DESIGNER NOTE: The specifications below are based on the best available information. Designer should modify the specifications to satisfy project-specific constraints.

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

1. general
   1. SUMMARY
      1. This section includes:
         1. Porous Asphalt Pavement
         2. Pavement Base
         3. Geotextile for Soil Separation
      2. Related Sections:

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

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

|  |  |
| --- | --- |
| Reference | Title |
| Caltrans | Standard Specifications (published by State of California Business, Transportation, and Housing Agency, Department of Transportation) |
| San Francisco DPW | Engineering Standard Specifications |
| AASHTO | Standards of the American Association of State Highway and Transportation Officials, 1998 or latest edition |
| ASTM | Annual Book of ASTM Standards, American Society for Testing and Materials, Philadelphia, PA, 1997 or latest edition. |
| NAPA IS 115 | Design, Construction, and Maintenance of Open-Graded Asphalt Friction Courses |
| NAPA IS 131 | Porous Asphalt Pavements for Stormwater Management, Design, Construction, and Maintenance. |

* + - 1. Caltrans Standard Specifications: Any references to Caltrans Standard Specifications invoke technical specifications in Section 39 for material, construction, and quality control and quality assurance only. Caltrans contractual requirements, general specifications, and measurement and payment do not apply.
      2. Caltrans Standard Specifications Term Equivalencies

|  |  |
| --- | --- |
| Terms Equivalencies | |
| Term or Clause in Caltrans Standard Specifications | Term or Clause in These Specifications |
| The Department | The Owner |
| OGFC | Porous Asphalt |

* 1. REFERENCES

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

* 1. SUBMITTALS
     1. Bid Submittals: The Contractor shall submit to the Owner the following as part of the bid proposal:
        1. Project experience and personnel qualification examples as specified in Section 1.05.B for the contractor and personnel assigned to this project.

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

* + 1. Pre-Installation Submittals: Submittals shall conform to the requirements of Caltrans Standard Specifications including:
       1. Proposed job mix formula per Section 1.05.B of this Specification.
       2. Proposed QC plan per Section 39‑1.04A (General Requirements for Contractor Quality Control) and Section 39‑2.02A (Quality control plan requirements for the “Standard Construction Process”). The QC Plan shall satisfactorily test the porous asphalt for compliance with Section 39‑2.02B (Quality Control for Standard Construction Process) of the Caltrans Standard Specifications, with the following modifications and additions:
          1. Aggregate durability index shall be tested in accordance with Caltrans Test Method 229 at least one time per each 750 tons of porous asphalt.
          2. Aggregate cleanliness value shall be tested in accordance with Caltrans Test Method 227 at least one time per each 750 tons of porous asphalt.
          3. Air voids shall be tested for by determining the bulk specific gravity in accordance with ASTM D6752 or AASHTO T275, the maximum theoretical specific gravity with AASHTO T209, and the voids by test ASTM D3203.
          4. Draindown shall be tested in accordance with ASTM D6390.
          5. Retained tensile strength shall be tested in accordance with AASHTO 283.
          6. Three (3) surface infiltration tests per ASTM C1701 shall be conducted per 10,000 square feet of porous asphalt, in place and one (1) additional test per 5,000 square feet of porous asphalt, or fraction thereof, in place. Document and record the results of each field infiltration test with a designated test number. Include infiltration rate, date pavement was placed, date test was taken, and location on the site (via stationing or other means) where test was performed in each test record. If minimum required field infiltration rate is not achieved at any location as defined in this Section, re-test for field infiltration rate at a new location for each failed field infiltration test. Coordinate location with Owner’s Representative.

The QC plan shall be consistent with the Caltrans Quality Control Quality Assurance Manual for Asphalt Concrete Production and Placement (latest version).

In addition to the Caltrans submittal requirements, the Contractor shall submit the following:

* + - 1. Source certificates, gradations, R-values, LA abrasion, and cleanness values of aggregates for base and reservoir course materials performed within one (1) month of product delivery to site.
      2. Product data sheets for geotextiles.
      3. Testing agency qualifications as specified in Section 1.05.A.
  1. QUALITY CONTROL AND QUALITY ASSURANCE
     1. General: Test and inspect asphalt 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.

