APPENDIX D: SPECIFICATIONS

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APPENDIX D: SPECIFICATIONS

This appendix details suitable materials and installation methods (i.e. specifications) for a variety of BMPs including a description of the material, applicability to a particular BMP, criteria for selection, and/or installation recommendations.

SOIL AMENDMENT SPECIFICATIONS

Applicability. Soil amendment (Organic Matter Compost, Mycorrhizae, and Mulch as described below) specifications apply to the following BMPs:

- Depaving Existing Pavement BMP
- Restored Soils BMP
- Contained Planters BMP
- Dispersion BMPs (Standard Details BMP 4.01 to 4.02)
- Tree Planting BMP (Standard Details BMP 10.01 to 10.04)
- Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
- Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
- LID Swale BMP (Standard Details BMP 3.01 to 3.09).
- Water Quality Conveyance Swale (Standard Details BMP 9.01 to 9.04)

Organic Matter Compost

Care should be taken to ensure that compost is clean and free of weeds, pollutants, or other deleterious materials that may impact plant health and water quality.

Organic matter compost shall meet the following criteria:

- Weed seed and pollutant free.
- 100% should pass a 1/2-inch screen.
- pH between 5.5 and 7.0. If the pH isn't quite right, it may be lowered by adding iron sulfate and sulfur or raised by adding lime. If lime is used, incorporate first into the compost, wet the compost down, and then fold mixture into the soil.
- Carbon nitrogen ratio between 30:1 and 35:1.
- Organic matter content between 40 and 50 percent.
- Fully composed. Earthy is good. Avoid compost that smells like ammonia.
- Metals should not exceed (mg/kg dry weight):
    - Arsenic ≤20 ppm
    - Cadmium ≤10 ppm
    - Copper ≤750 ppm
    - Lead ≤150 ppm
    - Mercury ≤8 ppm
    - Molybdenum ≤9 ppm
    - Nickel ≤210 ppm
    - Selenium1 ≤18 ppm
    - Zinc ≤1400 ppm

Organic matter compost may consist of the following:

- Mushroom Compost. The used bedding material from commercial mushroom production.
- US Compost Council Seal of Testing Assured compost. Visit http://compostingcouncil.org/participants to find a participating supplier near you. The STA

program is no guarantee of quality, only that the compost has been tested and those test results are available for the designer's review to compare against the criteria listed above.
- Any other organic matter meeting the criteria above except for those listed next.
- Peat Moss is not recommended since it is extracted from wetlands and has negative impacts on the watershed from which the peat moss was removed.

Mycorrhizae

Mycorrhizae are mushroom roots, and most plants in western Oregon have co-evolved with this material. Mushroom roots interact with the plant roots by feeding on the plant's waste and by bringing the plant nutrients, thereby expanding the effective root area of the plant by many fold. Plants receiving this kind of amendment consistently grow bigger and faster than plants without it.

Material Specifications. Many manufacturers/suppliers have mycorrhizae products specific to a particular BMP, such as for landscapes or eco-roofs with a variety of applications methods that may include hydromulching, broadcasting, tilling, or watering. You can buy amendments as pellets or water-soluble powder.
A non-BMP-specific mycorrhizae product with a mix of endo- and ectomycorrhizal species is acceptable for any plant-based BMP in this guidance.
Installation. Apply or incorporate per manufacturer's guidelines.

Mulch

Material Specifications. Mulch should be:
- Shredded wood chips (preferred for trees and shrubs)
  OR
- Coarse compost (not bark dust or bark chips) meeting the specifications in this section for "Organic Matter Compost"
- Spread in a 2-inch layer minimum over bare soil and between plantings to completely cover the soil and prevent erosion or weed intrusion.

Pull a few inches away from woody stems and trunks (*i.e.* shrubs and trees) to prevent rotting. Form a ring out of the material for holding extra water during the establishment period (see **Appendix E**). Materials to avoid include:
- Bark dust or bark chips. These tend to float more than the materials recommended above when water enters stormwater facilities. These should be avoided in other BMPs as well since they do not readily break down to provide nutritional support to the plants.
- Sawdust, grass clippings, and leaves. These will break down quickly, robbing the soil of nitrogen.

Installation. A 2 to 3-inch layer of coarse compost or shredded wood (not bark products) shall be used over the amended soil and between the plantings to completely cover the soil and prevent erosion and weed intrusion.

