

UNHSC Design Specifications for Porous Asphalt Pavement and Infiltration Beds



February 2014
Revision September 2016

UNHSC DESIGN SPECIFICATIONS FOR POROUS ASPHALT PAVEMENT AND INFILTRATION BEDS

TABLE OF CONTENTS

PART 1 GENERAL	5
1.1 DESCRIPTION.....	5
1.2 SUBMITTALS.....	5
1.3 Quality Control and Quality Assurance (QC/QA)	6
1.4 PROJECT CONDITIONS	6
A.Site Assessment should be performed per the steps outlined in IS 131 (NAPA, 2003). 6	
B.Construction Phasing should be performed as outlined in IS 131 (NAPA, 2003).....	6
C.Protection of Existing Infrastructure	6
D.Safety and Traffic Control	7
E. Weather Limitations.....	7
1.5 REFERENCES.....	7
PART 2 PRODUCTS.....	8
2.1 MATERIALS.....	8
A.Porous Media Infiltration Beds	8
1. Conceptual Design	8
2. Material for the choker course and reservoir course	8
3. Reservoir course thickness	10
4. Optional Bottom Liner	10
5. Filter course material.....	11
6. Filter blanket material	11
7. Non-woven geotextile filter fabric	11
8. Alternative materials	12
B.Porous Asphalt Mix	12
1. Mix materials	12
2. Anti-Stripping Mix Additives	15
3. Coarse Aggregate	15
4. Fine Aggregate	15
5. Recycled Asphalt (RAP).	15
6. Porous Asphalt Mix Design	15
7. Porous Asphalt Mix Production	16
8. Striping Paint.....	19
PART 3 EXECUTION.....	19
3.1 INSTALLATION.....	19
A.Porous Media Beds	19
1. Grade Control.....	19
2. Notification.	19
3. Subgrade preparation	19
4. Porous Media Bed Installation	20
5. QC/QA requirements for Porous Media Bed Construction.	21
6. Resurfacing	21
7. Porous Asphalt Pavement Installation	22
8. QC/QA for Paving Operations (optional as part of an installation contract).	25

LIST OF TABLES

Table 1. Submittal requirements.	6
Table 2: Gradations of choker, filter, and reservoir course materials.	9
Table 3: Non-woven geotextile filter fabric properties.	12
Table 4: Post-Blended SBS/SBR Binder QC Plan requirements.	14
Table 5: Porous Asphalt Mix Design Criteria.	16
Table 6: QC/QA testing requirements during production.	18
Table 7: QC/QA testing tolerances during production.	18
Table 8: QC/QA requirements for porous media bed construction.	21
Table 9: QC/QA requirements during paving.	26

LIST OF FIGURES

Figure 1: Typical Cross-Section for Pervious Pavement System	9
--	---

UNHSC DESIGN SPECIFICATIONS FOR POROUS ASPHALT PAVEMENT AND INFILTRATION BEDS

NOTICE

The specifications listed herein were developed by the UNHSC for UNHSC related projects and represent the author's best professional judgment. No assurances are given for projects other than the intended application. These design specifications are not a substitute for licensed, qualified engineering oversight and should be reviewed, and adapted as necessary.

ACKNOWLEDGEMENTS

The original 2007 specifications were completed by collaboration between the University of New Hampshire, of Durham, New Hampshire, and Pike Industries Inc., of Belmont, New Hampshire. The principal UNH authors were Joshua F. Briggs, Robert M. Roseen, PE, PhD, and Thomas P. Ballestero, PE, PhD, PH, CGWP, PG. The principal author from Pike Industries was the Corporate Quality Control Manager, Jeff Pochily. Other contributions to the project were made by Grant Swenson, also of Pike Industries. Revised specifications (2009) were prepared by the UNHSC after a round table discussion with New Hampshire Asphalt Manufacturers (Rick Charbonneau Mark Charbonneau, and Keith Dane of Continental Paving, Jeff Lewis of Brox Industries, and Mary Wescott, Dave Duncan, and Jeff Pochily of Pike Industries) and a round table discussion with design engineers. The 2009 specifications were also reviewed and revised by Antonio P. Ballestero, Jr., PE.

These latest modifications (2014) were authored by Thomas P. Ballestero, James J. Houle, and Timothy A. Puls of the UNHSC. The latest modifications were based upon UNHSC experiences as well as personal interviews with Mary Wescott and Dave Duncan of Pike Industries and Rick Charbonneau and Mark Charbonneau of Continental Paving. In addition, we are grateful to Jill Thomas, Executive Director of the Minnesota Asphalt Pavement Association for edits and comments.

The UNH Stormwater Center is housed within the Department of Civil and Environmental Engineering at the University of New Hampshire (UNH) in Durham, New Hampshire. Formerly, funding for the program was provided by the Cooperative Institute for Coastal and Estuarine Environmental Technology (CICEET) and the National Oceanic and Atmospheric Administration (NOAA).

COPYRIGHT NOTICE

This manual and its content are the property of the University of New Hampshire and may not be used in whole or in part without permission. The contents of all pages, including but not limited to text, graphics, images, logos or trademarks, have been created by the University of New Hampshire or its employees, and may not be copied or repurposed in whole or in part for any purpose without the expressed written permission of the Authors. Copyright © 2016 The University of New Hampshire. All Rights Reserved.

