

20-11 GREEN STREETS

Section 20-11 includes specifications corresponding to the March 2021 County of San Diego Green Streets Standard Drawings. Materials specified in this section include: Ground Cover/Mulch, Biofiltration Soil Media (BSM), Choker Layer, Reservoir Layer, Impermeable Liner, Structural Soil, Biofiltration Soil Media for Nutrient Impairments (BSMNI), Permeable Asphalt Pavement, Permeable Concrete Pavement, Permeable Interlocking Pavement, and Modular Concrete Porous Gutter.

Green Streets specifications shall conform to the provisions in Caltrans 2015 Standard Specifications Division III, Section 19 "Earthwork" and Section 20 "Landscape."

20-11.01 GROUND COVER/MULCH

Refer to 2015 Caltrans Specification 20-5.03B(2)(c) for rock mulch specifications

Refer to 2015 Caltrans Specification 20-5.03E(2)(d) for shredded bark mulch specifications.

20-11.01A General

Not Used

20-11.01A(1) Summary

Not Used

20-11.01A(2) Definitions

Not Used

20-11.01A(3) Submittals

Not Used

20-11.01A(4) Quality Assurance

Not Used

20-11.01B Materials

Not Used

20-11.01C Construction

Not Used

20-11.01D Payment

No Used

20-11.02 BIOFILTRATION SOIL MEDIA

20-11.02A General

20-11.02A(1) Summary

Biofiltration Soil Media (BSM) is a blend of sand, topsoil, and compost that is placed on a landscape surface to filter stormwater runoff and support plant growth. A summary of BSM specification requirements is included in Table 1.

Table 1. BSM Specification Requirements

Component	Requirement
BSM Material Composition	Submit vendor information supporting the following composition: <ul style="list-style-type: none">• Sand: 60-80% by volume• Topsoil: 0-20% by volume• Compost: 0-20% by volume
Agronomic Suitability	Submit lab test per 20-11.02A(4)(a)
Pathogen and Pollutant Limits	Submit lab test per 20-11.02A(4)(b)
Hydraulic Suitability	Perform field test 20-11.02A(4)(c)

20-11.02A(2) Definitions

Not Used

20-11.02A(3) Submittals

At least 30 days prior to ordering materials, the Contractor shall submit the following to the Engineer: source/supplier of BSM, location of source/supplier, a physical sample of the BSM, whole BSM test results from a third party independent laboratory, test results for individual component materials (if specifically requested), and description of proposed methods and schedule for mixing, delivery, and placement of BSM. The test results shall be no older than 120 days and shall accurately represent the materials and feed stocks that are currently available from the supplier.

20-11.02A(4) Quality Assurance

Close adherence to the material quality controls herein are necessary in order to support healthy vegetation, minimize pollutant leaching, and assure sufficient permeability to infiltrate/filter runoff during the life of the facility. Amendments may be included to adjust agronomic properties. Acceptance of the material will be based on test results certified to be representative. Test results shall be conducted no more than 120 days prior to delivery of the blended BSM to the project site. For projects installing more than 100 cubic yards of BSM, batch-specific tests of the blended mix shall be provided to the Engineer for every 100 cubic yards of BSM along with a site plan showing the placement locations of each BSM batch within the facility.

No delivery, placement, or planting of BSM shall begin until test results confirm the suitability of the BSM. The Contractor shall submit a written request for approval which shall be accompanied by written analysis results from a written report of a testing agency. The testing agency must be registered by the State for agronomic soil evaluation laboratory test fees shall be paid for by the Contractor.

20-11.02A(4)(a) Agronomic Suitability

The BSM shall conform to the requirements herein to support plant growth. All BSM shall be uniformly blended and tested in its blended state prior to testing and delivery:

- a) pH range shall be between 6.0-8.5.
- b) Salinity shall be between 0.5 and 3.0 millimho/cm (as measure by electrical conductivity)
- c) Sodium absorption ratio (SAR) shall be less than 5.0
- d) Chloride shall be less than 800 ppm.
- e) Cation exchange capacity shall be greater than 10 meq/100 g.
- f) Organic matter shall be between 2 and 5%.
- g) Carbon:Nitrogen ratio shall be between 15 and 40.

Textural class fraction shall adhere to limits in Table 2, as determined by ASTM Method D422 or an approved alternative method:

TABLE 2. Textural Class Fraction

Textural Class (ASTM D422)	Size Range	Mass Fraction (percent)
Gravel	Larger than 2 mm	0 to 25 of total sample
Clay	Smaller than 0.005 mm	0 to 5 of non-gravel fraction

Test results shall show the following information:

- a) Date of testing
- b) Project name, contractor name, and source of materials and supplier name
- c) Copies of all testing reports including, at a minimum, analytical results sufficient to confirm compliance with all requirements listed in this section.

20-11.02A(4)(b) Pathogens and Pollutant Limits

Select pathogens shall pass US EPA Class A standard, 40 CFR Section 503.32(a). Trace Metals shall pass US EPA Class A standard, 40 CFR Section 503.13, Table 1 for Ceiling Concentrations.

20-11.02A(4)(c) Hydraulic Suitability

BSM shall have the appropriate hydraulic properties for filtering stormwater. The saturated hydraulic conductivity of the whole BSM shall be measured according to the method detailed in the measurement of hydraulic conductivity (USDA Handbook 60, method 34b), commonly available as part of standard agronomic soil evaluation, or ASTM D2434 Permeability of Granular Soils (at approximately 85% relative compaction Standard Proctor, ASTM D698). BSM shall have a measured hydraulic conductivity of at least 5 inches per hour.

20-11.02B Materials

20-11.02B(1) Sand for BSM

Sand used in BSM should preferably be washed prior to delivery. A sieve analysis shall be performed in accordance with California Test 202, ASTM D 422, or approved equivalent method to demonstrate compliance with the sand gradation limits shown in Table 3. Fines passing the No. 200 sieve shall be non-plastic.

TABLE 3. Sand Gradation Limits

Sieve Size (ASTM D422)	Percentage Passing Sieve (by weight)	
	Minimum	Maximum
3/8-inch	100	100
#4	90	100
#8	70	100
#16	40	95
#30	15	70
#40	5	55
#100	0	15
#200	0	5

20-11.02B(2) Topsoil for BSM

Topsoil shall be free of hazardous materials and shall be consistent with a common definition of topsoil. Decomposed granite and derivatives of decomposed granite are not considered to be topsoil for the purpose of this specification.

Topsoil shall be classified as a sandy loam or a loamy sand according to the US Department of Agriculture soil classification system. In addition, a textural class analysis shall be performed in accordance with ASTM D422, or an approved alternative method to demonstrate compliance with the gradation limits in Table 4.

Table 4. Topsoil Textural Class

Textural Class (ASTM D422)	Size Range	Mass Fraction (percent)
Gravel	Larger than 2 mm	0 to 25 of total sample
Clay	Smaller than 0.005 mm	0 to 15 of non-gravel fraction

20-11.02B(3) Compost for BSM

Compost shall be produced at a facility inspected and regulated by the local enforcement agency for CalRecycle. Compost should also preferably be certified by the U.S. Composting Council's Seal of Testing Assurance Program (USCC STA) or an approved equivalent program. Compost shall not be produced from biosolids feedstock.

A sieve analysis shall be performed on the compost in accordance with ASTM D 422, or approved equivalent method to demonstrate compliance with the gradation limits show in Table 5.

Table 5. Compost Gradation Limits

Sieve Size (ASTM D422)	Percent Passing Sieve (by weight)
1/2"	97 to 100
#10	40 to 90

Organic Material Content of compost shall be 35% to 100% by dry weight and moisture shall be 25% to 60% wet weight basis. Physical contaminants (manmade inert materials) shall not exceed 1% by dry weight.