AGGREGATES

Applicability. The open-graded crushed aggregate specifications apply to the following BMPs:
- The underdrain assemblies included in the
  - Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
  - Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
  - LID Swale BMP (Standard Details BMP 3.01 to 3.09).
  - Water Quality Conveyance Swale (Standard Detail BMP 9.04)

- Porous Pavement BMP base rock and/or the rock trenches (Standard Details BMP 5.01 to 5.04)
- Soakage trench BMP (Standard Details BMP 6.01 to 6.03)
- Drywell BMP (Standard Details BMP 7.01 and 7.02)

Terminology. Rock and aggregate are used interchangeably throughout this guidance.

Material Specifications. Coarse aggregate shall meet the following requirements:

1. All aggregates shall be clean and washed rock. For BMPs with geotextile fabric (see specification below) below rock (*e.g.* Porous Pavement BMP, Soakage Trench BMP, and Drywell BMP), a maximum wash loss of 0.5% is required. Clean rock is generally delivered with a 2% wash loss, so rinsing in the truck or on-site, using appropriate erosion control methods, may be needed to prevent long-term geotextile clogging. For BMPs that do not incorporate a geotextile fabric, 2% wash loss as delivered is acceptable.
2. All aggregates in porous pavements shall meet the following requirements:
    a. Minimum Durability Index of 35
    b. Maximum Abrasion of 10% for 100 revolutions and maximum of 50% for 500 revolutions
3. Unless otherwise approved by the engineer, **base rock** shall be uniformly graded with the following gradation (AASHTO #3):

Table C-1. AASHTO #3 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
2 ½" (63 mm)	100
2" (50 mm)	90-100
1 ½" (37.5 mm)	35-70
1" (25 mm)	0-15
½" (12.5 mm)	0-5

If the above gradation cannot be met, the following gradation (AASHTO # 5) is acceptable with the approval of the licensed engineer and minimum voids of 40%:

Table C-2. AASHTO #5 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½" (37.5 mm)	100
1" (25 mm)	90-100
¾" (19 mm)	20-55
½" (12.5 mm)	0-10
3/8" (9.5 mm)	0-5

4. **Choker course aggregate** (porous pavement) or **storage rock (rock trench) aggregate** or **French drain rock** (vegetated stormwater facilities) shall have the following gradation (AASHTO # 57).

Table C-3. AASHTO #57 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½" (37.5 mm)	100
1" (25 mm)	95-100
½" (12.5 mm)	25-60
4 (4.75 mm)	0-10
8 (2.36 mm)	0-5

5. **Infill aggregate** and **bedding course** (permeable pavers) or **separation rock** (vegetated stormwater facilities) shall have the following gradation (AASHTO # 8).

Table C-4. AASHTO #4 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
½" (12.5 mm)	100
3/8" (9.5 mm)	85-100
4 (4.75 mm)	10-30
8 (2.36 mm)	0-10
16 (1.18 mm)	0-5

GEOTEXTILE FABRIC

Applicability. Geotextile fabric specifications apply to the following BMPs:

- Porous Pavement BMP base rock and/or the rock trenches (Standard Details BMP 5.01 to 5.04)
- Soakage trench BMP (Standard Details BMP 6.01 to 6.03)
- Drywell BMP (Standard Details BMP 7.01 and 7.02)

Material Specifications. Non-woven geotextile (drainage filter fabric) shall conform to the following criteria:

- Minimum flow rate of 95 gal/min/ft2 ASTM D-4491-85
- Grab tensile strength min 115 lb. ASTM D-4632-86
- Mullen Burst strength min 150 psi ASTM D-3786-80a
- Puncture resistance min 45 lb. ASTM D-4833-88
- Apparent opening size 60-90 U.S. Standard Sieve

Installation. Geotextile fabric shall be installed per the following guidance:

- Place geotextile in accordance with manufacturer's standards and recommendations.
- Adjacent strips of geotextile shall overlap a minimum of sixteen (16) inches.
- Secure geotextile at least four (4) feet outside of excavated area over exposed soil and take any steps necessary to prevent runoff or sediment from entering the pavement rock base.
- After porous pavement surface is installed, cut excess geotextile fabric at the interface between the ground and the pavement, so that it cannot be seen any longer.

Very Clean Rock Required. The presence of a geotextile fabric requires that the base rock be delivered clean and washed on-site before placement, if necessary. Otherwise, as water moves through the cross section, it will carry dirt particles down to the fabric and clog it, creating an impervious layer beneath the area you intended to be porous. One successful method for this is to hose the rock off in the delivery truck when it arrives. Another method is to dump the rock and wash off the pile, pulling rock from the top and applying water again, depending on the size of the pile. Inspect it visually on a regular basis for small rocks and dirt to know at what point in the pile you should start washing again.