DESIGNER NOTE: This specification does not include a test panel/mockup due to the difficulty of installation and because physical properties of the material are known from the plant test. Consider whether project design objectives warrant the cost of a test panel/mockup.

* + - 1. Contractor and Personnel Qualifications

DESIGNER NOTE: The designer should adjust the required qualifications for the contractor and personnel based on the availability of qualified bidders and project size, complexity, and risk.

* + - * 1. Contractor qualification: The Contractor shall provide documentation showing one of the following for the general contractor or paving subcontractor:

One (1) example owner-accepted porous asphalt project, similar (or greater) in extent to the proposed project, completed in the last one (1) year with reference.

OR

Three (3) example owner-accepted open graded friction course projects completed in the last one (1) year with references.

Documentation shall include name and address of project, and contact information for project owner.

* + - * 1. Personnel qualification: The Contractor or paving subcontractor shall provide a qualified foreman with experience installing porous asphalt and documentation showing with following:

One (1) example owner-accepted porous asphalt project, similar (or greater) in extent to the proposed project, completed in the last one (1) year with reference.

Documentation shall include name and address of project, and contact information for project owner.

The qualified foreman shall be onsite for the duration of asphalt work including preparation, placement, testing, and completion.

* + - * 1. Testing agency qualification: Agencies that perform testing on porous asphalt materials shall meet the requirements of Caltrans Standard Specification Section 39‑1.03A or be accredited by the AASHTO Accreditation Program (AAP) for the scope and standard being evaluated.
        2. Plant qualification: Batch or continuous mixing plants used for porous asphalt shall meet the requirements of Caltrans Standard Specification Section 39‑1.08A.
    1. Authorized Job Mix Formula (JMF): The mix design process shall conform to Caltrans Specification Section 39‑1.03 except as noted below.
       1. The final paragraph under Section 39‑1.03A is deleted and replaced with the following:
          1. Submit a complete JMF submittal including identification of asphalt binder percentage in form CEM‑3511 Contractor Job Mix Formula Proposal. Determine the optimum asphalt binder content using California Test 368 in a lab that meets the requirements of 1.05.A. of these specifications.

The products used in the JMF shall meet the requirements in Section 2.01 of this Specification.

The JMF shall meet the quality characteristics defined in Section 39‑2.02B (Quality Control for Standard Construction Process) with the modified and additional quality characteristics listed in the table below.

|  |  |  |
| --- | --- | --- |
| Quality Characteristics | Test Method | Requirement |
| Aggregate Durability Index | CT 229 | DI >= 35 |
| Aggregate Cleanness Value | CT 227 | CV >= 75 |
| Air Void Content by Corelok (%)1 | ASTM D6752 (with  AASHTO T209 and ASTM D3203) | 16–20% |
| Air Void Content by Paraffin Wax (%)1 | AASHTO T275 (with  AASHTO T209 and ASTM D3203) | 18–22% |
| Draindown (% of total weight) | ASTM D6390 | <= 3% |
| Retained Tensile Strength (%) | AASHTO 283 | >= 80% |
| Infiltration Rate  (Average Inches per Hour) | ASTM C1701 | See Note 2. |

1 Either method of determining air void content is acceptable.

2 The finish surface shall yield an infiltration rate that is consistent with the following: The average infiltration rate from three (3) infiltration tests conducted per ASTM C1701 shall be greater than 100 inches per hour with no single test less than 50 inches per hour. Water shall infiltrate rapidly and uniformly through the surface without formation of large puddles when applied at a rate of 5 gallons per minute (gpm).