Compost shall meet the following requirements as demonstrated through standard agronomic testing methods:

- a) **Carbon to nitrogen (C:N) ratio.** C:N shall be between 15:1 and 40:1, preferably above 20:1 to reduce the potential for nitrogen leaching/washout.
- b) **pH.** pH shall be between 6.0 and 8.5.
- c) **Soluble Salt Concentration.** Soluble Salt Concentration shall be less than 10 dS/m. (Method TMECC 4.10-A, USDA and U.S. Composting Council).
- d) **Stability.** Carbon Dioxide evolution rate shall be less than 3.0 mg CO₂-C per g compost organic matter (OM) per day or less than 6 mg CO₂-C per g compost carbon per day, whichever unit is reported. (Method TMECC 5.08-B, USDA and U.S. Composting Council). Alternatively, a Solvita rating of 5.5 or higher is acceptable.

20-11.02C Construction

20-11.02C(1) General

BSM shall be thoroughly mixed prior to delivery using mechanical mixing methods such as a drum mixer. The Contractor shall protect soils and mixes from absorbing excess water and from erosion at all times.

20-11.02C(2) Delivery

The Contractor shall not deliver or place soils in wet or muddy conditions.

20-11.02C(3) Storage

The Contractor shall not store materials unprotected during large rainfall events (>0.25-inches). If water is introduced into the material while it is stockpiled, the Contractor shall allow the material to drain to the acceptance of the Engineer before placement.

20-11.02C(4) Handling and Placement

BSM shall be lightly compacted and placed in loose lifts approximately 12-inches (300 mm) to ensure reasonable settlement without excessive compaction. Compaction within the BSM area should not exceed 75 to 85% standard proctor within the BSM. Machinery shall not be used in the bioretention facility to place the BSM. A conveyor or spray system shall be used for media placement in large facilities. Low ground pressure equipment may be authorized for large facilities at the discretion of the Engineer. Placement methods and BSM quantities shall account for approximately 10% loss of volume due to settling. Planting methods and timing shall account for settling of media without exposing plant root systems.

20-11.02D Payment

The contract price paid per cubic yard for BSM shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing BSM, complete in place, as shown on the plans and as directed by the Engineer.

20-11.03 CHOKER COURSE

20-11.03A General

20-11.03A(1) Summary

A typical biofiltration basin includes a BSM layer underlain by an aggregate gravel reservoir layer. In order to keep the BSM from migrating into the aggregate gravel layer, a choker or filter course is used.

20-11.03A(2) Definitions

Not Used

20-11.03A(3) Submittals

At least 30 days prior to ordering materials, the Contractor shall submit the following to the Engineer: source/supplier of material, location of source/supplier, a physical sample of the choker course materials, aggregate gradation test using the California Test Method 202 and description of proposed methods and schedule for mixing, delivery, and placement of the material. The test results shall be no older than 120 days and shall accurately represent the materials and feed stocks that are currently available from the supplier.

20-11.03A(4) Quality Assurance

Not Used

20-11.03B Materials

20-11.03B(1) General

The choker course consists of two layers of choking material increasing in particle size. The top layer of the choker course shall be constructed of thoroughly washed ASTM C33 fine aggregate sand material conforming to gradation limits contained in Table 1. The bottom layer of the choker course shall be constructed of thoroughly washed ASTM No. 8 aggregate material conforming to gradation limits contained in Table 2. Each layer shall be 2-3 inches thick.

20-11.03B(2) Choker Course Sand (ASTM C33)

The sand shall be clean, washed, and 2-3 inches thick with the gradation as shown below in Table 1.

Table 1. ASTM C33 Sand Gradation

Sieve Size	Percent of Particles Smaller than Sieve Size
0.375 inches	100
No. 4 (0.187 inches)	95-100
No. 8 (0.093 inches)	80-100
No. 16 (0.046 inches)	50-85
No. 30 (0.024 inches)	25-60
No. 50 (0.012 inches)	5-10
No. 100 (0.006 inches)	0-10
No. 200 (0.003 inches)	0

20-11.03B(3) Choker Course Pea Gravel (ASTM No. 8)

The pea gravel shall be clean, washed, and 2-3 inches thick with the gradation as shown below in Table 2. ASTM No. 89 Pea Gravel is also acceptable.

Table 2. ASTM No.8 Pea Gravel Gradation

Sieve Size	Percent of Particles Smaller than Sieve Size	
	ASTM No. 8	ASTM No. 89
0.5 inches	100	100
0.375 inches	85-100	90-100
No. 4 (0.187 inches)	10-30	20-55
No. 8 (0.093 inches)	0-10	5-30
No. 16 (0.046 inches)	0-5	0-5
No. 50 (0.012 inches)		0-5

20-11.03C Construction

20-11.03C(1) General

20-11.03C(2) Delivery

The choker course material shall be delivered to the installation site as uniform mixtures.

20-11.03C(3) Storage

The Contractor shall not store materials unprotected.

20-11.03C(4) Handling and Placement

Each layer of the choker course shall be spread in one operation. The bottom layer of the filter course (ASTM No.8 or ASTM No. 89) shall be installed to a thickness of 2-3 inches. The top layer of the filter course (ASTM C33) shall be installed to a thickness of 2-3 inches. Marker stakes shall be used to ensure uniform lift thickness. Filter course material shall be lightly compacted to approximately 80% standard proctor without the use of vibratory compaction.

20-11.03D Payment

The contract price paid per cubic yard for Choker Course Material shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing choker course, complete in place, as shown on the plans and as directed by the Engineer.

20-11.04 RESERVOIR LAYER

20-11.04A General

20-11.04A(1) Summary

A typical biofiltration basin includes biofiltration soil media layer underlain by an aggregate gravel reservoir layer. This layer is intended as temporary storage for stormwater runoff prior to infiltration into native soils or discharge through an underdrain system.

20-11.04A(2) Definitions

Not Used

20-11.04A(3) Submittals

At least 30 days prior to ordering materials, the Contractor shall submit the following to the Engineer: source/supplier of material, location of source/supplier, a physical sample of the choker course materials, aggregate gradation test using the California Test Method 202 and description of proposed methods and schedule for mixing, delivery, and placement of the material. The test results shall be no older than 120 days and shall accurately represent the materials and feed stocks that are currently available from the supplier.

20-11.04A(4) Quality Assurance

Not Used

20-11.04B Materials

20-11.04B(1) Reservoir Layer Gradation

The reservoir gravel layer shall be clean and washed gravel and crushed rock. No recycled asphalt or concrete will be permitted. AASHTO No. 57 stone shall be used with the gradation shown in Table 1. Other types of gravel may be accepted at the discretion of the Engineer. The thickness of the layer is defined in the plans.

The reservoir gravel layer shall be clean, washed, and 2-3 inches thick with the gradation as shown below in Table 1.

Table 1. AASHTO No. 57 Stone Gradation

Sieve Size	Percent of Particles Smaller than Sieve Size
1.5 inches	100
1 inch	95-100
0.5 inch	25-60
No. 4 (0.187 inches)	0-10
No. 8 (0.093 inches)	0-5

20-11.04C Construction

20-11.04C(1) General

20-11.04C(2) Delivery

The reservoir layer material shall be delivered to the installation site as uniform mixtures.

20-11.04C(3) Storage

The Contractor shall not store materials unprotected.

20-11.04C(4) Handling and Placement

The reservoir layer shall be placed in lifts no greater than 12". Marker stakes shall be used to ensure uniform lift thickness. The reservoir layer shall be lightly compacted to approximately 80% standard proctor without the use of vibratory compaction.

20-11.04D Payment

The contract price paid per cubic yard for Reservoir Layer shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing choker course, complete in place, as shown on the plans and as directed by the Engineer.

20-11.05 IMPERMEABLE LINER

20-11.05A General

20-11.05A(1) Summary

20-11.05A(2) Definitions

Not Used

20-11.05A(3) Submittals

Submit the following:

1. Certificate of compliance
2. Test sample representing each lot
3. Minimum average roll values

Label submittals with the manufacturer's name and product information.