TREATMENT SOIL

A treatment soil is a naturally occurring or engineered mix which may include clay, silt, sand, gravel, compost, microorganisms, and mycorrhizae that has the desired physical and chemical properties needed to clean stormwater as it passes through it. It must have a variety of physical and chemical properties.

Treatment soils meeting the specifications below may include:

- Undisturbed native soil
- Amended Planting Soil (referred to in **Appendix F** Standard Details for rain gardens, stormwater planters and LID swales), which may be either:
    - Amended native soil

- Imported soil mix

Imported treatment soil mixes in Western Oregon have a variety of names, which may be marketed as bioretention soil mix (BSM), planting soil, amended soil, engineered soil, 3-way mix, or others.

Applicability. Treatment soil specifications apply to the following BMPs:

- Depave Existing Pavement BMP
- Restored Soils BMP
- Contained Planters BMP
- Dispersion BMPs (Standard Details BMP 4.01 to 4.02)
- Tree Planting BMP (Standard Details BMP 10.01 to 10.04)
- Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
- Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
- LID Swale BMP (Standard Details BMP 3.01 to 3.09).
- Water Quality Conveyance Swale (Standard Details BMP 9.01 to 9.04)

Material Specifications for All Treatment Soils. All treatment soils should be:

- Tested and confirmed to infiltrate between 0.5 inches per hour and 12 inches per hour[1] per Appendix C.
- Be free of weed seeds. If soil is imported, the supplier should be able to certify this condition through industry standard best practices.
- Be free of contaminants & hazardous materials[1]

Material Specifications for Imported Soil Mixes. All imported soil mixes should be tested for and meet the following criteria to a minimum depth as shown on the standard details in Appendix F:

- An organic content matter (OM) from 8-10% by weight[1]
- A cation exchange capacity (CEC) greater than 5 millequivalents/100 grams of dry soil[1]
- Between 2 – 5% clayey fines[1]
- pH between 5.5 and 7.5[2]
- 60% Loamy sand[1]
- 40% organic matter compost[1]
- Conform to the following gradation:

Table C-5. Imported Soil Gradation Specifications.

U.S. Sieve Size	Percent Passing
3/8-inch	100
#4	95-100
#10	75-90
#40	25-40
#100	4-10
#200	2-5

Additional Specifications for Amended Native Soil. Amended native soil is the soil on the site mixed with organic matter compost (required) and gravelly sand (optional).

[1] Test undisturbed native soil for both the undisturbed native soil and amended native soil conditions per Appendix C. Test imported soil mixes in a lab according to the guidance provided in this memo retrieved from the State of Washington's Water Quality Manual: http://www.ecy.wa.gov/programs/wq/stormwater/bsmresultsguidelines.pdf

[2] Low Impact Development Center specifications. Retrieved from: http://www.lowimpactdevelopment.org/epa03/biospec_left.htm

Organic Matter Compost. Material should meet the specifications described above for organic matter compost.

Gravelly Sand. Use of gravelly sand is optional. For clayey soils, gravelly sand must be blended into the soil simultaneously with organic matter compost. **Caution! Never fold sand alone into clayey soils.** With insufficient quantities of sand, this action is likely to cement the soil creating a barrier to infiltration.

Gravelly sand should be free of organic material, contaminants, and hazardous materials, and should conform to the following gradation, which should be compared against the gradation of material provided by your quarry:

Table C-6. Gravelly Sand Gradation Specifications.

U.S. Sieve Size	Percent Passing
2-inch	100
3/4-inch	70-100
1/4-inch	50-80
No. 40	15-40
No. 200	0-3

Mixing. Mix soil and amendments to a homogeneous (i.e. all the same) consistency. Do not mix compost, sand, and native soil in the rain or wet conditions. Even in dry weather, soils and amendments themselves should not be overly wet.

Choose from two different soil blends as follows:

- Organic matter compost only = 2 (soil):1 (organic matter compost)
- Organic matter compost and gravelly sand = 2(soil):1(organic matter compost):1(sand)

Storage. Store stockpiles of amended native soil mix in a manner that prevents them from becoming wet from rain, receiving stormwater runoff or other sources of water, or contaminated by fine soil or other undesirable materials. All stockpiles of mixed soil material should be protected and covered.

Placement. Place amended native soil mix in lifts not exceeding 8 inches in loose thickness. Compact lightly after each lift. Do not over compact soil mix with mechanical equipment after placement; following the construction steps in this guidance, soils have already been compacted by spraying water on them or boot tamping. After all lifts have been placed, grade soil to finish grades as specified on the plans.