PART 1 GENERAL

1.1 DESCRIPTION

- A. This specification is intended to be used for porous asphalt pavement in parking lot, sidewalk, and light duty road applications, although heavy duty applications are possible and have been documented. Stormwater management functions of porous asphalt installations include water quality treatment, peak flow reduction, storm volume reduction via groundwater recharge, and increased hydrograph time lag. This specification is intended for a cold climate application based upon the field experiences of porous asphalt systems designed, installed, and monitored by the UNHSC since 2005. The specification can be adapted to projects elsewhere provided that selection of materials and system design reflects local conditions, constraints, and objectives.
- B. The work of this Section includes subgrade preparation, installation of the underlying porous media beds, and porous asphalt mix (mix) design, production, and installation. Porous media beds refer to the material layers underlying the porous asphalt pavement. Porous asphalt pavement refers to the compacted mix of modified asphalt, aggregate, and additives.
- C. The porous asphalt pavement specified herein is modified after the National Asphalt Pavement Association (NAPA) specification outlined in *Design, Construction, and Maintenance Guide for Porous Asphalt Pavements, Information Series 131* (2003) and *Design, Construction, and Maintenance of Open-Graded Friction Courses, Information Series 115* (2002).
- D. Alternative specifications for mix, such as Open Graded Friction Courses (OGFC) from Federal Agencies or state Departments of Transportation (DOT), may be used if approved by the Engineer. The primary requirements for the specifications of the mix are performance grade (PG) asphalt binder, binder content, binder draindown, aggregate gradation, air void content, retained tensile strength (TSR).

1.2 SUBMITTALS

- A. Submit a list of materials proposed for work under this Section including the name and address of the materials producers and the locations from which the materials are to be obtained.
- B. Submit certificates, signed by the materials producers and the relevant subcontractors, stating that materials meet or exceed the specified requirements, for review and approval by the Engineer.
- C. Submit samples of materials for review and approval by the Engineer. For mix materials, samples may be submitted only to the QA inspector with the Engineer's approval.
- D. Submittal requirements for samples and certificates are summarized in

E. Table 1 and discussed in further detail in the Materials section.

Table 1. Submittal requirements.

Material or Pavement Course*	Properties to be reported on Certificate**
choker course, reservoir course	gradation, max. wash loss, min. durability index, max. abrasion loss, air voids (reservoir course)
filter course	gradation, permeability/ sat. hydraulic conductivity
filter blanket (graded filter)	gradation
geotextile filter fabric	manufacturer's certification, AOS/EOS, tensile strength
striping paint	certificate
binder	PGAB certification
coarse aggregate	gradation, wear, fracture faces (fractured and elongated)
fine aggregate	gradation
silicone	manufacturer's certification
Fibers (optional)	manufacturer's certification
mineral filler (optional)	manufacturer's certification
fatty amines (optional anti-strip)	manufacturer's certification
hydrated lime (optional anti-strip)	manufacturer's certification

* Samples of each material shall be submitted to the Engineer (or QA inspector for mix). These samples must be in sufficient volume to perform the standardized tests for each material.

** These are the minimum properties to be reported, additional material properties may be required (refer to Materials Section).

1.3 Quality Control and Quality Assurance (QC/QA)

- A. Use appropriate equipment and 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.
- B. Codes and Standards - All materials, methods of construction, and workmanship shall conform to applicable requirements of AASHTO, ASTM Standards, NHDOT Standard Specifications for Road and Bridge Construction (or similar state DOT) specifications, latest revised (including supplements and updates), or other standards as specified.
- C. QC/QA requirements for mix production are discussed in the Materials Section, and for construction of the porous media beds and paving, in the Execution Section.

1.4 PROJECT CONDITIONS

- A. Site Assessment should be performed per the steps outlined in IS 131 (NAPA, 2003).
- B. Construction Phasing should be performed as outlined in IS 131 (NAPA, 2003).
- C. Protection of Existing Infrastructure
 1. Protect adjacent work from the unintended dispersal/splashing of pavement materials. Remove all stains from exposed surfaces of pavement, structures, and grounds. Remove all waste and spillage. If necessary, limit access to adjacent work/structures with appropriate signage and/or barriers.
 2. Protection of pavement work area from run-on during construction and post-construction periods minimize maintenance and prolong pavement lifespan.

3. Proper erosion and sediment control practices shall be provided in accordance with existing codes and regulations. 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. This includes the regular, appropriate inspection and maintenance of the erosion and sediment control measures.
4. Restore damaged areas, including existing pavement on or adjacent to the site that was damaged as a result of construction work, to their original condition or repair as directed to the satisfaction of the Engineer at no additional cost.

D. 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 and vehicles around and within the construction area and to organize the smooth flow of traffic.

E. Weather Limitations

1. In cold climates, porous asphalt, open graded friction course, or dense-mixed asphalt is generally not placed between November 15 and March 15. More specifically when the ambient air temperature at the pavement site in the shade away from artificial heat is below 16 °C (60 °F) or when the actual ground temperature is below 10 °C (50 °F) any placement of porous asphalt materials should proceed with extreme caution, and is generally not recommended. Only the Engineer may adjust this air temperature requirement, soil temperature requirement, or extend the dates of the pavement season.
2. The Contractor shall not pave on days when it is raining or when rain is forecast for the day, unless a change in the weather results in favorable conditions as determined by the Engineer.