20-11.05A(4) Quality Assurance

Not Used

20-11.05B Materials

Impermeable liner must be reinforced or unreinforced tri-polymer geomembrane material made of polyvinyl chloride (PVC), ethylene interpolymmer alloy, and polyurethane or a comparable polymer combination. The geomembrane must be sufficiently flexible to cover and closely conform to 90 degree edges and corners of the filter bed excavation at ambient temperatures as low as 45 degrees Fahrenheit without application of heat. Geomembrane must have the following properties, specified as minimum or maximum, not average roll properties:

30 MIL Liner Properties

Certified Properties	Test Method	Requirement
Thickness ±5%	ASTM D 5199	0.030"
Tensile - lb. force/in. width, min	ASTM D 882	73
100% Modulus - lb. force/in. width, min.	ASTM D 882	30
Tear Strength (lb./in., min.)	ASTM D 1004	8
Dimensional Stability (% change max.)	ASTM D 1204	3
Impact Cold Crack (°C)	ASTM D 1790	-29
Index Properties	Test Method	Requirement

Specific Gravity (min.)	ASTM D 792	1.20
Water Extraction (% max.)	ASTM D 1239	0.15
Volatile Loss (% max.)	ASTM D 1203(A)	0.70
Resistance to Soil Burial (% change max.)	ASTM G 160	5
1. Breaking Factor		20
2. Elongation at Break		20
3. Modulus at 100% Elongation		
Hydrostatic Resistance (psi, min.)	ASTM D 751(A)	100
Plasticizer Min. Ave. Molecular Weight	ASTM D 2124	400

Minimum Specifications for EPI Factory Fabricated Seams:		
Peel Strength, lbs./in. width	ASTM D 7408	15
Shear Strength, lbs./in. width	ASTM D 7408	58.4

All factory-produced seams must have a minimum bonded width of 1-1/4 inches, and must have a minimum shear strength of 320 pounds when tested in accordance with ASTM D 751 (Modified per NSF Standard No. 54). Failure must occur in the base geomembrane material.

Submit a Certificate of Compliance from the manufacturer of the geomembrane.

20-11.05C Construction

Impermeable liner must be placed directly on the surface excavation as shown. The excavated surface must be clean and free of sharp objects. Field seams must have an overlap of 12 inches minimum. Field seams must be bonded with an electrically-heated hot-wedge device as recommended by the manufacturer. Hot air extrusion welding devices or solvent bonding chemicals must not be used. The temperature of the bonded geomembrane must not exceed 165 degrees Fahrenheit immediately before contacting the filter bed excavation. Before installation of geomembrane, demonstrate to the Engineer that the equipment, techniques, and personnel proposed for the bonding of field seams can produce vapor-tight seams under similar weather and work conditions near the job site. Field seams must be inspected and, when ordered by the Engineer, must be tested and pass the Vacuum Box Test. Construction equipment must not be operated directly on the geomembrane. Any material damaged by your equipment or operations must be replaced or repaired to the satisfaction of the Engineer.

20-11.05D Payment

The contract price paid per square yard for impermeable liner shall include full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to install the geomembrane lining, including field seams, complete in place, as shown on the plans, and as directed by the Engineer. The quantity to be paid for will be the area covered not including additional geomembrane for overlapping seams.

20-11.06 STRUCTURAL SOIL

20-11.06A General

20-11.06A(1) Summary

Section 20-11.03 includes specification for all Structural Soil work and related items as indicated on the drawings or as specified herein.

20-11.06A(2) Definitions

Not Used

20-11.06A(3) Submittals

At least 30 days prior to ordering materials, the installing contractor shall submit to the Engineer representative samples, certificates, manufacturer's literature and test results per the manufacturer's specifications. No materials shall be ordered until the required samples, certificates, manufacturer's literature, producer's current license and test results have been reviewed and approved by the Engineer. The Engineer reserves the right to reject any material that does not meet the manufacturer's specifications. Delivered materials shall closely match the approved samples.

20-11.06A(4) Quality Assurance

Quality assurance procedures and testing shall meet the requirements of the manufacturer's specifications.

20-11.06B Materials

Structural Soil shall be selected from the products as described below or approved equal. Soil mix requirements shall be per manufacturer's specifications. Acceptable soil systems include suspended pavements, structural cells, and several types of structural soils:

- A. Suspended pavements include structural slabs that span between structural supports that allow uncompacted growing soil beneath the sidewalk, and commercially available structural systems. Manufacturer details and certification must be provided for commercial systems. Structural calculations and details must be provided for Suspended Pavement installations.
- B. Structural cells Such as Silva Cell™ or StrataCell™ are commercially-available structural systems placed subsurface that support the sidewalk and are filled with amended soil. Manufacturer details and certification must be provided for commercial systems. Amended soil placed within structural cells shall be a minimum of 30 inches.
- C. Proprietary structural soil systems, such as CU-Structural Soil™ or Stalite Structural Soil, or equivalent, may be used.

20-11.06C Construction

Delivery, storage, handling, site preparation and installation shall meet the requirements of the manufacturer's specifications.

20-11.06D Payment

The contract price paid per the bid item unit of measure for Structural Soil shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing Structural Soil, complete in place, as shown on the plans and as directed by the Engineer.

20-11.07 BIOFILTRATION SOIL MEDIA FOR NUTRIENT IMPAIRMENTS

20-11.07A General

20-11.07A(1) Summary

Bioretention Soil Media (BSM) for nutrient impaired receiving waters is intended to filter storm water and support plant growth while further reducing the potential to leach nutrients. This specification includes requirements that apply to BSM used in stormwater treatment BMPs, including bioretention and biofiltration that drain to receiving waters impaired by nutrients.

BSM shall conform to the provisions in Caltrans 2015 Standard Specifications Division III, Section 19 "Earthwork" and Section 20 "Landscape."

A summary of BSM specification requirements is included in Table 1.

Table 1. BSM Specification Requirement Summary

Component	Requirement
BSM Material Composition	Sand: 60-70% by volume Coco Coir: 20-25% by volume Biochar: 10-15% by volume
Alternative Blends	Acceptable but subject to approval by the Engineer.
BSM Permeability	Greater than 5 inches/hour; testing is required to demonstrate.
Agronomic Suitability Requirements	Limits for salts and potential toxins.
Water Quality Related Limits	Requirements related to specific pollutants when water quality of receiving waters is impaired for those pollutants.

20-11.07A(2) Definitions

Not Used

20-11.07A(3) Submittals

At least 30 days prior to ordering materials, you shall submit the following to the Engineer: source/supplier of BSM, location of source/supplier, a physical sample of the BSM, whole BSM test results from a third party independent laboratory, test results and/or manufacturer specification sheets for individual component materials as required, and description of proposed methods and schedule for mixing, delivery, and placement of BSM. The test results shall be no older than 120 days and shall accurately represent the materials and feed stocks that are currently available from the supplier.

20-11.07A(4) Quality Assurance

Close adherence to the material quality controls herein are necessary in order to support healthy vegetation, minimize pollutant leaching, and assure sufficient permeability to infiltrate/filter runoff during the life of the facility. Amendments may be included to adjust agronomic properties. Acceptance of the material will be based on test results certified to be representative. Test results shall be conducted no more than 120 days prior to delivery of the blended BSM to the project site. For projects installing more than 100 cubic yards of BSM, batch-specific tests of the blended mix shall be provided to the Engineer for every 100 cubic yards of BSM along with a site plan showing the placement locations of each BSM batch within the facility.

Test results shall demonstrate conformance to agronomic suitability, hydraulic suitability, and chemical suitability criteria listed in Sections 20-11.07A(4)(a), 20-11.07A(4)(b), and 20-11.07A(4)(c) respectively. No delivery, placement, or planting of BSM shall begin until test results confirm the suitability of the BSM.

You shall submit a written request for approval which shall be accompanied by written analysis results from a written report of a testing agency. The testing agency must be registered by the State for agronomic soil evaluation laboratory test fees shall be paid for by you.

20-11.07A(4)(a) Agronomic Suitability

The BSM shall conform to the requirements herein to support plant growth. BSM which requires amending to comply with the below specifications shall be uniformly blended and tested in its blended state prior to testing and delivery:

- h) pH range shall be between 6.0-8.5.
- i) Salinity shall be between 0.5 and 3.0 millimho/cm (as measure by electrical conductivity)
- j) Sodium absorption ratio (SAR) shall be less than 5.0
- k) Cation exchange capacity shall be greater than 10 meq/100 g.