IMPERMEABLE LINER

Applicability. Impermeable liners may be used to line the sides of infiltration rain gardens, stormwater planters, LID swales, and water quality conveyance swales (to prevent undercutting of adjacent structures during infiltration) or the sides and bottom of lined facilities. Specifications apply to the following BMPs:

- Rain Garden BMP (Standard Details BMP 1.01 to 1.06)
- Stormwater Planter BMP (Standard Details BMP 2.01 to 2.06)
- LID Swale BMP (Standard Details BMP 3.01 to 3.09).
- Water Quality Conveyance Swale (Standard Details BMP 9.01 to 9.04)

Material Specifications. Impermeable liners may be a 45-mil (minimum) low density polyethylene (LDPE), 45-mil (minimum) ethylene propylene diene monomer (EPDM) or bentonite clay mat per manufacturer guidance.

Placement. Make sure that the liner is installed securely at a height equal to the depth of water that may be ponded or flowing during any storm, not just the design storm. If an outlet structure is present, attach the liner to the outlet structure with the appropriate adhesive or mechanically.

If an LDPE or EPDM liner will be used, make sure that it's a single, solid piece big enough to be installed underneath the entire facility area or that pieces are glued or otherwise waterproofed together per manufacturer guidelines. Overlapping sheets will not adequately prevent infiltration.
If the design calls for a bentonite clay mat, follow the manufacturer's guidance for installation.

POROUS ASPHALT PAVEMENT SPECIFICATION

This specification has been provided courtesy of Tom Cahill of Cahill Associates. This specification has been adapted for conditions throughout Western Oregon but should be further completed with specific information for your project.

Where project-specific changes to this specification are needed, information has been ***[bracketed, changed to italics, and in the color green similar to this text.]***

Blue information in a box is provided to give you more information on how to complete the project-specific changes. Except for the sentence "This specification has been provided courtesy of Tom Cahill of Cahill Associates.", delete the above paragraph and all blue text and incorporate these specifications into your construction documents and/or contract drawings.

Summary

The work of this Section includes subgrade preparation, and base course, choker base course, and porous bituminous paving.

Part 1: Submittals

- Submit a list of materials proposed for work under this Section including the name and address of the materials producer and the location from which the materials are to be obtained.
- Submit certificates, signed by the materials producer and the paving subcontractor, stating that materials meet or exceed the specified requirements.
- Submit samples of base rock and choker course aggregate, non-woven geotextile, and porous bituminous asphalt for review and approval by the Engineer.
- The asphalt mixing plant shall certify the aggregate mix, abrasion loss factor, polymer additive, binder draindown, tensile strength ratio, resistance to stripping by water and asphalt content in the mix.

Quality Assurance

- Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work in this section.
- Codes and Standards
    - All materials, methods of construction and workmanship shall conform to applicable requirements of Oregon Department of Transportation, unless otherwise specified.

ODOT has been using open graded HMAC as a top course over impervious pavement for years to reduce spray and hydroplaning.

Project Conditions

A. Protection of Existing Improvements

1. Protect adjacent work from splashing or paving materials. Remove all stains from exposed surfaces of paving, structures, and grounds. Remove all waste and spillage.
2. Do not damage or disturb existing improvements or vegetation. Provide suitable protection where required before starting work and maintain protection throughout the course of the work.
3. Restore damaged improvements, including existing pavement on or adjacent to the site that has been damaged as a result of construction work, to their original condition or repair as directed to the satisfaction of the Owner, and authority having jurisdiction at no additional cost.

B. Safety and Traffic Control
   1. Notify and cooperate with local authorities and other organizations having jurisdiction when construction work will interfere with existing roads and traffic.
   2. Provide temporary barriers, signs, warning lights, flaggers, and other protections as required to assure the safety of persons, vehicles, and bicycles around the construction area and to organize the smooth flow of traffic.

C. Weather Limitations
   1. Do not place bituminous paving mixtures between *[November 1 and April 1]*, unless otherwise permitted in writing by the Engineer.

Change this to reflect the period where your region's average temperatures may be colder than 55 degrees.

   2. Do not place porous bituminous paving mixtures when surfaces are wet or when the ambient temperature is 55 degrees Fahrenheit of lower.

D. Annual Book of ASTM Standards, 1997 or latest edition; American Society for Testing and Materials, West Conshohocken, PA.
E. Standard Specifications, latest edition; Oregon Department of Transportation (ODOT)
F. Standards of the American Association of State Highway and Transportation Officials (AASHTO), 1998 or latest edition.

Part 2: Products

Materials

A. Base Courses
   1. All aggregates within reservoir course shall meet the following:

      a. Maximum Wash Loss of 0.5%
      b. Minimum Durability Index of 35
      c. Maximum Abrasion of 10% for 100 revolutions and maximum of 50% for 500 revolutions

Our volcanic rocks like basalt are going to meet this durability index, so this shouldn't be hard to find in Oregon. Same with abrasion.

