to each other during handling, placement, and design service life. At least 95 percent by weight of the material shall be polyolefins or polyesters. The material shall be free from defects or tears. The geotextile shall also be free of any treatment or coating which might adversely alter its hydraulic or physical properties after installation. The geotextile shall conform to the properties specified herein:

|  |  |  |
| --- | --- | --- |
| Geotextile Property | Test Method | Requirement |
| Grab Tensile Strength, minimum in weakest direction | ASTM D4632 | 200 lbs/in |
| Apparent Opening Size (AOS) | ASTM D4751 | 40 to 50 |
| Ultraviolet (UV) Radiation Stability, minimum strength retained after 500 hours in weatherometer | ASTM D4355 | 50% |
| Flow Rate, minimum | ASTM D4491 | 140 gal/min/ft2 |

DESIGNER NOTE: The designer should consider including specifications for signage and pavement markings in this section.

1. EXECUTION
   1. GENERAL
      1. Prevent runoff from adjacent pervious and impervious surfaces from entering the permeable pavement area (e.g., stabilize adjacent areas, flow diversion) until authorization is given by the Engineer/Landscape Architect. For capital projects, redevelopment projects, and any project where the permeable pavement is in the public ROW (i.e., with an SFPW encroachment permit), refer to SFPUC Specification Section 01 57 29 Temporary Protection of Green Infrastructure Facilities.
      2. Exclude equipment from permeable pavement areas that have been excavated to subgrade. No equipment shall operate on subgrade within the facility once excavation has begun, including during and after excavation. Equipment may operate on the placed aggregate surface.
      3. Prevent foreign materials and substances, such as silt laden run-off, construction debris, etc. from entering or being stored in the facility at any point during construction.
      4. Do not dump materials or substances except the aggregate within the permeable pavement area. Any foreign materials or substances shall be removed prior to aggregate placement.
   2. SUBGRADE PREPARATION AND PROTECTION
      1. Construct subgrade to +/- 3/4 inch of the grades and slopes specified on the Plans.
      2. Grading of subgrade shall be with low ground pressure equipment when within six (6) inches of final subgrade elevation.
      3. Compact subgrade to 90 percent (+/- 2 percent) of the maximum dry density per standard Proctor test (ASTM D698), or as directed by the Geotechnical Engineer. Determination of in-place density shall be made using a nuclear gauge per ASTM D6939.

DESIGNER NOTE: The designer should set compaction requirements based on consideration of site specific geotechnical properties of the native soil (e.g., permeability, stiffness) and performance requirements for the pavement section (e.g., traffic loading, infiltration, cost).

* + 1. Areas of the subgrade which are over-compacted, as determined by the Geotechnical Engineer, shall be ripped/tilled to a depth of 12 inches (minimum) or as directed by the Geotechnical Engineer and shall be recompacted in accordance with Section 3.02.C. Contractor shall locate all utilities within pavement footprint prior to ripping and re-compacting subgrade.
    2. Proof-roll prepared subgrade with loaded dump truck, remove soft spots, and replace with permeable structural fill as directed by the Engineer to achieve uniform subgrade.

DESIGNER NOTE: Other subgrade verification methods may be required if site conditions limit proof rolling. Consult with geotechnical engineer for acceptable methods.

* + 1. After compaction and proof roll, scarify subgrade ¼‑ to ½‑inch deep by hand rake. Once scarified, materials or equipment shall not be permitted within the prepared subgrade area so as to avoid recompaction or clogging of the scarified subgrade.
    2. The subgrade shall be protected from over-compaction or contamination by silty run-off or other contaminants.
       1. Provide physical barriers or direct traffic to eliminate unnecessary vehicular traffic on the subgrade during construction in accordance with SFMTA and SFDPW ordinances and specifications.
       2. Provide flow diversion and erosion control measures to protect the permeable pavement area from sedimentation until the upstream catchment area is thoroughly stabilized.
    3. Areas of subgrade over-compacted by construction traffic or other impacts by the Contractor or Subcontractors shall be ripped/tilled and re-compacted in accordance with Section 3.02.D. All work and materials required to correct the over-compacted subgrade, including utility locates within the pavement footprint, shall be at the Contractor’s expense.
    4. Areas of subgrade contaminated by the accumulation of silty material following rains or other debris or contamination shall be removed and disposed at the Contractor’s expense.
    5. The subgrade shall be inspected and accepted by the Engineer prior to placement of the geotextile or pavement base.
    6. Place geotextile, if required, on scarified subgrade. Care shall be taken to provide full coverage and to prevent the geotextile from being torn. Damaged geotextile shall be repaired as indicated by the manufacturer and to the satisfaction of the Engineer, at no additional cost to the Owner. Overlaps of the geotextile shall be a minimum of 1 foot or to the manufacturer’s recommendation, whichever is greater.