Test results shall show the following information:

- d) Date of testing
- e) Project name, your name, and source of materials and supplier name
- f) Copies of all testing reports including, at a minimum, analytical results sufficient to confirm compliance with all requirements listed in this section.

20-11.07A(4)(b) Hydraulic Suitability

The blended BSM shall have the appropriate hydraulic properties for filtering stormwater. The BSM shall conform to the requirements herein to support plant growth. BSM which requires amending, shall be uniformly blended and tested in its blended state prior to testing and delivery.

20-11.07A(4)(b)(i) Testing

The saturated hydraulic conductivity of the whole BSM shall be measured according to the method detailed in the measurement of hydraulic conductivity (USDA Handbook 60, method 34b), commonly available as part of standard agronomic soil evaluation.

The BSM shall have a hydraulic conductivity of at least 5-inches per hour, or at least 2 times higher than the design infiltration rate of the underlying soil, whichever is greater.

20-11.07A(4)(c) Chemical Suitability for Areas Draining to Impaired Receiving Waters

20-11.07A(4)(c)(i) General

Limits may be waived at the discretion of the Engineer if it is determined by the Engineer that it is unreasonable to meet the specification using locally-available materials (available within 100 miles).

20-11.07A(4)(c)(ii) Testing

Potential for pollutant leaching shall be assessed using the Saturated Media Extract Method (aka, Saturation Extract) that is commonly performed by agronomic laboratories. Samples may be rinsed with up to five pore volumes before collecting extract for analysis.

20-11.07A(4)(c)(iii) BSM Limits in Areas Draining to Nutrient Impaired Receiving Waters

The limits in this section are in terms of the concentration of a parameter in water that has been contacted with the BSM.

Table 4. BSM Limits

Pollutant	Saturation Extract
Phosphorus	< 1 mg/L

20-11.07B Materials

20-11.07B(1) General

Not Used

20-11.07B(2) Sand for BSM

20-11.07B(2)(a) General

Sand used in BSM should preferably be washed prior to delivery. If sand is not washed it must still meet sieve analysis requirements in Table 5. ASTM C-33 sand, size #16 sand, and size #12/20 sand are all appropriate sand types for BSM.

20-11.07B(2)(b) Gradation Limits

A sieve analysis shall be performed in accordance with California Test 202, ASTM D 422, or approved equivalent method to demonstrate compliance with the gradation limits shown in Table 5. Fines passing the No. 200 sieve shall be non-plastic.

Table 5. Sand Gradation Limits

Sieve Size (ASTM D422)	Percentage Passing Sieve (by weight)	
	Minimum	Maximum
3/8-inch	100	100
#4	90	100
#8	70	100
#16	40	95
#30	15	70
#40	5	55
#100	0	15
#200	0	5

20-11.07B(3) Coconut Coir for BSM

20-11.07B(3)(a) General

Coconut coir is a renewable resource harvested from ground mature coconut husk.

20-11.07B(3)(b) Testing

Coconut coir is often processed in salt water. Testing is required to assure that the material has been washed sufficiently to remove excess salinity and other potential pollutants.

Table 6. Coconut Coir Testing Limits

Specification Metric	Analytical Method	Numeric Range
Electrical conductivity	Saturation Extract Method	<4 mmhos/cm
Synthetic Precipitation Leaching Protocol	Saturation Extract Method	TP: max 0.1 mg/L. Ortho-P: max 0.1 mg/L. Diss Cu: max 8 µg/L. NO3-NO2: max 0.1 mg/L

20-11.07B(4) Biochar for BSM

20-11.07B(4)(a) General

Biochar is a charcoal-like soil amendment that is made from burning waste organic material in an oxygen free process called pyrolysis. It is a high carbon wood ash. The material shall be derived from wood not bone or manure. It shall be a medium coarse texture with minimal fines.

20-11.07B(4)(b) Testing

Table 7. Biochar Testing Limits

Specification Metric	Analytical Method	Numeric Range
Maximum passing 100 sieve	Sieve analysis	10 percent
Synthetic Precipitation Leaching Protocol	Saturation Extract Method	TP: max 1.2 mg/L. Ortho-P: max 1.2 mg/L. Diss Cu: max 5 µg/L. NO3+NO2: max 0.1 mg/L

20-11.07C Construction

20-11.07C(1) General

BSM shall be thoroughly mixed prior to delivery using mechanical mixing methods such as a drum mixer. You shall protect soils and mixes from absorbing excess water and from erosion at all times.

20-11.07C(2) Delivery

You shall not deliver or place soils in wet or muddy conditions.

20-11.07C(3) Storage

You shall not store materials unprotected during large rainfall events (>0.25-inches). If water is introduced into the material while it is stockpiled, you shall allow the material to drain to the acceptance of the Engineer before placement.

20-11.07C(4) Handling and Placement

BSM shall be lightly compacted and placed in loose lifts approximately 12-inches (300 mm) to ensure reasonable settlement without excessive compaction. Compaction within the BSM area should not exceed 75 to 85% standard proctor within the BSM. Machinery shall not be used in the bioretention facility to place the BSM. A conveyor or spray system shall be used for media placement in large facilities. Low ground pressure equipment may be authorized for large facilities at the discretion of the Engineer. Placement methods and BSM quantities shall account for approximately 10% loss of volume due to

settling. Planting methods and timing shall account for settling of media without exposing plant root systems.

20-11.07D Payment

The contract price paid per cubic yard for Bioretention Soil Media shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing Bioretention Soil Media, complete in place, as shown on the plans and as directed by the Engineer.

20-11.08 PERMEABLE CONCRETE PAVEMENT

20-11.08A General

20-11.08A(1) Summary

This section includes specifications for furnishing, constructing, and curing permeable concrete pavement.

Permeable concrete must comply with Caltrans 2015 Standard Specifications Section 90-2 "Minor Concrete," except that Section 90-2.02B "Cementitious Material" does not apply.

20-11.08A(2) Definitions

Not Used

20-11.08A(3) Submittals

Submit test data supporting your minimum cementitious material determination. Using trial batches is recommended.

Submit documentation of certifications of permeable concrete placement crew members.

Submit cores.

Before starting permeable concrete work, submit:

1. Test results for the void content of hardened concrete. Use core specimens obtained from a previous project that used the same mix design or from trial batch concrete. Calculate void content under section 20-11.08A(4)(g).
2. Test results for the void content of fresh concrete under ASTM C 1688/C 1688M.

20-11.08A(4) Quality Assurance

20-11.08A(4)(a) General

Not Used

20-11.08A(4)(b) Test Panels

The Engineer uses authorized test panels as the standard when evaluating the texture and color of the pavement surface.

Before paving operation starts, construct test panels at the jobsite. Use the materials, tools, equipment, personnel, and methods you will use in the work. Construct at least 2 test panels. Each panel must be at least 225 sq ft. If joints are shown, construct the joints within each panel. Test panels must meet the requirements for surface finish, void content, infiltration rate, thickness, and joints.

Take 3 core samples from each panel. The void content of each core must be within the specified range. Perform an infiltration rate test on each test panel.

If the Engineer rejects the test panels, construct new test panels.

Obtain authorization of the test panels before placing other permeable concrete pavement.

Remove and dispose of rejected test panels. Authorized test panels must remain in place until all permeable concrete pavement is completed. If authorized test panels are not constructed within the limits shown for permeable concrete pavement, remove and dispose of them.

20-11.08A(4)(c) Prepaving Conference

Contractor shall schedule a prepaving conference at a mutually agreed upon time and place to meet with the Engineer. Make the arrangements for the conference facility. Contractor shall discuss methods of performing each item of the work.

Prepaving conference attendees must sign an attendance sheet provided by the Engineer. The prepaving conference must be attended by your:

1. Project superintendent
2. Permeable concrete construction foreman and your National Ready Mix Concrete Association (NRMCA) certified permeable concrete craftsman. If you do not employ a craftsman, your NRMCA certified permeable concrete installer must attend.
3. Earthwork construction foreman
4. Base construction foreman
5. Concrete quality control or technical services manager.