1.5 REFERENCES

1. *General Porous Asphalt Bituminous Paving and Groundwater Infiltration Beds*, specification by UNH Stormwater Center, October, 2009.
2. *Design, Construction, and Maintenance Guide for Porous Asphalt Pavements, Information Series 131*, National Asphalt Pavement Association (NAPA), November, 2008.
<http://www.asphaltpavement.org/>
3. *Design, Construction, and Maintenance of Open-Graded Friction Courses, Information Series 115*, NAPA, May, 2002. <http://www.asphaltpavement.org/>
4. *Annual Book of ASTM Standards*, American Society for Testing and Materials, Philadelphia, PA, 2014 or latest edition. <http://www.astm.org/Standard/>
5. *Standards of the American Association of State Highway and Transportation Officials (AASHTO)*, 2014 or latest edition. <http://www.ihs.com/products/industry-standards/organizations/aashto/index.aspx>
6. *Section 401- Plant Mix Pavements – General*, in *Standard Specifications for Road and Bridge Construction – State of New Hampshire Department of Transportation*, 2010.
http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/specifications/documents/2010_Spec_Book.pdf

7. *Section 02725 - General Porous Pavement and Groundwater Infiltration Beds*, specification from NAPA Porous Asphalt Seminar handout, Cahill Associates, Inc., 2004.
8. *Correlations of Permeability and Grain Size*, Russell G. Shepherd, *Groundwater* 27 (5), 1989.
9. *Groundwater*, R. Allan Freeze and John A. Cherry, 1979.

PART 2 PRODUCTS

2.1 MATERIALS

A. Porous Media Infiltration Beds

1. Below the porous asphalt itself are located various layers intended for structure, hydrologic control, and water quality improvement (Figure 1). From top to bottom: a 4" – 8" (10 - 20 cm) minimum thickness layer of choker course of crushed stone; an 8" to 12" (20 cm to 30 cm) minimum thickness layer of filter course of poorly graded sand (a.k.a. bank run gravel or modified 304.1); 3" (8 cm) minimum thickness filter blanket (pea gravel) that is an intermediate setting bed between the filter course and the reservoir course below; and a reservoir course of crushed stone, thickness dependent on required storage, desired infiltration, and underlying native materials. Alternatively, the pea gravel layer could be thickened and used as the reservoir course depending upon subsoil suitability. This alternative simplifies subbase construction. The fine gradation of the filter course is for enhanced filtration (water quality improvement) and delaying infiltration (this layer throttles the downward movement of water). The high air void content of the uniformly graded crushed stone reservoir course maximizes storage of filtered water thereby allowing more time for water to infiltrate the native soil below between storms; and creates a capillary barrier that arrests any upwards vertical water movement and in doing so prevents winter freeze-thaw and heaving. The filter blanket is placed to prevent downward migration of filter course material into the reservoir course. An optional perforated or slotted drain pipe installed in the reservoir course is for hydraulic relief (typically raised off of the bottom of the reservoir stone layer for enhanced groundwater recharge, if no groundwater recharge is desired, pipe is at base of stone or even in a lower section (trench) of stone). Nonwoven geotextile filter fabric (geotextile) is used only for stabilizing the sloping sides of the porous asphalt system excavation and is not to be used on the bottom of the system unless needed for structural reasons. Filter fabrics are not recommended as a horizontal layer between any of the above mentioned layers.

For high permeability soils (saturated infiltration rate of > 2 inches per hour {5 cm/hr}) where infiltration to groundwater is acceptable, the reservoir course and filter blanket may be unnecessary. In cold regions, the filter blanket should be included to create a capillary barrier in lieu of more detailed study of frost heave susceptibility.

2. Material for the choker course and reservoir course shall meet the following:

Maximum Wash Loss of 0.5%

Minimum Durability Index of 35

Maximum Abrasion Loss of 10% for 100 revolutions, and maximum of 50% for 500 revolutions.