* + - 1. Once verified and accepted by the Engineer, the JMF meeting the criteria above shall become the Authorized JMF. Acceptance of the JMF shall be per Caltrans Standard Specification Section 39‑1.03G, except that verification of the JMF by the City of San Francisco shall be considered equivalent to verification of the JMF by Caltrans. Any adjustments or renewals of the JMF shall be per Caltrans Standard Specifications Section 39‑1.03 (Hot Mix Asphalt Mix Design Requirements). Submit a letter from the asphalt supplier with the recommended temperature ranges for mixing, laying, breakdown rolling, and finished rolling, as well as the recommended maximum temperature of the finished mat before placement of subsequent lifts.
    1. Responsibilities of Contractor
       1. General: Conform to the requirements set forth in Section 39‑1.04 (Contractor Quality Control) and Section 39‑2.02 (Standard Construction Process Contractor Quality Control) of the Caltrans Standard Specifications.
       2. Pre-Placement Conference: A mandatory pre-placement conference will take place, including at a minimum the Engineer, the Owner, the general Contractor, and paving subcontractor, to review preparation, placement, testing procedures, and responsibilities.
       3. Quality Control: Contractor quality control inspection and testing of porous asphalt shall be conducted in accordance with the approved QC plan.
       4. Load Slip: Provide a load slip certified by a licensed weightmaster showing combined mixture weight for each load of porous asphalt transported to the location.
       5. Infiltration Rate Testing: Perform surface infiltration tests per ASTM C1701 as described below.
          1. Three (3) test locations per 10,000 square feet of porous asphalt in place.
          2. One (1) additional test location per 5,000 square feet of porous asphalt, or fraction thereof, in place.

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

* + - 1. Required Inspections: Notify the Engineer at least 5 business days prior placement of porous asphalt.
      2. Failed Tests: Each test shall meet the acceptance criteria as defined in this section. For any single quality characteristic except smoothness, if two consecutive quality control test results do not comply with the action limits or specifications:
         1. Stop production.
         2. Notify the Engineer.
         3. Take corrective action.
         4. Demonstrate compliance with the specifications before resuming production and placement.

DESIGNER NOTE: The following table is a Sample Contractor Quality Control Sampling and Testing Plan; it is provided to illustrate the type and frequency of testing that may be required The Contractor will need to develop a similar table as part of their QC plan. Frequency and standard for all tests should be project specific.