Do not start paving work until the listed personnel have attended the prepaving conference.

20-11.08A(4)(d) Personnel Qualifications

The paving crew must meet one of the following criteria:

1. Crew must employ 1 or more NRMCA certified pervious concrete craftsman who must be onsite actively working with and guiding the placement crew during permeable concrete placement.
2. Crew must employ 3 or more NRMCA certified pervious concrete installers who must be onsite actively working with and guiding the placement crew during permeable concrete placement.
3. Crew must employ 1 or more NRMCA certified pervious concrete installer and 3 or more NRMCA certified pervious concrete technicians who must all be onsite actively working with and guiding the placement crew during permeable concrete placement.

20-11.08A(4)(e) Plastic Concrete Testing

For each day of paving, test permeable concrete for unit weight under ASTM C 1688 at least once for each 150 cu yd placed or fraction thereof. Unit weight must be within 5 lb/cu ft of the submitted mixture proportions.

20-11.08A(4)(f) Cores

For each day of paving, core 3 samples for each 10,000 sq ft or fraction thereof. The Engineer determines coring locations.

20-11.08A(4)(g) Void Content

The void content must be 22 percent or less.

The Contractor shall calculate the void content of a core specimen using the following equation:

$$V = 100 - [(Ws - Wi) \times 4 \times F / (H \times D^2 \times Pi)] \times 100$$

where:

V = void content, percent

Ws = saturated weight of the core under ASTM C 140, lb or g

Wi = immersed weight of the core under ASTM C 140, lb or g

F = 27.69 if measurements are in pounds and inches, 1000 if measurements are in grams and mm

H = height of the core, inches or mm

D = diameter of the core, inches or mm

Pi = 3.14159

Dimensions D and H are measured with calipers to the nearest 0.02 inch or 0.5 mm.

20-11.08A(4)(h) Infiltration Rate

Test the infiltration rate under ASTM C1701. Perform 3 tests in areas up to 25,000 sf. Conduct one test for each additional 10,000 sf. Separate each test location by at least 20 ft. Do not perform tests (1) if there is standing water on the pavement surface or (2) less than 24 hours after 1/4 inch or more of rain. The infiltration rate must be at least 100 inches/hour.

20-11.08A(4)(i) Penetration

The specifications for penetration in Caltrans 2015 Standard Specifications Section 90-1.02G(6) "Quantity of Water and Penetration or Slump" do not apply to permeable concrete.

20-11.08B Materials

The maximum size aggregate for the pavement surface must not exceed 1/2 inch. If the pavement is constructed in 2 or more layers, layers below the surface layer may have a larger maximum size aggregate.

Determine the minimum cementitious material content per Caltrans 2015 Standard Specifications Section 90-1.02B "Cementitious Materials". The cementitious material content must not exceed 590 lbs/cu yd.

If you determine the minimum cementitious material content to be less than 425 lb/cu yd, instead of Equation 2 in Caltrans 2015 Standard Specifications Section 90-1.02B(3) "Supplementary Cementitious Materials," use:

$$(425 - MSCM - PC) \geq 0$$

Choose a combined aggregate grading such that 100 percent of the aggregate passes the maximum specified size sieve and the resulting concrete complies with the specified void content.

The mixing time in a stationary mixer must be at least 90 seconds.

Transport mixed concrete to the delivery point in a truck mixer operating at the manufacturer's designated agitating speed. Discharge permeable concrete from the truck mixer within 60 minutes of batching. If you use a hydration stabilizer, an additional 60 minutes is allowed.

Joint filler for isolation joints must (1) be preformed expansion joint filler for concrete, bituminous type, and (2) comply with ASTM D 994.

20-11.08C Construction

20-11.08C(1) General

Not Used

20-11.08C(2) Subgrade Preparation

Immediately before placing pavement, grade and finish the subgrade. The subgrade must:

1. Comply with the specified compaction and grading
2. Be free of loose and extraneous material
3. Be uniformly moist and free of standing or flowing water.

The finished subgrade surface must not project into the pavement cross-section at any point. Verify the finished subgrade surface by:

1. Means of a template supported on the side forms for fixed form method
2. Measuring from the offset guide line or survey marks for extruded or slip form methods.

Fill areas of subgrade lower than the required grade with permeable concrete pavement. No payment is made for pavement used to fill these low areas.

20-11.08C(3) Paving

Place permeable concrete pavement under Caltrans 2015 Standard Specifications Section 40-1.03F(1) "Placing Concrete, General" except the 4th paragraph does not apply.

Place permeable concrete when the air temperature is above 40 degrees F.

Spread, compact, and shape permeable concrete pavement under Caltrans 2015 Standard Specifications Section 40-1.03F(4) "Stationary Side-Form Construction" or under Section 40-1.03F(5) "Slip form Construction." Vibrators must not be used. You may use wood side forms.

Compact permeable concrete to the required cross section. If you construct permeable concrete pavement in 2 or more layers, compact the lower layer before placing the next layer. Do not allow cold joints between layers. Compact within 30 minutes after spreading the permeable concrete. Do not disturb placed plastic concrete. Do not allow foot traffic on the un-compacted surface.

Use hand tampers to compact the concrete along the formed edges. After compaction and repair of surface flaws no further finishing is required.

If you delay placing 2 consecutive loads of permeable concrete by 20 minutes or more, form a construction joint. The joint must comply with Caltrans 2015 Standard Specifications Section 40-1.03B(2) "Construction Joints" except you must remove the bulkhead and dampen the face with an atomized spray when placement continues.

20-11.08C(4) Joints

Construct contraction joints, where shown, by scoring concrete with a grooving tool and rounding corners with an edger tool or by saw-cutting hardened concrete to a depth of at least 1/4 of the pavement depth.

Construct an isolation joint at pre-existing structures that abut or penetrate the permeable concrete area. The isolation joint must extend the full depth of the permeable concrete. Place and secure the isolation joint material before placing concrete.

For sidewalks construct joints under Caltrans 2015 Standard Specifications Section 73-1.03 "Concrete Curbs and Sidewalks, Construction."

20-11.08C(5) Finishing

The finished surface must not vary more than 0.02 foot from a 12-foot straightedge except at grade changes.

If placing pavement around or adjacent to miscellaneous structures such as manholes or pipe inlets, do not finish the miscellaneous structures to final grade until the pavement is finished beyond the miscellaneous structure.

20-11.08C(6) Curing

After placement, do not allow the permeable concrete surface to dry. Cure permeable concrete under Caltrans 2015 Standard Specifications Section 90-1.03B(4) "Waterproof Membrane Method" except keep the membrane in place at least 168 hours. Do not use unconfined soil to secure the membrane. During the cure period, check the concrete daily and ensure:

1. Membrane is not displaced or damaged
2. Moisture is condensed under the membrane

Immediately repair any damaged membrane and replace any displaced membrane. If there is no condensation, place 1.5 gallons of water per square yard of concrete surface under the membrane.

20-11.08D Payment

Permeable concrete pavement is measured in cubic yards. The contract price paid per cubic yard for permeable concrete pavement shall include full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to install the permeable concrete pavement, complete in place, as shown on the plans, and as directed by the Engineer.

Payment for preparing the subgrade is not included in the payment for permeable concrete pavement.

20-11.09 PERMEABLE INTERLOCKING CONCRETE PAVEMENT

20-11.09A General

20-11.09A(1) Summary

This section includes specifications for furnishing and installing concrete pavers for permeable interlocking concrete pavement (PICP).

Caltrans 2015 Standard Specifications Section 40-1 does not apply.

20-11.09A(2) Definitions

bundle: Several paver layers packaged together.

paver layer: Concrete pavers manufactured into patterned layers and ready for mechanical installation.

mechanical installation: Using a machine to lift and install paving layers.

laying face: Exposed, vertical face of a row of concrete pavers complete in place.