   2. Unless otherwise approved by the Engineer, base rock shall be uniformly graded with the following gradation (AASHTO number 3):

Table C-7. AASHTO #3 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
2 ½" (63 mm)	100
2" (50 mm)	90-100
1 ½" (37.5 mm)	35-70
1" (25 mm)	0-15
½" (12.5 mm)	0-5

If the above gradation cannot be met, the following gradation (AASHTO size number 5) is acceptable with the approval of the Engineer and minimum void space of 40%:

Most uniformly graded rock has 40% voids, so this shouldn't be a big deal to find in Oregon.

Table C-8. AASHTO #5 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½" (37.5 mm)	100
1" (25 mm)	90-100
¾" (19 mm)	20-55
½" (12.5 mm)	0-10
3/8" (9.5 mm)	0-5

3. Choker course aggregate shall have the following gradation (AASHTO size number 57).

Table C-9. AASHTO #57 Gradation Specifications.

U.S. Standard Sieve Size	Percent Passing
1 ½" (37.5 mm)	100
1" (25 mm)	95-100
½" (12.5 mm)	25-60
4 (4.75 mm)	0-10
8 (2.36 mm)	0-5

4. Non-woven geotextile (drainage filter fabric) shall conform to the following:
    a. Minimum flow rate of 95 gal/min/ft^2 ASTM D-4491-85
    b. Grab tensile strength min 115 lb ASTM D-4632-86
    c. Burst strength min 150 psi ASTM D-3786-80a
    d. Puncture resistance min 45 lb ASTM D-4833-88
    e. Apparent opening size 60-90 U.S. Standard Sieve
    f. Non-woven geotextile shall be Mirafi 160N, or approved equal.

5. 2-foot wide rock edge drain shall be 1 to 2 ½" diameter washed screen crushed aggregate with no fines.

This is a backup overflow system if the pavement surface clogs. Tip the pavement a minimum of 1% towards this edge drain and design and install the edge drain to connect/sit on top of the reservoir course. If the pavement is clogged, rainfall will turn into runoff, but will still be infiltrated.

B. Porous Bituminous Asphalt

1. In accordance with ODOT Section 00745, ½" Open Grade Level 3 HMAC mix except as modified by the following:

Click on this link to download Word doc with ODOT specs.

2. Bituminous surface course for porous paving shall be *[two and one-half (2.5) inches thick]* with a bituminous mix of 5.5% to 6% by weight dry aggregate. In accordance with ASTM D6390, draindown of the binder shall be no greater than 0.3%. If more absorptive aggregates, such as limestone, are used in the mix then the amount of bitumen is to be based on the testing procedures outlined in the National Asphalt Pavement Association's Information Series 131 – "Porous Asphalt Pavements" (2003) or ODOT equivalent.

Thickness of asphalt is often 2.5 to 3 inches thick, but this varies with the project. Get recommendation from geotechnical engineer for your soils and traffic loading.
The draindown is critical or the pavement will clog due to the binder being too viscous and draining down the interface between the asphalt and the rock and sealing the pavement at that interface.
Click on the purple text link to buy "Porous Asphalt Pavements" document.

3. For traffic bearing surfaces, use neat asphalt binder modified with an elastomeric polymer to produce a binder meeting the requirements of *[PG 70-22]* in accordance with ODOT Section 00744.11. The elastomeric polymer shall be styrene-butadiene-styrene (SBS), or approved equal, applied at a rate of 3% by total weight of the binder. The composite materials shall be thoroughly blended at the asphalt refinery or terminal prior to being loaded into the transport vehicle. The polymer modified asphalt binder shall be heat and storage stable.

Varies with location. Get recommendation from geotechnical engineer or reference Chapter 3 of the Asphalt Association of Oregon publication "Asphalt Pavement Design Guide". This value SHOULD work for the Willamette Valley.

The contractor shall submit a certification letter from the polymer-modified asphalt supplier to the Engineer before the mix is placed on the project. The certification letter from the supplier will include the following:

a. Type of elastomer polymer used to modify the asphalt.
b. Quality control sampling and testing procedures used to certify the polymer modified asphalt prior to shipping to the Contractor's asphalt plant.
c. Information on the storage and stability of the polymer modified asphalt.
d. Recommended mixing and compaction temperatures.
e. A statement saying that the polymer modified asphalt will comply with these specifications.