| Sample Contractor Quality Control Sampling and Testing Plan | | | | | | |
| --- | --- | --- | --- | --- | --- | --- |
| Quality Characteristic | Test Standard | Frequency | Sample Location | Contractor Responsibility | Attribute or Tolerance | |
| Plant Operations | | | | | | |
| Aggregate Gradation | CT 202 | 1/750 tons | Plant | Plant Inspector | 1/2" | TV ± 6 |
| 3/8" | TV ± 6 |
| No. 4 | TV ± 7 |
| No. 8 | TV ± 5 |
| No. 30 | TV ± 4 |
| No. 200 | TV ± 2 |
| Asphalt Binder Content | CT 382 | Daily | Plant | Plant Inspector | Design ± 0.5% | |
| Percent of crushed particles coarse aggregate (%, min) | CT 205 | 1/project | Plant | Plant Inspector |  | |
| One fractured face |  |  |  |  | 90 | |
| Two fractured faces |  |  |  |  | 75 | |
| Fine aggregate (%, min)  (Passing no. 4 sieve and retained on no. 8 sieve.) |  |  |  |  |  | |
| One fractured face |  |  |  |  | 90 | |
| Los Angeles Rattler (%, max) | CT 211 | 1/project | Plant | Plant Inspector |  | |
| Loss at 100 rev. |  |  |  |  | 12 | |
| Loss at 500 rev. |  |  |  |  | 40 | |
| Aggregate Durability Index | CT 229 | 1/750 tons | Plant | Plant Inspector | DI > 35 | |
| Aggregate Cleanness Value | CT 227 | 1/750 tons | Plant | Plant Inspector | CV > 75 | |
| Asphalt Temp. | Recorded | Continuous | Plant | Plant Inspector | 120–190 | |
| Plant Mix Temperature | Recorded | Continuous | Plant | Plant Inspector | 165 Maximum | |
| Aggregate moisture content | CT 226 | 2/day | Plant | Plant Inspector | For adjusting the plant controller at the HMA plant | |
| Flat and elongated particles (%, max by weight @ 5:1) | CT 235 | 1/project | Plant | Plant Inspector | Report Only | |
| Street Operations | | | | | | |
| Subgrade Preparation | Visual | Daily | Jobsite | Field Inspector | Smooth and Clean | |
| Asphalt Paver & Hopper | Visual and Measure | Daily | Jobsite | Field Inspector | Manufacturer Standards | |
| Compaction Equipment | Visual and Measure | Daily | Jobsite | Field Inspector | Manufacturer Standards | |
| Compaction Process | Visual | Continuous | Jobsite | Field Inspector | Per Specifications | |
| Pavement Temp. at Breakdown | Temperature Equipment | Hourly | Mat Behind Paver | Field Inspector | Per Specifications | |
| Asphalt Binder Content | CT 382 | Daily | Mat Behind Paver | Field Inspector/Tester | Design ± 0.5% | |
| HMA Moisture Content (%, max) | CT 226 | Daily | Mat Behind Paver | Field Inspector/Tester | 1.0 | |
| Lift Thickness | Measured | Hourly | Mat Behind Paver | Field Inspector | Per Specifications | |
| Pavement Temp. at Finish | Temperature Equipment | Daily | At Finish Roller | Field Inspector | Per Specifications | |
| Air Void Content by Paraffin Wax (%) | AASHTO T275  (with AASHTO T209 and ASTM D3203) | Daily | Cores of Finished Surface | Field Inspector | 16–20% | |
| Tensile Strength | AASHTO 283 | Daily | Cores of Finished Surface | Engineer | >= 80% | |
| Long./Transverse Joints | Visual | Continuous | Pavement Joints | Field Inspector | Industry Standards | |
| Smoothness | 10 ft straightedge | Hourly | Finished Surface | Field Inspector | Per Specifications | |
| Street Operations (continued) | | | | | | |
| Infiltration Rate  (average Inches per hour) | ASTM C1701 | Three (3) test locations per 10,000 square feet of pervious asphalt, in place  One (1) additional test location per 5,000 square feet of pervious asphalt, or fraction thereof, in place | Finished Surface | Field Inspector | Each Test: 50”/hr min  Daily Avg.: 100”/hr min | |
| Pavement Transitions | Visual | Daily | AC Transitions | Field Inspector | Per Specifications | |

* + 1. Acceptance: Acceptance of porous asphalt shall be determined based on the criteria defined in Section 39‑2.03A (Acceptance) of the Caltrans Standard Specifications, with the following modifications and additions:
       1. Source aggregate will not be subject to acceptance testing once is has been approved as part of the JMF, unless samples are requested by the Engineer.
       2. Air Voids: Air voids shall be tested for by determining the bulk specific gravity in accordance with ASTM D6752 or AASHTO T275, the maximum theoretical specific gravity with AASHTO T209, and the voids by test ASTM D3203.
       3. Retained Tensile Strength: Retained tensile strength shall be tested in accordance with AASHTO 283.

Test results for air voids, draindown, and retained tensile strength shall be consistent with the characteristics of the approved JMF.

* + - 1. Infiltration Testing
         1. Infiltration Rate Testing: The average of all surface infiltration tests shall be greater than 200 inches per hour with no single test less than 100 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 porous asphalt 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 200 inches per hour with no single test less than 100 inches per hour
  + For porous asphalt not subject to run-on OR 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
    - * 1. Infiltration Visual Testing: Visual flood testing of the surface shall be conducted by application of clean water at the rate of at least 5 gpm over the surface, using a hose or other distribution devise. Water used for the test shall be clean, free of suspended solids and deleterious liquids and will be provided at no extra cost to the Owner. All applied water shall infiltrate directly without large puddle formation or surface runoff, and shall be observed by the Engineer. The Engineer shall mark areas where large puddles form in the field. Areas with slow infiltration shall not exceed 10 percent of the total surface.

DESIGNER NOTE: Smoothness specification should be revised as needed to reflect project design objectives (e.g., smoothness specifications from Section 212 of the City Streets and Highways specifications).