Figure 1: Typical Cross-Section for Pervious Pavement System

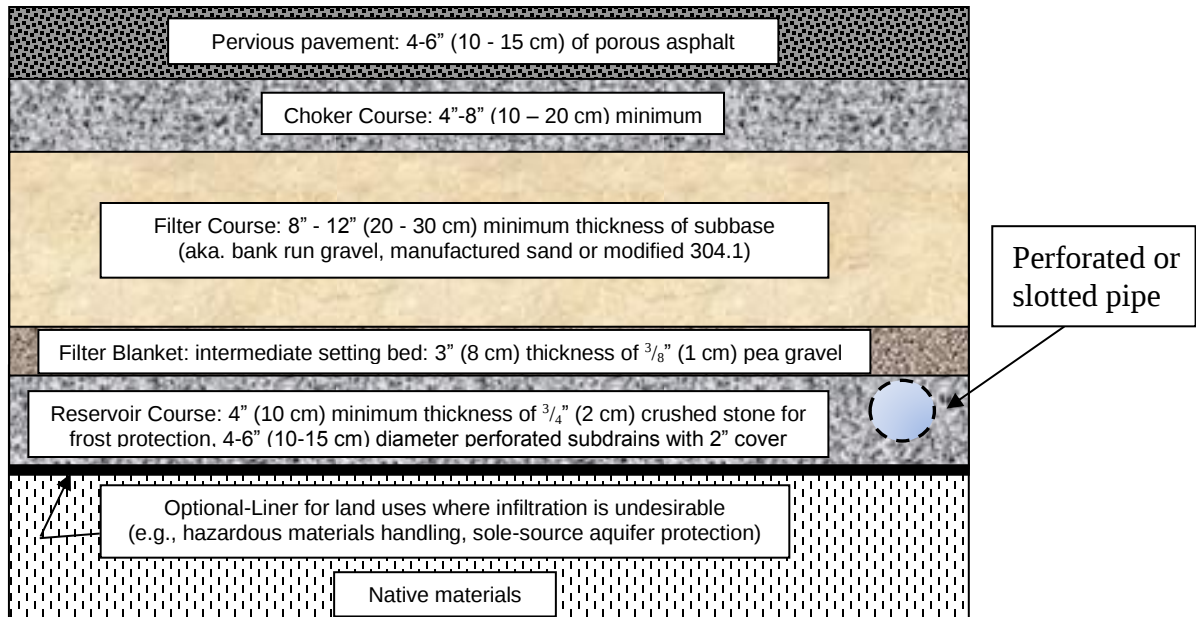


Table 2: Gradations of choker, filter, and reservoir course materials.

US Standard Sieve Size Inches/mm	Per Cent Passing (%)			
	Choker Course (AASHTO No. 57/ No. 67*)	Filter Course (Manufactured Sand/Modified NHDOT 304.1)	Reservoir Course (AASHTO No. 3)	Reservoir Course Alternative** (AASHTO No. 5)
6/150	-	100	-	-
2½/63	-	-	100	-
2 /50	-	-	90 – 100	-
1½/37.5	100	-	35 – 70	100
1/25	95 - 100	-	0 – 15	90 – 100
¾/19	-	-	-	20 - 55
½/12.5	25 - 60	-	0 - 5	0 - 10
3/8/9.5	-	-	-	0 - 5
#4/4.75	0 - 10	70-100	-	-
#8/2.36	0 - 5	-	-	-
#200/0.075	-	0 – 6***	-	-

* Alternate gradations (e.g. AASHTO No. 67) may be accepted upon Engineer's approval.

** Alternate gradations (e.g. AASHTO No. 5) may be accepted upon Engineer's approval.

*** Preferably less than 4% fines

Material for the choker course and reservoir course shall have the AASHTO No. 57 and AASHTO No. 3 gradations, respectively, as specified in Table 2. If the AASHTO No. 3 gradation cannot be met, AASHTO No. 5 is acceptable with approval of the Engineer. AASHTO no. 3 is also suitable for the choker course.

3. Reservoir course thickness is dependent upon the following criteria (that vary from site to site). The reservoir course is located at the interface between native materials and the filter blanket.
 - a. A 4-in (10 cm) minimum thickness of reservoir course to act as a capillary barrier for frost heave protection.
 - b. 4-in. (10 cm) minimum thickness if the underlying native materials are well drained (Hydrologic Group A soils).
 - c. 8-in. (20 cm) minimum thickness if subdrains are installed. Subdrains insure that the subbase is well drained
 - d. Subdrains, if included, are elevated a minimum of 4" (10 cm) from the reservoir course bottom to provide storage and infiltration for the water quality volume. For lower permeability native soils, perforated or slotted drain pipe is located in the stone reservoir course for drainage. This drain pipe can be day lighted to receiving waters or wetlands or connected into other stormwater management infrastructure (catch basin, storm sewer, etc.). If the system is lined and infiltration is undesirable, subdrains are at the bottom of the reservoir course.
 - e. Subbase thickness is determined from subbase materials having sufficient void space to store the design storm.

Example: If the design storm is 5.1" (13 cm) of rainfall depth, and the reservoir void space is 30%, then the minimum subbase thickness = $5.1''/0.3 = 17''$ (43.2 cm). This example reflects infiltration from solely the porous asphalt surface and no additional runoff.
 - f. The total porous pavement system thickness (porous pavement layer down to the base of the stone reservoir course) thickness is $\geq 0.65 * \text{local design depth of frost}$.

Example: Durham, New Hampshire design depth of frost = 48" (122 cm) = $D_{\text{maximum frost}}$, therefore the *minimum* depth to the base of the stone reservoir course = $0.65(48'') = 32''$ (81 cm).
4. Optional Bottom Liner is only recommended for aquifer protection or infiltration prevention. If a liner is employed, stone reservoir course and subdrains must be included above the liner. This liner is to be located at the interface between subbase and native materials and is dependent upon the following:
 - a. As with any infiltration system, care must be taken when siting porous asphalt systems close to locations where hazardous materials are handled/trafficked, or where high contaminant loading may threaten groundwater, or where infiltration is undesirable (nearby foundations, buried utilities, slope stability, etc.). In such cases, the porous asphalt system can be lined to prevent infiltration yet still improve stormwater quality, lag hydrograph peak, and dramatically reduce hydrograph peak flow.
 - b. Refer to state or USEPA guidelines regarding the use of infiltration systems (USEPA, 1999, CalTrans, 2003, WI DNR, 2004, USEPA, 2004).
 - c. Suitable liners may include Hydrologic Group D soils, HDPE liners, or equivalent. Refer

to state or USEPA guidelines regarding selection of impermeable liners (USEPA, 2004). Liner permeability should be no greater than 0.4 in/day = 1 cm/day.