4. Add hydrated lime at a dosage rate of 1.0% b weight of the total dry aggregate to mixes containing granite. Hydrated lime shall meet the requirements of ASTM C977. The additive must be able to prevent the separation of the asphalt binder from the aggregate and achieve a required tensile strength ratio (TSR) of at least 80% on the asphalt mix.

The asphaltic mix shall be tested for its resistance to stripping by water in accordance with ASTM D-3625. If the estimated coating area is not above 95 percent, anti-stripping agents shall be added to the asphalt.

Part 3: Execution

Installation

A. Base Course

1. Owner shall be notified at least 24 hours prior to all base courses and porous paving work.
2. Subgrade Preparation
   a. Existing subgrade under pavement areas shall NOT be compacted or subjected to excessive construction equipment traffic prior to geotextile and stone bed placement.

Your geotechnical engineer can recommend equipment that might be used for your soils. For instance, in sandy soils, track equipment may not cause excessive compaction. In clays soils, though, it is very likely to and some means of working from the side or building a deep haul road to spread the loads over the soils would be needed.

   b. Where erosion of subgrade has caused accumulation of fine materials and/or surface ponding, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 6" with a spring tooth rake or equivalent and a light tractor.

"Light equipment" means hand tools. Even foot traffic can compact clay soils!

   c. Bring subgrade of base course to line, grade, and elevations indicated. Fill and lightly re-grade with aggregate base course material any areas damaged by erosion, ponding, or traffic compaction before placing the aggregate. All bed bottoms are level grade.

3. Base Course Installation
   a. Upon completion of subgrade work, the Engineer shall be notified and shall inspect at his discretion before proceeding with reservoir and choker course installation.
   b. Geotextile and base course aggregate shall be placed immediately after approval of the subgrade preparation. Any accumulation of debris or sediment, which has taken place after approval of subgrade shall be removed prior to installation of geotextile at no cost to the Owner.
   c. Place geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of geotextile shall overlap a minimum of sixteen inches (16"). Secure geotextile at least four (4) feet outside of excavated area and take any steps necessary to prevent any runoff or sediment from entering the storage bed.
   d. Install reservoir base course in 8-inch maximum lifts. Lightly compact each layer with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregates to grades indicated on the drawings.
   e. Install choker base course aggregate evenly over surface of rock trench, sufficient to allow placement of pavement, and notify Engineer for approval. Choker base course shall be sufficient to allow for even placement of asphalt, but no thicker than 1 inch in depth.

This choker course evolved as a means to lock the lightly compacted, open-graded (i.e. no fines) reservoir course rocks into place so the porous asphalt can be rolled out evenly. If this course is too thin, the reservoir course will roll. Too thick, and the choker course will then be the rock that rolls around under the weight of the roller.
The reservoir course is made up of 1-1.5" diameter rock and the thickness of the choker course needed to lock the pavement in place is a function of what reservoir gradation you use. The 1-inch minimum depth is a guide and can vary somewhat.

   f. Following placement of base course aggregate, the geotextile shall be folded back along all bed edges to protect against sediment washout along bed edges. At least a four (4)

foot strip shall be used to protect beds from adjacent bare soil. This edge strip shall remain in place until all bare soils contiguous to the rock trenches are stabilized and vegetated or the porous bituminous asphalt is installed. In addition, take any necessary steps to prevent sediment from washing into beds during site development. When the site is fully stabilized, temporary sediment control devices may be removed.

"Fully stabilized" means 90% vegetative cover with deep roots, not just grass fuzz that's just come up. Fuzz/shallow roots aren't going to hold soil and the pavement can get clogged.

B. Porous Bituminous Asphalt
   1. Transporting Material
      a. Transporting of mix to the site shall be in vehicles with smooth, clean dump beds that have been sprayed with a non-petroleum release agent.
      b. The mix shall be covered during transport to control cooling.

   2. Porous bituminous asphalt shall not be stored more than 90 minutes before placement.
   3. Asphalt Placement
      a. The porous bituminous surface source shall be laid in one lift directly over the storage bed and stone base course to a *[2.5]* inch finished thickness.

Varies by project. Match to spec above.

      b. The laying temperature of the bituminous mix shall be between 300 degrees Fahrenheit and 350 degrees Fahrenheit (based on the recommendations of the asphalt supplier).
      c. Installation shall take place when ambient temperatures are 55 degrees Fahrenheit or above, when measured in the shade away from artificial heat.
      d. The use of a remixing material transfer device between the trucks and the paver is highly recommended to eliminate cold lumps in the mix.
      e. The polymer-modified asphalt is very difficult to rake; a well-heated screed should be used to minimize the need for raking, which can clog the pavement.
      f. Compaction of the surface course shall take place when the surface is cool enough to resist a 10-ton roller. One or two passes is all that is required for proper compaction. More rolling could cause a reduction in the surface porosity, which is unacceptable.