* + - 1. Smoothness: Porous asphalt smoothness shall be checked with a 10‑foot straightedge. Vertical measurement shall be taken between the pavement’s determined plane and straight edge in a direction perpendicular and parallel to the centerline. The finished pavement shall be uniform to a degree such that no variations greater than 3/8‑inch are present between the straightedge and pavement surface.
      2. Grade: Porous asphalt shall be true to designed spot elevations plus or minus ½ inch and shall not deviate from designed slope more than ¼ inch in ten (10) feet. Where abutting existing facilities such as sidewalks, walkways, curbs, driveways or other pavements, the porous asphalt shall be flush.
      3. Line: Porous asphalt margins shall be true to designed lines plus or minus ½ inch at any point.
      4. Slope: Porous asphalt shall be sloped as shown on the Plans. Slope shall be consistent to within 1/4 inch in ten (10) feet.
      5. Thickness: Each core sample shall be equal to the minimum section depth or more as specified on the Plans.

DESIGNER NOTE: Revise the load slip specification as needed to align with the measurement and payment specifications.

* + - 1. Load Slip: Each load of porous asphalt transported to the location of placement shall have a load slip delivered with the load that is certified by a licensed weightmaster and includes the combined mixture weight.

DESIGNER NOTE: Designer should specify consequences of any failed acceptance tests (e.g., reduced payment for lower infiltration rate and lower percent voids, reduced payment for failed smoothness tests) or if consequences are full replacement.

* + - 1. Reduced Payment Factors: The reduced payment factors in Caltrans Standard Specification 39‑2.03A (Testing) do not apply.

DESIGNER NOTE: The following table is a Sample Owner Quality Assurance Sampling and Testing Plan is provided to illustrate the type and frequency of testing that may be required. Frequency and standard for all tests should be project specific.

| Sample Owner Quality Assurance Sampling and Testing Plan | | | | | |
| --- | --- | --- | --- | --- | --- |
| Quality Characteristic | Test Standard | Frequency | Sample Location | Responsibility | Attribute or Tolerance |
| Plant Operations | | | | | |
| Street Operations | | | | | |
| Asphalt Binder Content | CT 382 | Daily | Hopper | Engineer | Design ± 0.5% |
| HMA Moisture Content (%, max) | CT 226 | Daily | Hopper | Engineer | 1.0 |
| Lift Thickness | Measured | Hourly | Cores of Finished Surface | Engineer | Per Specifications |
| Air Void Content by Paraffin Wax (%) | AASHTO T275  (with AASHTO T209 and ASTM D3203) | Daily | Cores of Finished Surface | Engineer | 16–20% |
| Tensile Strength | AASHTO 283 | Daily | Cores of Finished Surface | Engineer | >= 80% |
| Long./Transverse Joints | Visual | Continuous | Pavement Joints | Engineer | Per Specifications |
| Smoothness | 10 ft straightedge | Hourly | Finished Surface | Engineer | Per Specifications |
| Infiltration Rate  (average inches per hour) | ASTM C1701 | 3/day | Finished Surface | Engineer | Each Test: 50”/hr min Daily Avg.: 100”/hr min |
| Pavement Transitions | Visual | Daily | AC Transitions | Engineer | Per Specifications |

1. PRODUCTS

DESIGNER NOTE: If a product is not available, the designer needs to ensure that the desired voids and surface texture will meet the desired pavement characteristics for surface smoothness, voids, and bonding.

* 1. POROUS ASPHALT

Porous Asphalt mixture must comply with the approved Job Mix Formula (See Section 1.05 of this Specification). The components of the asphalt mixture must comply with the specifications below.

* + 1. Asphalt Binder: Asphalt binder must comply with Caltrans Specification Section 92 except as noted below.
       1. Performance Graded (PG) Asphalt Binder: PG asphalt binder must be PG 70‑10 per Caltrans Specification Section 92‑1.02B.
       2. PG Polymer Modified Asphalt Binder:

PG polymer modified asphalt binder must be PG 76‑22 PM per Caltrans Specification Section 92‑1.02B for use in vehicular applications.

PG polymer modified asphalt binder must be either PG 64‑28 PM or PG 76-22 PM per Caltrans Specification Section 92-1.02B for use in pedestrian applications.