20-11.09A(3) Submittals

For jointing and bedding aggregates submit:

1. Gradation under California Test 202
2. Crushed particle under California Test 205
3. Abrasion loss under California Test 211
4. Cleanness value under California Test 227

For pavers submit:

1. Four manufactured, representative full-size samples of each type, thickness, finish, and color
2. Laboratory test reports indicating compliance with ASTM C 936

Submit PICP installation crew qualifications.

20-11.09A(4) Quality Assurance

20-11.09A(4)(a) General

Not Used

20-11.09A(4)(b) Prepaving Conference

Before starting earthwork, schedule a prepaving conference at a mutually agreed upon time and place to meet with the Engineer. Make the arrangements for the conference facility. Discuss methods of performing each step of the work.

Prepaving conference attendees must sign an attendance sheet provided by the Engineer. The prepaving conference must be attended by your:

1. Project superintendent
2. Paving construction foreman
3. Earthwork construction foreman
4. Base construction foreman
5. Foremen overseeing each installation crew
6. Paver manufacturer representative
7. Testing laboratory representative

Do not start PICP work until the listed personnel have attended the prepaving conference.

20-11.09A(4)(c) Test Panels

The Engineer uses authorized test panels as the standard when evaluating the texture and color of the PICP surface.

As a first order of work, construct test panels at the jobsite. Use the materials, tools, equipment, personnel, and methods you will use in the work. Construct at least 2 test panels. Test panels must meet the requirements for surface finish, thickness, and joints.

Test panels must be:

1. Constructed at an authorized location
2. At least 15 by 15 ft if the pavers are installed manually
3. At least 35 by 35 ft if the pavers are installed mechanically
4. Installed using the same personnel, materials, equipment, and methods to be used in the work

If the Engineer rejects the test panels, construct new test panels.

Obtain authorization of the test panels before placing other PICP.

Remove and dispose of rejected test panels. Authorized test panels must remain in place until all PICP is completed. If authorized test panels are not constructed within the limits shown for PICP, remove and dispose of them.

20-11.09A(4)(d) Just in Time Training

Not Used

20-11.09A(4)(e) Personnel Qualifications

Foremen overseeing each installation crew must hold a current PICP installer technician course certificate from the Interlocking Concrete Pavement Institute.

20-11.09A(4)(f) Aggregate

At least once per project, test aggregate as shown in the following table:

Test	Test method
Sieve analysis	CT 202
Percent of crushed particles, course aggregate, 2 fractured faces, percent minimum	CT 205
Los Angeles Rattler, loss at 500 revolutions, percent maximum	CT 211
Cleanness value	CT 227

20-11.09A(4)(g) Infiltration Rate

Test the infiltration rate of the completed PICP surface under ASTM C1701. Perform 3 tests in areas up to 25,000 sf. For areas over 25,000 sf, conduct one test for each additional 10,000 sf or fraction thereof. Each test location must be separated by at least 20 ft. Do not perform tests (1) if there is standing water on the pavement surface or (2) less than 24 hours after 1/4 inch or more of rain. The infiltration rate must be at least 100 inches/hour.

20-11.09B Materials**20-11.09B(1) General**

The aggregate for bedding and jointing must be graded within the limits shown in the following table:

Sieve size	Percentage passing		
	No. 8	No. 89	No. 9
1/2 inch	100	100	100
3/8 inch	85–100	90–100	100
No. 4	10–30	20–55	85–100
No. 8	0–10	5–30	10–40
No. 16	0–5	0–10	0–10
No. 50	--	0–5	0–5

If the joints between pavers are 1/4 inch wide or less, use no. 89 or no. 9 aggregate.

At least 95 percent of the aggregate particles must have at least 2 fractured faces.

The abrasion loss of the aggregate must not exceed 40 percent.

The cleanness value of the aggregate must be at least 80.

20-11.09B(2) Pavers

Pavers must comply with ASTM C 936 except the requirements for resistance to freezing and thawing do not apply.

Pavers must be at least 3-1/8 inch thick for vehicular applications and must be at least 2-3/8 inch thick for pedestrian applications.

20-11.09C Construction**20-11.09C(1) General**

Not Used

20-11.09C(2) Subgrade and Bedding

Immediately before placing bedding, the subgrade must be

1. Compacted and graded as specified
2. Free of loose and extraneous material
3. Free of standing or flowing water.

Moisten, spread, and screed the bedding over the subgrade. Test the screeded surface for smoothness with a 12-foot straightedge. The surface must be within 0.03 ft of the straightedge's lower edge.

Keep all vehicles off the screeded surface. If you disturb the subgrade, recompact and regrade. If you disturb the screeded surface, screed the surface and retest for smoothness with the straightedge.

20-11.09C(3) Pavers and Jointing Aggregate

Install pavers in the pattern shown. Maintain straight pattern lines.

Fill gaps at the edges of the PICP area with cut pavers. Cut pavers must be at least one-third of a whole paver. Use a masonry saw to cut the pavers.

Fill the joints with dry jointing aggregate by sweeping. Remove excess aggregate by sweeping.

Compact jointing aggregate and seat the pavers into the bedding course using a low-amplitude, 75-90 Hz plate compactor capable of at least 5,000 lbf. Make two passes across the PICP with the plate compactor. Do not compact within 6 ft of the unconfined edges of the PICP. Remove and replace any cracked pavers.

Apply additional jointing aggregate and fill within 1/4-inch of the top of the pavers. Remove excess aggregate by sweeping.

For each day of paving, fill joints, seat pavers, and apply additional jointing aggregate to within 6 ft of the laying face.

Test the PICP surface for smoothness with a 12-foot straightedge. The surface must be within 0.03 ft of the straightedge's lower edge.

Joints formed along the bond lines of the paver pattern must be straight. Joints must not deviate more than 0.04 ft. from a straight line. Measure the joint deviation from a 50-ft string line pulled over contiguous joint lines.

The surface elevation of the PICP must be 0.03 to 0.04 ft above adjacent drainage inlets, concrete collars, or channels.

Protect PICP from sediment deposition and damage due to subsequent construction activity on the site.

At least _____ days after placement of PICP, adjust the PICP by applying additional jointing aggregate to within 1/4-inch of the top of the pavers. Remove excess aggregate by sweeping.

20-11.09D Payment

PICP is measured in square feet. The contract price paid per square feet for permeable interlocking concrete pavers shall include full compensation for furnishing all labor, materials, equipment, tools, and incidentals necessary to install the permeable concrete interlocking pavers, complete in place, as shown on the plans, and as directed by the Engineer.

20-11.10 MODULAR POROUS CONCRETE GUTTER

20-11.10A General

20-11.10A(1) Summary

This section includes specifications for placing modular porous concrete gutter slabs manufactured.

20-11.10A(2) Definitions

Not Used

20-11.10A(3) Submittals

Not Used

20-11.10A(4) Quality Assurance

Note Used

20-11.10B Materials

The average core compressive strength at 28 days per ASTM C42/C42M. In addition to conforming to ACI 522R-06 and other applicable ASTM specifications.

Concrete average unit weight of 125 PCF (+/- 5%) conforming to ACI 522R-06.

The modular porous concrete paving slabs shall include permanent lifting points (two per panel) embedded in the surface of the slabs for ease of installation, maintenance, removal, and re-installation.

20-11.10C Construction

20-11.10C(1) General

Precast porous concrete slabs shall not be placed until they have achieved 85% of their minimum compressive strength.

Slabs to be configured or field cut as necessary to accommodate site specific conditions.

Do not allow adjacent materials to come into direct contact with the sides of the concrete paving slabs.

Provide ¼-inch open joint spacer plate per manufacturer's recommendations.

20-11.10C(2) Subgrade Preparation

Immediately before placing the precast slabs, grade and finish the subgrade. The subgrade must:

1. Comply with the specified compaction and grading
2. Be free of loose and extraneous material
3. Be uniformly moist and free of standing or flowing water.

20-11.10D Payment

The contract price paid per square feet for modular porous concrete gutter shall include full compensation for furnishing all labor, material, equipment, tools, and incidentals necessary to install the modular porous concrete gutter slabs, complete in place, as shown on the plans, and as directed by the Engineer.