This is really important, so be on–site the first day to talk to the paving contract about this and observe the rolling. Otherwise, you could end up with a clogged pavement from the first day of its installation.

   4. After final rolling, no vehicular traffic of any kind shall be permitted on the surface until cooling and hardening has taken place, and in no case within the first 72 hours. Provide barriers as necessary to prevent vehicular use; remove at the direction of the Engineer.
   5. Transition to adjacent impervious bituminous paving shall be merged neatly with flush, clean lines. Finished paving shall be even, without pockets, and graded to elevations shown on drawing.
   6. Porous pavement area shall at no time be used for equipment or materials storage during construction, and under no circumstances shall vehicles be allowed to deposit landscape materials on paved porous surfaces.

Best practice: Lay a tarp down. This is a best practice for ALL pavements since most contractors are not fond of sweeping and organic material on impervious surfaces is often just power washed into the drain.
Another best practice: Put up a sign, so all your sub-contractors know what and where the porous pavement is and how they should change their practices. Mention this at the weekly meeting, too, since contractors come and go.

7. Repair of Damaged Paving
   a. Any existing pavement on or adjacent to the site that has been damaged because of construction work shall be repaired to the satisfaction of the Owner.

8. Field Quality Control
   a. The full permeability of the pavement surface shall be tested by application of clean water at the rate of 5 gallons per minute over the surface, using a hose or other distribution device. Water used for the test shall be clean, free of suspended solids and deleterious liquids. All applied water shall infiltrate directly without puddle formation or surface runoff and shall be observed by the Engineer and Owner.
   b. Testing and Inspection: Employ at Contractor's expense an inspection firm acceptable to the Engineer and Owner to perform soil inspection services, staking and layout control, and testing and inspection of site grading and pavement work. Inspection and list of tests shall be reviewed and approved in writing by the Engineer prior to starting construction. A licensed Engineer must sign all test reports.
   c. Test in-place base and surface course for compliance with requirements for thickness and surface smoothness. Repair or remove and replace unacceptable work as directed by the Owner.
   d. Surface Smoothness: Test finished surface for smoothness and even drainage, using a ten (10) foot to centerline of paved area. Surface will not be accepted if gaps or ridges exceed 3/16 of an inch.
9. Grade Control
   a. Establish and maintain required lines and elevations. The Engineer shall be notified for review and approval of final stake lines for the work before construction work is to begin. Finished surfaces shall be true to grade and even, free of roller marks and free of low spots to form puddles. All areas must drain.
   b. If, in the opinion of the Owner, based upon reports of the testing service and inspection, the quality of the work is below the standards, which have been specified, additional work and testing will be required until satisfactory results are obtained.

STRUCTURAL TREE SOIL MIX SPECIFICATIONS

Structural Soil

Structural soil shall consist of a mixture of gravel, soil and admixtures as described below. The following sources are approved to supply the materials. Other sources may be approved, based upon satisfactory test results however, it is the contractor's responsibility to provide the required information or testing needed to approve the source.

Engage a licensed engineer to provide site preparation specifications, pavement sections, and construction oversight as required by the following sections.

Materials

Structural Soil shall consist of the following materials:

1. Crushed rock (3/4" to 1 ¼" diameter)
2. Loam/organic Topsoil
3. Soil Binder such as "Stabilizer"
4. Water

Proportions of materials

The major components of the structural soil mixture are crushed rock and topsoil. Since when mixed together some of the topsoil fills in the voids of the crushed rock material the sum of the rock and topsoil volumes does not equal the volume of the structural soil material. There is approximately a 10% volume reduction due to mixing the materials together.

Material	Amount for 1 CY of Structural Soil	Amount for 4.6 CY of Structural Soil
Crushed Rock	23.2 cubic feet	4 cubic yards
Topsoil	5.9 cubic feet	1 cubic yard
Soil Binder	13.7 oz	4 pounds
Water	1.6 gallon	46 gallons

The target moisture content is 20% by weight of the topsoil weight. The above water content assumes the topsoil is dry. The amount of water that will need to be added depends on the moisture content of the raw materials. Actual amounts of water used will be determined during mixing based on observations of the material through the mixing procedure below.