- d. Filter fabrics or geotextile liners are not recommended for use as a separation layer (filter blanket) on the bottom of the porous asphalt system (at the base of the stone reservoir subbase) if designing for infiltration. Filter fabric usage in stormwater filtration has been known to clog prematurely. Graded stone filter blankets are recommended instead. Additionally, geotextile filter fabrics should not be used as any horizontal layer within the porous asphalt system.
 - e. Geogrids may be used if designing on poor structural or low hydraulic conductivity soils. Geogrid usage is limited to the bottom and possibly sides of the excavation.
5. Filter course material shall have a hydraulic conductivity (also referred to as coefficient of permeability) of 10 to 60 ft/day (0.0036 to 0.022 cm/sec) at 95% compaction unless otherwise approved by the Engineer. Great care needs to be used to not over-compact materials. Over-compaction results with loss of infiltration capacity. The filter coarse material is commonly referred to as a bankrun gravel (modified NHDOT 304.1). In order to select an appropriate gradation, coefficient of permeability may be estimated through an equation that relates gradation to permeability, such as described in *Correlations of Permeability and Grain Size* (Shepherd, 1989) or in *Section 8.7 Estimation of Saturated Hydraulic Conductivity* (Freeze and Cherry, 1979). Preferably, the coefficient of permeability (saturated hydraulic conductivity) for the selected filter course material shall be measured by ASTM D5084 and reported to the Engineer.
 6. Filter blanket material between the filter course and the reservoir course shall be an intermediate size between the finer filter course above, and the coarser reservoir course below, for the purpose of preventing the migration of a fine setting bed into the coarser reservoir material. An acceptable gradation shall be calculated based on selected gradations of the filter course and reservoir course using criteria outlined in the *HEC 11* (Brown and Clyde, 1989). A pea-gravel with a median particle diameter of 3/8" (9.5 mm) is commonplace.
 7. Non-woven geotextile filter fabric (*only recommended* for the sloping sides of the porous asphalt system excavation) shall be Mirafi 160N, or approved equivalent and shall conform to the specifications in Table 3. Mirafi ® 160N is a non-woven geotextile composed of polypropylene fibers, which are formed into a stable network such that the fibers retain their relative position. 160N is inert to biological degradation and resists naturally encountered chemicals, alkalis, and acids.

Table 3: Non-woven geotextile filter fabric properties.

Mechanical Properties	Test Method	Unit	Minimum Average Roll Values	
			MD*	CD**
Grab Tensile Strength	ASTM D 4632	kN (lbs)	0.71 (160)	0.71 (160)
Grab Tensile Elongation	ASTM D 4632	%	50	50
Trapezoid Shear Strength	ASTM D 4533	kN (lbs)	0.27 (60)	0.27 (60)
Mullen Burst Strength	ASTM D 3786	kPa (psi)	2100 (305)	2100 (305)
Puncture Strength	ASTM D 4833	kN (lbs)	0.42 (95)	0.42 (95)
Apparent Opening Size (AOS)	ASTM D 4751	mm (US Sieve)	0.212 (70)	0.212 (70)
Permittivity	ASTM D 4491	sec ⁻¹	1.4	1.4
Permeability	ASTM D 4491	cm/sec	0.22	0.22
Flow Rate	ASTM D 4491	lpm/m ² (gpm/ft ²)	4,477 (110)	4,477 (110)
UV Resistance (at 500 hours)	ASTM D 4355	% strength retained	70	70

Physical Properties	Test Method	Unit	Typical Value
Weight	ASTM D 5261	g/m ² (oz/yd ²)	217 (6.4)
Thickness	ASTM D 5199	mm (mils)	1.9 (75)
Roll dimension (width x length)		m (ft)	4.5 x 91 (15 x 300)
Roll area		m ² (yd ²)	410 (500)
Estimated roll weight		kg (lb)	99 (217)

*MD - Machine Direction; **CD - Cross-machine Direction

- Alternative materials for the porous media beds filter blanket, and geotextile may be substituted at the discretion of the Engineer.

B. Porous Asphalt Mix

- Mix materials consist of performance grade asphalt binder (PGAB), coarse and fine aggregates, and optional additives such as polymer modified asphalt (PMA), fibers, or other select additives. Materials shall meet the requirements of the NAPA's Design, Construction, and Maintenance of Open-Graded Friction Courses, Information Series 115 (2002) and Design, Construction, and Maintenance Guide for Porous Asphalt Pavements, Information Series 131, except where noted otherwise below or approved in writing by the Engineer.

Polymer Modified PGAB The asphalt binder shall be a polymer and/or fiber modified performance grade asphalt binder (PGAB) used in the production of Superpave Hot Mix Asphalt (HMA) mixtures. Ideally for maximum durability, the PGAB shall be two grades stiffer than that required for dense mix asphalt (DMA) parking lot installations, which is often achieved by adding a polymer and/or fiber. In New Hampshire the standard DMA asphalt binder is PG 64 -28, meaning that the preferred asphalt binder for

porous asphalt applications is PG 76 -22. The PGAB polymer modifiers are to be either styrene butadiene rubber (SBR) or styrene butadiene styrene (SBS). SBS is generally reserved for large projects as pre-blending is required. SBR is feasible for smaller projects as it can be blended at the plant. The dosage of fiber additives shall be added at 1.5% by total mixture volume. Fibers are a simple addition either manually for a batch plant or automated for larger plants. The binder shall meet the requirements of AASHTO M320.