* + 1. Aggregates: Aggregates shall conform to Caltrans Specification Section 39‑1.02E for Open Graded Friction Course (OGFC) with the following additions and modifications:
       1. Durability Index: 35 (minimum) tested in accordance with California Test 229 at least once per 750 tons of porous asphalt.
       2. Cleanness Value: 75 (minimum) tested in accordance with California Test 227 at least once per 750 tons of porous asphalt.
       3. Aggregate for porous asphalt shall meet the following gradation:

|  |  |
| --- | --- |
| Porous Asphalt Aggregate Gradation | |
| Sieve1 | Percent Passing by Weight |
| 3/4 inch | 100 |
| 1/2 inch | 85 to 100 |
| 3/8 inch | 55 to 75 |
| No. 4 | 10 to 25 |
| No. 8 | 5 to 12 |
| No. 30 | 0 to 10 |
| No. 200 | 0 to 3 |

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

* + 1. Materials Not to Be Used: The following materials shall not be used unless approved in advance by the Engineer.
       1. Geosynthetic pavement interlayer
       2. Tack Coat (except on vertical faces of curbs, edges of PCC structures, or when paving over areas with impermeable bases).
       3. Asphalt Rubber Binder.
       4. Crumb Rubber Modifier.
       5. Reclaimed Asphalt Pavement.
       6. Paint Binder per Section 212.06 of the DPW Standard Specifications
    2. Job Mix Formula (JMF): The JMF shall comply with the requirements of Section 1.05.C of this Specification.
  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 are not permitted. The 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 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 two (2) layers as specified on the Plans and included herein:
        1. “Base Course” shall be ASTM No. 3 (modified) or ASTM No. 57 (modified) stone per Section 2.02.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 2.02.C.

DESIGNER NOTE: This layer of the pavement base is intended to provide storage and drainage of the pavement, structural support, and a capillary break. The materials specified should be crushed, clean, washed gravel 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: 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 coarser graded materials or reduction in permeability relative to the underlying material. Refer to the 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.
       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. 2 (modified) | ASTM No. 3 (modified) | ASTM No. 8 (modified) | ASTM No. 57 (modified) |
| 3 inch | 100 | – | – | – |
| 2 1/2 inch | 90 to 100 | 100 | – | – |
| 2 inch | 35 to 70 | 90 to 100 | – | – |
| 1 1/2 inch | 0 to 15 | 35 to 70 | – | 100 |
| 1 inch | – | 0 to 15 | – | 95 to 100 |
| 3/4 inch | 0 to 5 | – | – | – |
| 1/2 inch | – | 0 to 5 | 100 | 25 to 60 |
| 3/8 inch | – | – | 85 to 100 | – |
| No. 4 | – | – | 10 to 30 | 0 to 10 |
| No. 8 | – | – | 0 to 10 | 0 to 5 |
| No. 16 | – | – | 0 to 5 | – |
| No. 1002 | 0 to 2 | 0 to 2 | 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 sieve.

* + - 1. L.A. Abrasion: 30 percent (maximum) tested in accordance with ASTM C 131.
      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. GEOTEXTILE FOR SOIL SEPARATION

DESIGNER NOTE: 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 +/- ¾ 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 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.
    3. 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.
    4. 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.
    5. 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.
    6. 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.
    7. The subgrade shall be inspected and accepted by the Engineer prior to placement of the geotextile or pavement base.
    8. 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 the Contractor’s expense. 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. The pavement base 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. 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 porous asphalt.
  1. POROUS ASPHALT PREPARATION

DESIGNER NOTE: Designer should specify where a tack coat should be applied, if at all. See 3.04.A.2 for list of potential locations.