Mixing procedure

1. Mix structural soil in batches of an appropriate size for the equipment being used. The result is to be a material that is uniformly blended together. Do not batch in quantities that will not allow the equipment to completely mix the material. Determine batch size and quantities of each material needed for the batch.
2. Start with half of the crushed rock material.
3. Add all the topsoil material.
4. Add the soil binder.
5. Add half of the estimated water.
6. Add the other half of the crushed rock material.
7. Mix the material together.
8. Slowly add water to the mixture and continue to mix. The final amount of water will vary with moisture content of the crushed rock and topsoil. Add water in incremental amounts and mix the material between the additions of water.
9. Stop adding water and mixing when there is a minute amount of free topsoil remaining. The topsoil will coat the crushed rock and not fall out of the material. All of the crushed rock should be uniformly coated with topsoil. There should be no clumps of topsoil or uncovered crushed rock in the mixture.
10. If too much water is added to the mixture water will drain out of the material and the topsoil will wash off the crushed rock. If this occurs this batch of material is to be discarded and shall not be incorporated into the completed work.

Placement

1. Protect soils and mixes from absorbing excess water and from erosion at all times. Do not store materials unprotected from rainfall events. Do not allow excess water to enter site prior to compaction. If water is introduced into the material after grading, allow material to drain or aerate to optimum compaction moisture content.
2. All areas to receive Structural Soil mixture shall be inspected by the licensed engineer before starting placement of mixture. All defects such as incorrect grading, compaction and inadequate drainage, etc., shall be corrected prior to beginning placement of Structural Soil.
3. Confirm that the sub-grade is at the proper elevation and compacted or uncompacted, as indicated by the plans and/or site preparation specifications. Sub-grade elevations shall slope parallel to the

finished grade. Clear the excavation of all construction debris, trash, rubble and foreign material. Fill any over excavation with approved fill and compact to the required sub-grade compaction.

4. Install Structural Soil in 6-inch lifts and compact each lift to 85 percent of maximum density using lightweight, handheld compaction equipment. Delay compaction 24 hours if moisture content exceeds maximum allowable and protect Structural Soil with plastic or plywood as directed by the Engineer. Do not overcompact. Engage a testing company to test field density of each lift, especially in the beginning when the contractor is "getting a feel" for compacting the material to the appropriate density.
5. The water service lines that cross the structural soil material fill area may be corroded and fragile. The contractor shall take care when working around the water service lines. If a service line is damaged, develops a leak or is bent, the service line shall be replaced as per City of Grants Pass standards at the contractor's expanse. The structural soil that will be the bedding for the water service lines shall compacted to conform to the grade of the water service line. The contractor shall not compact the immediate vicinity above a water service line until a fill depth of 12-inches above the water service line is reached.
6. Bring Structural Soils to finished grades as shown on the drawings. Immediately protect the Structural Soil material from contamination from water by covering with plastic or plywood as directed by the Engineer.
7. The Engineer may periodically check the material being delivered and installed at the site for mixture proportions and consistency with the material requirements of these specifications. If the installed material varies significantly from the specified material, the Contractor shall remove the material and replace with the specified Structural Soil material at no extra cost to the Contracting Agency.

Measurement

Structural Soil per cubic yard shall be measured by the neat lines as shown on the plans.

Payment

Payment of the bid item "Structural Soil" per cubic yard shall include all costs to supply, mix, haul, place and compact the structural soil material. All costs associated with subgrade preparation shall be included in this bid item.

Additional Information: Physical Tests

The following are the results of physical tests performed on materials used in a successful structural tree soil project in Olympia, WA. Materials should closely approximate the materials found here.

Rock. Crushed Rock, Gradation of 100% passing 1.25 inch, 26% passing 0.75 inch, 4% passing 0.25 inch and 0.5% passing No 40 sieve by weight.

Soil. ASTM D2487 Soils Classification SW-SC Well-graded Sand with Silty Clay. With a composition of 9% Gravel, 81% Sand, 8% Silt and 2% Clay. Organic Content of 8.3% dry weight.

Stabilizer. Stabilizer as supplied by Stabile Inc. 2218 E magnolia Street Phoenix Arizona 85034 USA (602) 225- 5900 & 1(800) 336-2468 Phone (602) 225-5902 Fax

Structural Soil. Compaction and bearing tests were performed on the structural soil mixture. The proctor density of the material was 138.7 pounds per cubic foot. The California Bearing Ratio (CBR) value at 100% density was 74.

Since a high voids content was desired, 85% compaction was the target for the project. This resulted in a CBR value of 30. Subgrades in Olympia are compacted to 95% under roads and 90% under non-traffic areas. Generally, if this compaction reaches a CBR value of 20 it would be adequate for supporting our standard 4-inch concrete sidewalk or standard roadway sections. A CBR value of 30 provided sufficient bearing capacity for the sidewalk and provided about one third voids content in the structural soil.