The PGAB may be pre-blended or post-blended. The pre-blended binder can be blended at the source or at a terminal. For post-blended addition, the modifier can either be in-line blended or injected into the pugmill at the Plant.

The following asphalt mix designs are recommended (listed in order of increasing strength):

1. PG 64-28 with 5 pounds of fibers per ton of asphalt mix. This mix is no longer considered suitable for PA wearing course applications in any development. It may be used as a base course where approved by the engineer for smaller projects with lower traffic counts or loading potential.
2. Post-Blended PG 64-28 SBR (to effectively obtain PG 76 -22*) at 1.5% by volume with 5 pounds of fibers per ton of asphalt mix. This mix is recommended for large projects > 1acre where high durability pavements are needed. The SBR will be supplied by an approved PGAB supplier holding a Quality Control Plan approved by the state DOT. A Bill of Lading (BOL) will be delivered with each transport of PG 64-28 SBR. A copy of the BOL will be furnished to the QA inspector at the Plant. A Post-Blended SBR Binder Quality Control Plan (Table 4) will be submitted to the Engineer for approval at least 10 working days prior to production.

**It is noted that with post-blended SBR blends performance grade is assumed as it is impossible to be determined.*

3. Pre-Blended PG 76-28 modified with SBS (this mix has been used with great success since 2011 in New England). This mix is recommended for large sites anticipating high wheel load (H-20) and traffic counts for maximum durability. The SBS will be supplied by an approved PGAB supplier holding a Quality Control Plan approved by the state DOT. A Bill of Lading (BOL) will be delivered with each transport of PG 76-28 SBS. A copy of the BOL will be furnished to the QA inspector at the Plant.

Quality control plans may always be altered at the discretion of the Engineer and based on feasible testing as suggested by the asphalt producer. Certain QC testing requirements during production may not be feasible for small projects in which limited asphalt is generated. Some testing methods cannot be completed during the time needed during small batch (less than approximately 50 tons of porous asphalt mix) production. The feasibility should be assessed with the Engineer and producer.

Table 4: Post-Blended SBS/SBR Binder QC Plan requirements.

The QC Plan will Contain 1. Company name and address 2. Plant location and address 3. Type of facility 4. Contact information for the Quality Control Plan Administrator 5. QC test to be performed on each PGAB 6. Name(s) of QC testing lab to perform PC and process control testing 7. Actions to be taken for PGAB and Polymer Modifier in non-compliance 8. List of mechanical controls (requirements below) 9. List of process controls and documentation (requirements below)
List of Mechanical Controls 1. Liquid Polymer Modifier no-flow alert system with an "alert" located in the control room and automatic documentation of a no flow situation on the printout 2. Provide means of calibrating the liquid Polymer Modifier metering system to a delivery tolerance of 1% 3. A batching tolerance at the end of each day's production must be within 0.5% 4. Mag-flow meter (other metering system may be considered) 5. Method of sampling liquid Polymer Modifier
List of Process Controls and Documentation 1. Printouts of liquid Polymer Modifier and PGAB quantities must be synchronized within 1 minute of each other 2. Polymer Modifier supplier certification showing the percent of Polymer Modifier solids in liquid Polymer Modifier 3. Test results of a lab sample blended with the specified dosage of Polymer Modifier. At a minimum, provide the name of the PGAB and liquid Polymer Modifier suppliers and PGAB information such as grade and lot number and Polymer Modifier product name used for the sample 4. MSDS sheet for liquid Polymer Modifier 5. Handling, storage and usage requirements will be followed as required by the liquid Polymer Modifier manufacturer 6. At a minimum, provide a table showing proposed rate of Polymer Modifier liquid (L/min) in relation to HMA production rate (tons per hour) for the percent solids in liquid Polymer Modifier, quantity of Polymer Modifier specified for HMA production and the specific gravity of the Polymer Modifier 7. QCT or QC plan administrator must be responsible for documenting quantities and ensuring actual use is within tolerances. All printouts, calculations, supplier certifications, etc., must be filed and retained as part of the QCTs daily reports 8. Method and frequency of testing at the HMA plant including initial testing and specification testing

* This plan shall be submitted to the engineer 10 days before production

2. Anti-Stripping Mix Additives.

The mix shall be tested for moisture susceptibility and asphalt stripping from the aggregate by AASHTO T283, or improved updated method. If the retained tensile strength (TSR) < 80% upon testing, a heat stable additive shall be furnished to improve the anti-stripping properties of the asphalt binder. Test with one freeze-thaw cycle (rather than five recommended in *NAPA IS 115*). The amount and type of additive (e.g. fatty amines or hydrated lime) to be used shall be based on the manufacturer's recommendations, the mix design test results, and shall be approved by the Engineer.

Silicone shall be added to the binder at the rate of 1.5 mL/m³ (1 oz. per 5000 gal).

Fibers may be added per manufacturer and *NAPA IS 115* recommendation if the draindown requirement cannot be met (<0.3% via ASTM D6390) provided that the air void content requirement is met (>18%, or >16% as tested with CoreLok device).

Additives should be added per the relevant DOT specification and *NAPA IS 115*.

3. Coarse Aggregate.

Coarse aggregate shall be that part of the aggregate retained on the No. 8 sieve; it shall consist of clean, tough, durable fragments of crushed stone, or crushed gravel of uniform quality throughout.