DESIGNER NOTE: The use of geotextile under permeable pavement systems should be avoided unless required by the project geotechnical engineer as it can be prone to subsurface clogging.

* 1. PAVEMENT BASE
     1. Construct pavement base to the lines, grades, and thicknesses shown on the Plans.
     2. Place the pavement base so as to prevent loaded dump trucks from driving directly on the prepared subgrade.
     3. Compact pavement base, in six (6)‑inch (maximum) lifts, by making a minimum of three passes over the pavement base material with a ten (10)‑ton vibratory roller, or as directed by the Geotechnical Engineer. The first two (2) passes (minimum) shall be in vibratory mode. Acceptance of the pavement base will be based on Engineer’s observation that compaction has achieved an unyielding surface. Compaction equipment shall be accepted by the Engineer prior to use.

DESIGNER NOTE: For areas or sites that cannot accommodate a vibratory roller compactor, consider allowing compaction of pavement base with a 13,500 lbf (60 kN) minimum vibratory plate compactor with a compaction indicator. At least two passes should be made over each lift of the aggregates.

* + 1. Pavement base shall be true to the designed grade and slope, +/- 0.05 feet, after compaction for each layer. In the event of low spots, additional material shall be added and recompacted. In the event of high spots, excess material shall be removed and the area recompacted.
    2. Pavement base materials shall be protected from over-compaction or contamination by silty run-off or other contaminants.
       1. Provide physical barriers or direct traffic to eliminate unnecessary vehicular traffic on the pavement base during construction in accordance with SFMTA and SFDPW ordinances and specifications.
       2. Do not subject placed and compacted gravel leveling course to any pedestrian or vehicular traffic before unit paver installation begins.
       3. Provide flow diversion and erosion control measures to protect the permeable pavement area from sedimentation until the upstream catchment area is thoroughly stabilized.
    3. Any damage to the pavement base (including contamination by silty run-off) shall be repaired to the satisfaction of the Engineer at the Contractor’s expense. Contaminated pavement base shall be removed and replaced to the limits as determined by the Engineer.
    4. The pavement base shall be inspected and accepted by the Engineer prior to placing any pavers.

DESIGNER NOTE: Consider developing a testing plan for the required testing and inspection of the pavement base. Verification of the in-place density/compaction of the open graded base materials is typically not possible with the use of a nuclear densometer due to nature of these materials. Therefore, other means to verify these materials are firm and unyielding (such as observation of the compaction process by a geotechnical engineer) are necessary.

DESIGNER NOTE: Consider requiring the Contractor to compact aggregates without crushing them.

* 1. PAVERS AND JOINT/OPENING FILL MATERIAL
     1. Lay the unit pavers in the pattern(s) and joint widths shown on the Plans. 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 all openings and joints with joint filler aggregate conforming to Section 2.02.
     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 to 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 feet (2 m) of the unrestrained edges of unit pavers.
     8. Apply additional joint filler 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 feet (2 m) of the laying face must be left fully compacted and joints must be filled at the completion of each working day.
     10. Compacted unit pavers shall meet the acceptance criteria set forth in Section 1.05.C.
  2. PROTECTION OF PAVEMENT
     1. Pavement surface shall be kept clean and free of clogging debris and soils from the Contractor’s operations and all upstream and adjacent debris. If debris or soils contaminate the pavers/joints, the pavement shall be cleaned at the Contractor’s expense and to the satisfaction of the Engineer. If pavement cannot be unclogged, it shall be removed and replaced at the Contractor’s expense and to the satisfaction of the Engineer.
     2. Paver installation (Sub) Contractor shall return to the site after 6 months from the completion of the Work and provide the following as needed to fully meet the specifications described herein: 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 the original bid price and with no additional compensation.
  3. REJECTION
     1. Pavers that do not meet the acceptance criteria set forth in Section 1.05.C will be rejected by the Engineer on a lot by lot basis. Permeable/porous unit pavers that have been rejected by the Engineer or the Contractor shall be removed and replaced at no additional cost to the Owner.

END OF SECTION