Payment for preparing the subgrade is not included in the payment for modular porous concrete gutter.

20-11.11 PERMEABLE PAVEMENT (GENERAL CALTRANS SPECS)

20-11.11A General

20-11.11A(1) Summary

This work shall consist of constructing a permeable asphalt pavement on a prepared sub-grade.

The permeable asphalt pavement shall consist of a mixture of aggregates, bituminous binder material including polymer modified asphalt, fibers, mineral filler, anti-strip additives, and other optional additives as specified under Caltrans 2015 Standard Specifications Section 39 "Asphalt Concrete," or as directed by the Engineer.

1. Asphalt Surfaces: Use Open Graded Friction Course (OGFC) per Caltrans 2015 Standard Specifications Section 39 as the non-structural wearing course for permeable asphalt paving.
2. Permeable Base: Use Asphalt Treated Permeable Base (ATPB) per Caltrans 2015 Standard Specifications Section 29 as the structural layer for permeable asphalt pavement. No modification to existing standard specifications is required.

20-11.11A(2) Definitions

Not Used

20-11.11A(3) Submittals

Not Used

20-11.11A(4) Quality Assurance

Note Used

20-11.11B Materials

Not Used

20-11.11C Construction

Not Used

20-11.11D Payment

The unit of measure for Permeable Asphalt Pavement will be tons. The number of tons will be the actual number of tons complete in place, as weighed on approved truck scales. The Engineer will deduct the weight of all material lost, wasted, damaged, rejected or applied in excess of the Engineer's direction or contrary to these specifications.

The contract price paid per ton for Permeable Asphalt Pavement shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing Permeable Asphalt Pavement, complete in place, as shown on the plans, and as directed by the Engineer.

20-11.12 PERMEABLE ASPHALT PAVEMENT

20-11.12A General

20-11.12A(1) Summary

This work shall consist of constructing permeable asphalt pavement on a prepared sub-grade.

The permeable asphalt pavement shall consist of a mixture of aggregates, bituminous binder material including polymer modified asphalt, fibers, mineral filler, anti-strip additives, and other optional additives as specified under Caltrans 2015 Standard Specifications Section 39 "Asphalt Concrete."

Reference to the following test methods shall utilize the latest version of these documents.

AASHTO T96 -Standard Method of Test for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact

AASHTO T209 -Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures

AASHTO T275 -Standard Method of Test for Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens

AASHTO T283 -Standard Method of Test for Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

ASTM D3203 -Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures

ASTM D4791 -Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate

ASTM D5821 -Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate

ASTM D6390 -Standard Test Method for Determination of Draindown Characteristics in Uncompacted Asphalt Mixtures

ASTM D6752 -Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method

NAPA IS-115 -Open-Graded Asphalt Friction Courses, Design, Construction & Maintenance

NAPA IS-131 - Porous Asphalt Pavements for Stormwater Management NAPA – National Asphalt Pavement Association

20-11.12A(2) Definitions

Not Used

20-11.12A(3) Submittals

20-11.12A(3)(a) Job Mix Formula

The Contractor shall develop for approval a job mix formula (JMF) for proportioning of each type of permeable asphalt pavement proposed for use (surface, leveling, base, or other) in accordance with Caltrans 2015 Standard Specifications Section 39-2.01A(3)(b) "Job Mix Formula" and Section 39-2.01A(4)(b) "Job Mix Formula Verification." At least thirty (30) working days before construction, Contractor shall furnish job mix designs for the permeable asphalt, which shall include at a minimum all mix design described in this specification.

20-11.12A(3)(b) Contractor Qualifications

At the time of bid submission, Contractor shall submit the name and qualifications of the permeable asphalt installer, providing written evidence of project experience and proficiency in successfully completing permeable asphalt pavement construction including a minimum of three (3) completed

projects, total square footage to exceed the project quantities with owner information, addresses of each project, and the following:

- (i) Job mix designs used;
- (ii) In-Situ pavement test results

20-11.12A(3)(c) Producer Qualifications

Within seven (7) days after notice to proceed, the Contractor shall furnish the name and location of an asphalt plant that is an authorized material source as defined by Caltrans' *Certification Program for Suppliers of Asphalt* and will produce and provide permeable asphalt.

- a. Material Sources: Submit a list of materials proposed for work under this Section including the name and address of all material sources and all bituminous mixing plants.
- b. Certificates: Submit certificates, signed by the material sources and the relevant subcontractors, stating that the materials meet or exceed the specified requirements.
- c. Samples: Submit samples of all materials and all current test results of the mix for review and approval by the Engineer

20-11.12A(3)(d) Testing Agency

Within seven (7) days of notice to proceed, Contractor shall furnish the name and location of a third-party QA Inspection Agency with experience in testing permeable asphalt, who will oversee and document mix production. Use of testing services will not relieve the contractor of the responsibility to furnish materials and construction in full compliance with the Contract.

20-11.12A(4) Quality Assurance

20-11.12A(4)(a) Pavement Samples

The Contractor shall cut 4-inch minimum diameter core samples for air voids and thickness plus box samples from the compacted pavement for testing within 24 hours of placement. Samples of the mixture shall be taken for the full depth of the pavement every 200 tons of placement or 1 sample per day, whichever is greater, or as directed by the Engineer.

20-11.12A(4)(b) Testing

20-11.12A(4)(b)(i) Quality Insurance Inspector

- a. The Contractor shall provide, at the Contractors' sole expense, and the Engineer's approval, a third-party QA Inspector to oversee and document mix production. All mix testing results during production shall be submitted to the QA Inspector.
- b. The Quality Control (QC) plan may be altered at the discretion of the Engineer and based on written recommendations from the QA Inspector.
- c. For small batch production, the Engineer may also modify or eliminate some testing requirements in the QC plan.

20-11.12A(4)(b)(ii) Testing During Paving

- a. The Contractor shall sample, test and evaluate the mix in accordance with the methods and minimum frequencies in the Table 1. Test results shall be delivered to the Engineer.

Table 1: QA/QC testing requirements during production

Test	Minimum Frequency	Test Method
Temperature in Trucks Prior to leaving Plant	Six times per day	-
Gradation	Greater of either (a) 1 per 500 tons, (b) 2 per day, or (c) 3 per job	AASHTO T30
Binder Content	Greater of either (a) 1 per 500 tons, (b) 2 per day, or (c) 3 per job	AASHTO T164
Air Void Content	Greater of either (a) 1 per 500 tons, (b) 2 per day, or (c) 3 per job	ASTM D6752

- b. Testing of the temperature, binder content, and air void content shall be within the limits set by this specification.
- c. Testing of the gradation shall not vary from the approved design mix by more than the tolerances in Table 2.

Table 2: QA/QC testing tolerances during production

Sieve Size	Percent Passing
0.75	--
0.50	+ 6.0
0.375	+ 6.0
No. 4	+ 5.0
No. 8	+ 4.0
No. 200	+ 2.0
% PGAB	+ 0.4, -0.2

- d. Should the asphalt fail to meet all testing requirements initially, production modifications shall be made until the permeable asphalt mix is within required tolerances. After the corrective action has been taken, the resulting mix will be sampled and tested again, at the Contractor's expense.
- e. If the re-sampled asphalt fails to meet all testing requirements again, the Engineer will be immediately informed and provided with the test results. The Engineer may determine that it is in the best interest of project that production is ceased at that time. The Contractor will be responsible for all costs associated with the inability of the asphalt plant to meet all testing requirements.
- f. QA/QC requirements during paving are summarized in Table 3.

Table 3. QA/QC requirements during paving

Activity Schedule	Frequency	Tolerance
Inspect truck beds for pooling (draindown)	every truck	NA
Take surface temp. behind joint heater	each pull	6°C (10°F) of compaction temp
Test surface smoothness & positive drainage with a 10 ft straight edge	After compaction	4.5 mm (3/16")
Hose test with at least 5 gpm water	after compaction	immediate infiltration, no ponding

20-11.12A(4)(b)(iii) Testing After Paving

The full permeability of the pavement surface shall be tested prior to final acceptance in accordance with ASTM D6390.