Coarse aggregate shall be crushed stone or crushed gravel and shall have a percentage of wear as determined by AASHTO T96 of not more than 40 percent. In the mixture, at least 75 percent, by mass (weight), of the material coarser than the 4.75 mm (No. 4) sieve shall have at least two fractured faces, and 90 percent shall have one or more fractured faces (ASTM D5821). Coarse aggregate shall be free from clay balls, organic matter, deleterious substances, and not more than 8.0% of flat or elongated pieces (>3:1) as specified in ASTM D4791.

4. Fine Aggregate.

The fine aggregate shall be that part of the aggregate mixture passing the No. 8 sieve and shall consist of sand, screenings, or combination thereof with uniform quality throughout. Fine aggregate shall consist of durable particles, free from injurious foreign matter. Screenings shall be of the same or similar materials as specified for coarse aggregate. The plasticity index of that part of the fine aggregate passing the No. 40 sieve shall be not more than 6 when tested in accordance with AASHTO T90. Fine aggregate from the total mixture shall meet plasticity requirements.

5. Recycled Asphalt (RAP).

Recycled asphalt can be used to supplement, or in place of, fine aggregate. RAP should be a ½" minus or properly managed product with known asphalt content in quantities not to exceed more than 10% by weight.

6. Porous Asphalt Mix Design.

The Contractor shall submit a mix design at least 10 working days prior to the beginning of production. The Contractor shall make available samples of coarse aggregate, fine aggregate,

RAP, fibers and a sample of the PGAB that will be used in the design of the mixture. A certificate of analysis (COA) of the PGAB will be submitted with the mix design. The COA will be certified by a laboratory meeting the requirements of AASHTO R18. The Laboratory will be certified by the state DOT, regional equivalent (e.g. NETTCP), and/or qualified under ASTM D3666. Technicians will be certified by the regional certification agency (e.g. NETTCP) in the discipline of HMA Plant Technician.

The mixture will be designed according to the NAPA IS 131, with the exception of testing for air void content. Bulk specific gravity (SG) used in air void content calculations shall not be determined and results will not be accepted using AASHTO T166 (saturated surface dry), since it is not intended for open graded specimens (>10% AV). Bulk SG shall be calculated using AASHTO T275 (paraffin wax) or ASTM D6752 (automatic vacuum sealing, e.g. CoreLok). Air void content shall be calculated from the bulk SG and maximum theoretical SG (AASHTO T209) using ASTM D3203.

The materials shall be combined and graded to meet the composition limits by mass (weight) as shown in Table 5.

7. Porous Asphalt Mix Production

- a. Mixing Plants. Mixing plants shall meet the requirements of hot mix asphalt plants as specified in the state DOT or regional equivalent unless otherwise approved by the Engineer (e.g. *Section 401- Plant Mix Pavements – General for Quality Assurance specifications in the Standard Specifications for Road and Bridge Construction – State of New Hampshire DOT, 2010, or latest revised edition and including supplemental specifications and updates*).

Table 5: Porous Asphalt Mix Design Criteria

Sieve Size (inch/mm)	Percent Passing (%)
0.75/19	100
0.50/12.5	85-100
0.375/9.5	55-75
No.4/4.75	10-25
No.8/2.36	5-12
No.200/0.075 (#200)	2-4
Binder Content (AASHTO T164)	5.8 - 6.5%
Air Void Content (ASTM D6752)	16.0-22.0%
Draindown (ASTM D6390)*	≤ 0.3 %
Retained Tensile Strength (AASHTO 283)**	≥ 80 %
Cantabro abrasion test on unaged samples	≤ 20%
Cantabro abrasion test on 7 day aged samples	≤ 30%

* Either method is acceptable

**Cellulose, mineral, or polyester fibers may be used to reduce draindown.

***If the TSR (retained tensile strength) values fall below 80% when tested per NAPA IS 131 (with a single freeze thaw cycle rather than 5), then in Step 4, the contractor shall employ an antistripping additive, such as hydrated lime (ASTM C977) or a fatty amine, to raise the TSR value

above 80%.

- b. Preparation of Asphalt Binder. The asphalt material shall be heated to the temperature specified in the state DOT specification (if using a DOT spec for the mix) in a manner that will avoid local overheating. A continuous supply of asphalt material shall be furnished to the mixer at a uniform temperature.
- c. Preparation of Aggregates. The aggregate for the mixture shall be dried and heated at the mixing plant before being placed in the mixer. Flames used for drying and heating shall be properly adjusted to avoid damaging the aggregate and depositing soot or unburned fuel on the aggregate.

Mineral filler, if required to meet the grading requirements, shall be added in a manner approved by the Engineer after the aggregates have passed through the dryer.

The above preparation of aggregates does not apply for drum-mix plants.

- d. Mixing. The dried aggregate shall be combined in the mixer in the amount of each fraction of aggregate required to meet the job-mix formula and thoroughly mixed prior to adding the asphalt material.

The dried aggregates shall be combined with the asphalt material in such a manner as to produce a mixture that when discharged from the pugmill is at a target temperature in the range that corresponds to a recommended range supplied by the PGAB supplier.

The asphalt material shall be measured or gauged and introduced into the mixer in the quantity determined by the Engineer for the particular material being used and at the temperature specified in the relevant specification.

After the required quantity of aggregate and asphalt material has been introduced into the mixer, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the asphalt material throughout the aggregate is secured and there is no residual moisture in the coated aggregate.

All plants shall have a positive means of eliminating oversized and foreign material from being incorporated into the mixer.