* + 1. Preparation for placement of porous asphalt pavement shall comply with Section 39‑1.09 of the Caltrans Standard Specifications, except as noted below.
       1. Pavement Base: Confirm that the completed pavement base conforms to these specifications.
       2. Tack Coat: Shall not be used except on vertical faces of curbs, edges of PCC structures, or when paving over areas with impermeable bases.
       3. Geosynthetic Pavement Interlay: Shall not be used.
       4. Environmental Conditions: Do not place porous asphalt when the ambient temperature is less than 60 degrees Fahrenheit, on any wet surface, or when the average ground surface temperature is less than 45 degrees Fahrenheit.
       5. Qualified Personnel: The qualified foreman as defined in 1.05.B.2 shall be onsite for the duration of porous asphalt preparation.
  1. POROUS ASPHALT PLACEMENT

DESIGNER NOTE: Designer should specify where a tack coat should be applied (e.g., face of curb, structures,) if at all.

* + 1. Porous asphalt equipment, transportation, spreading, and compacting shall comply with the Caltrans Specification applicable to Open Graded Friction Course (OGFC), except as noted below or as specified in the approved mix design.
    2. Qualified Personnel: The qualified foreman as defined in 1.05.B.2 shall be onsite for the duration of porous asphalt placement.
    3. Spreading and Compacting Equipment: shall conform to Section 39‑1.10 of the Caltrans Standard Specifications except that pneumatic tire rollers shall not be used.

DESIGNER NOTE: The compaction could be established by the contractor rather than prescribed below depending on whether the contracting agency prefers to take a prescriptive approach or performance based approach. Prescriptive is used here because full depth porous asphalt is an emerging technology and there are limited density specifications for open graded (porous) asphalt mixtures. But care must be taken to ensure this prescriptive specification is compatible with the acceptance criteria.

* + 1. Spreading and Compacting:

The type of rollers to be used and their relative position in the compaction sequence shall be dictated by the contractor provided the requirements below are met and the completed porous asphalt meets the required quality characteristics specified in Section 1.05. Deviation from the requirements below must be approved in advance by the Engineer.

* + - 1. The porous asphalt shall be laid in lifts of up to 4 inches in thickness using approved equipment to achieve the total thickness indicated in the Plans.

DESIGNER NOTE: Designer should consider using thinner lifts to the extent practical to ensure better compaction.

* + - 1. The temperature of the Porous HMA mix during laying, breakdown rolling, and finished rolling, shall be within the supplier-recommended temperature range.
      2. Breakdown rolling shall be performed with one or two passes of a 7.5‑ to 10‑ton vibratory roller operated in low amplitude mode when the mix temperature is within the supplier-recommended temperature range.
      3. Finished rolling shall be performed with a double-drum finish roller operated in static mode when the mix temperature is within the supplier-recommended temperature range.
      4. Finished paving shall be even, without pockets, and graded to elevations shown on the Plans. Finished porous asphalt shall meet the acceptance criteria for Smoothness set forth in Section 1.05.D.

DESIGNER NOTE: Designer should specify details of the straightedge test and tolerance if different than specified in Section 1.05E.

* + - 1. The Contractor shall take care to insure that the porous asphalt lifts join completely to previous lifts. The Contractor shall keep the time between lift placements to a minimum, keeping the surface of the previous lift clear from dust and moisture between lifts, and restrict traffic from initial lifts until the full depth of asphalt pavement has been placed.
      2. Sufficient time shall be allowed between lifts to allow the asphalt to set and cool to at or below the supplier recommended maximum temperature for placement of subsequent lifts.
  1. OPENING TO TRAFFIC
     1. After final rolling, no vehicular traffic of any kind shall be permitted on the pavement surface until cooling and hardening has taken place, and in no case within the first six (6) hours. Provide traffic control measures as necessary to prevent vehicular use and remove when no longer required.
  2. PROTECTION OF PAVEMENT
     1. Hardened porous asphalt 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 porous pavement voids, the pavement shall be cleaned at the Contractor’s expense and to the satisfaction of the Engineer. If porous asphalt pavement cannot be unclogged, it shall be removed and replaced at the Contractor’s expense and to the satisfaction of the Engineer.
  3. REJECTION
     1. Porous asphalt that does not meet the acceptance criteria set forth in Section 1.05.E will be rejected by the Engineer. Porous asphalt that has been rejected by the Engineer shall be removed and replaced at the Contractor’s expense.

End of Section