- a. Test in-place base and surface course for compliance with requirements for thickness, void content and unit weight as described above by using 1' x 1' slab samples. Repair or remove and replace unacceptable work, as directed by the Engineer, at the Contractor's cost.
- b. Surface Smoothness: Test finished surface for smoothness using a 10-foot straightedge applied parallel with and at right angles to the centerline of the paved area. Surface will not be accepted if gaps or ridges exceed 3/16 of an inch. The smoothness requirements specified herein apply only to the top lift of each layer, when asphalt is constructed in more than one lift.

20-11.12A(4)(b)(iv) Test Results

Testing agency shall provide pavement test result:

- a. Air void content shall be calculated using California Test 309 (Compact specimen and determine bulk specific gravity in accordance with CT 308 Method B.
- b. Test results per Table 4.

Table 4 – Certification Requirements

Material*	Properties to be reported on Certificate**
binder PGAB	Certification
coarse aggregate	gradation, wear, fracture faces (fractured and elongated)
fine aggregate	Gradation
Silicone, when applicable	manufacturer's certification
Fibers, when applicable	manufacturer's certification
Mineral filler, when applicable	manufacturer's certification

* Samples of each material shall be submitted to the Engineer. Samples must be in sufficient quantity to perform tests for each material.

** At a minimum; more material properties may be required by the Engineer.

20-11.12B Materials

The materials for permeable asphalt pavement shall meet the requirements of:

1. **Asphalt Surfaces:** Use Open Graded Friction Course (OGFC) per Caltrans 2015 Standard Specifications Section 39 as the non-structural wearing course for permeable asphalt systems. No modification to existing standard specifications is required.
2. **Permeable Base:** Use Asphalt Treated Permeable Base (ATPB) per Caltrans 2015 Standard Specifications Section 29 as the structural layer for permeable asphalt systems. No modification to existing standard specifications is required.
3. **Coarse aggregate:** must comply with the 1 inch by no. 4 primary size coarse aggregate specified in Caltrans 2015 Standard Specification Section 90-1.02C(4)(b).
4. **Additives:** additives such as cellulose or mineral filler, or anti-strip additives, if used, shall be listed in the Job Mix Formula and approved by the Engineer.

20-11.12C Construction

20-11.12C(1) Weather and Seasonal Restrictions

Comply with the following:

1. The ambient air temperature during the past 24 hours shall be above 50°F
2. The asphalt laying temperature should be within 10°F of the compactive temperature in the approved job mix design.

20-11.12C(2) Hauling of Asphaltic Materials

1. The asphalt shall be transported in clean vehicles with tight, smooth dump beds that have been sprayed with a non-petroleum release agent or soap solution to prevent the mixture from adhering to the dump beds. Mineral filler, fine aggregate, slag dust, and similar materials shall not be used to dust truck beds.
2. The open graded mix shall be covered during transport to protect the mix from weather and to minimize mix cooling and prevent lumps. Long hauls, particularly those in excess of 25 miles may result in separation of the mix and its rejection, and are not recommended.

20-11.12C(3) Preparation of Grade

1. Sub-Grade Preparation – Shall be in accordance with the Caltrans 2015 Standard Specifications Section 24.
2. Base Materials – Shall be in accordance with the Caltrans 2015 Standard Specifications Section 25 and Section 26.

20-11.12C(4) Spreading and Finishing

1. Pre-Placement Conference -A mandatory pre-placement conference will take place at least seven (7) days prior to installation of work and shall include at a minimum the Engineer and Contractor's superintendent, asphalt installer, and QA inspector.
2. Contact surfaces such as curbing, gutters, and manholes shall be painted with a thin, uniform coat of Type RS-1 emulsified asphalt immediately before the asphalt mixture is placed against them.
3. Place the asphalt using self-propelled paving equipment with an activated screed or strike-off assembly capable of being heated if necessary, and capable of spreading and finishing the mixture without segregation. Track pavers are required unless otherwise directed by the Engineer.
4. The use of water to cool the pavement is prohibited.
5. Place lifts no more than 24 hours after each previous lift to minimize the use of tack coats. Tack coats will only be allowed if approved by the Engineer.
6. The finished surface shall be of a uniform texture and evenness, and shall not show any indication of tearing, shoving, or pulling of the pavement during placement.

20-11.12C(5) Compaction of Permeable Asphalt

1. Roll the asphalt using a two-axle tandem roller when it is cool enough to withstand the roller without displacement of the asphalt, and using rollers sufficient to compact the asphalt without crushing the aggregate or compromising the required void content and infiltration rates.
2. The number, mass (weight), and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. Generally, one breakdown roller will be needed for each paver used in the spreading operation.
 - a. Breakdown rolling shall occur when the mix temperature is between 275 and 325°F.
 - b. Intermediate rolling shall occur when the mix temperature is between 200 and 275°F.
 - c. Finish rolling shall occur when the mix temperature is between 150 and 200°F.
3. Unless otherwise specified by the Engineer, the longitudinal joints shall be rolled first. Next, the Contractor shall begin rolling at the low side of the pavement and shall proceed toward the center or high side with lapped rolling parallel to the centerline.
4. Roll until all roller marks are gone however avoid excessive rolling which could reduce the infiltration capabilities of the asphalt.
5. To prevent adhesion of the mixture to the rolls, rolls shall be kept moist with clean water or water mixed with very small quantities of detergent or other approved materials. Excess liquid will not be permitted.
6. Along forms, curbs, headers, walls, and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot or lightly oiled hand tampers, smoothing irons or with mechanical tampers. On depressed areas, either a trench roller or cleated compression strips may be used under the roller to transmit compression to the depressed area.
7. Rollers will not be stopped or parked on the freshly placed mixture; Foot-traffic shall not be allowed on fresh asphalt for at least 24-hours.
8. Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with fresh hot mixture. The mixture shall be compacted to conform to the surrounding area with segregation. Any area showing deficiencies shall be replaced at the Contractor's expense.

20-11.12C(6) Joints

1. Joints between old and new pavements or between successive days work shall be made to ensure a thorough and continuous bond between the old and new mixtures. Whenever the spreading process is interrupted long enough for the mixture to attain its initial stability, the paver shall be removed from the mat and a joint constructed.
2. Butt joints shall be formed by cutting the pavement in a vertical plane at right angles to the centerline, at locations approved by the Engineer. The Engineer will determine locations by using a straightedge at least 16 feet long. The butt joint shall be thoroughly coated with Type RS-1 emulsified asphalt just prior to depositing the pavement mixture when paving resumes.
3. Tapered joints shall not be allowed. Longitudinal joints that have become cold shall be coated with Type RS-1 emulsified asphalt before the adjacent mat is placed. If directed by the Engineer, joints shall be cut back to a clean vertical edge prior to applying the Type RS-1 emulsified asphalt.

20-11.12C(7) Protection of Asphaltic Pavement

Minimum times prior to opening pavement to traffic are as follows:

- After pavement has been permitted to cool to below 100 °F for all traffic, and;
- 24 hours for pedestrian traffic, and;

- As directed by Engineer for vehicular traffic.

The Contractor shall protect the permeable asphalt from severe weather conditions and contamination by dust, dirt, mud or other fine grained material or sediment. The asphalt shall be protected by an approved method from the time of placement until final acceptance of the project. Any damage to the permeable asphalt caused by the contractor's equipment shall be repaired by the contractor at no cost to the owner. Any portion of the permeable asphalt that becomes contaminated to the extent that drainage is reduced or inhibited shall be removed and replaced at no expense to the County.

20-11.12D Payment

The unit of measure for Permeable Asphalt Pavement will be tons. The number of tons will be the actual number of tons complete in place, as weighed on approved truck scales. The Engineer will deduct the weight of all material lost, wasted, damaged, rejected or applied in excess of the Engineer's direction or contrary to these specifications.

The contract price paid per ton for Permeable Asphalt Pavement shall include full compensation for furnishing all labor, materials, tools, equipment, and incidentals and for doing all work involved in constructing Permeable Asphalt Pavement, complete in place, as shown on the plans, and as directed by the Engineer.