- e. QC During Production

The Contractor shall provide process control and/or QC test results to the Engineer or the Engineer's designee. The QC plan may be altered at the discretion of the Engineer and based on feasible testing as suggested by the asphalt producer. Certain QC testing requirements during production may not be feasible for small projects in which limited asphalt is generated. Some testing methods cannot be completed during the time needed during small batch production. The feasibility should be assessed with the Engineer and producer.

The mixing plant shall employ a Quality Control Technician (QCT). The QCT will perform QC testing and will be certified in the discipline of HMA Plant Technician by the relevant certifying agency (e.g. NETTCP in New England). The Contractor shall sample,

test and evaluate the mix in accordance with the methods and minimum frequencies in Table 6 and the Post-Blended SBR Binder Quality Control Plan (if applicable).

Table 6: QC/QA testing requirements during production.

Test	Min. Frequency	Test Method
Temperature in truck at plant	6 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
Binder Draindown	Greater of either (a) 1 per 500 tons, (b) 1 per day, or (c) 1 per job	ASTM D6390

If an analyzed sample is outside the testing tolerances immediate corrective action will be taken by the contractor. After the corrective action has been taken the resulting mix will be sampled and tested. If the re-sampled mix test values are outside the tolerances the Engineer will be immediately informed. The Engineer may determine that it is in the best interest of the project that production is ceased. The Contractor will be responsible for all mix produced for the project.

- f. Testing Tolerances During Production. Testing of the QC requirements shall be within the limits set in Table 6. The paving mixture produced should not vary from the design criteria for aggregate gradation and binder content by more than the tolerances in Table 7.

Table 7: QC/QA testing tolerances during production.

Sieve Size (inch/mm)	Percent Passing
0.75/19	-
0.5/12.5	± 6.0
0.375/9.5	± 6.0
0.187/4.75	± 5.0
0.093/2.36	± 4.0
0.0029/0.075	± 2.0
% PGAB	± 0.3

- g. Plant Shutdown and Rejection of Mix. Should the porous asphalt mix not meet the tolerances specified in this section upon repeat testing, the Engineer may reject further loads of mix. Mix that is loaded into trucks during the time that the plant is changing operations to comply with a failed test shall not be accepted, and should be recycled at the plant.

8. Striping Paint shall be latex, water-base emulsion, ready-mixed, and complying with pavement marking specifications PS TT-P-1952.

PART 3 EXECUTION

3.1 INSTALLATION

A. Porous Media Beds

1. 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 puddle-forming low spots. All areas must drain freely. Excavation elevations should be within ± 0.1 ft (± 3 cm).
- b. If, in the opinion of the Engineer, 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.
- c. General criteria for watershed area to treatment area ratios for permeable pavements are defined by the state. Hybrid designs (dense-mix drive-lanes with permeable pavement parking stalls) have been used to address diminished strength of permeable asphalt materials in high traffic volume/load locations. A 1:1 watershed area to permeable pavement area is preferred (implying no runoff). Improvements to materials and designs have addressed many of the strength deficiencies associated with older designs and materials specifications.

2. Notification.

The Engineer shall be notified at least 24 hours prior to all porous media bed and porous pavement work.

3. Subgrade preparation

- a. The existing native subgrade material under all bed areas shall NOT be compacted or subject to excessive construction equipment traffic prior to stone bed placement. Compaction is acceptable if an impermeable liner is used at the base of the porous asphalt system and infiltration is not desired.
- b. Where erosion of the native material subgrade has caused accumulation of fine materials and/or surface ponding at the base of the excavation, this material shall be removed with light equipment and the underlying soils scarified to a minimum depth of 6 inches (15 cm) with a York rake or equivalent and light tractor.
- c. Bring subgrade of stone porous media bed to line, grade, and elevations indicated. Fill and lightly regrade any areas damaged by erosion, ponding, or traffic

compaction before the placing of the stone. For parking lots all bed bottoms are level grade to promote uniform infiltration. For road applications, typically the slope of the bottom of excavation parallels that of the road surface. Interior berms in the stone layer are then necessary to prevent infiltrated water from flowing in the reservoir stone parallel to the road. Interior berms should be almost as tall as the reservoir course thickness and made of relatively impermeable material (this may be accomplished with geofabric or geotextile). On the upstream side of the berm, water may infiltrate. If soil infiltration capacity is low, then a drainage pipe should be located on the upstream side of the berm to remove water from the reservoir course and drain (daylight) to natural receiving waters, wetlands, or plumbed into existing stormwater drainage infrastructure (swales, catch basins, storm sewers).

4. Porous Media Bed Installation

- a. Upon completion of subgrade work, the Engineer shall be notified and shall inspect at his/her discretion before proceeding with the porous media bed installation.
- b. Side slope geotextile (when used) and porous media bed aggregate shall be placed immediately after approval of subgrade preparation. Any accumulation of debris or sediment which has taken place after approval of subgrade shall be removed prior to installation of geotextile or porous media at no extra cost to the Owner.
- c. Place side slope geotextile in accordance with manufacturer's standards and recommendations. Adjacent strips of geotextile shall overlap a minimum of sixteen inches (16" or 41 cm). Secure geotextile at least four feet (1.2 m) outside of the bed excavation and take any steps necessary to prevent any runoff or sediment from entering the storage bed.
- d. Install coarse aggregate in lifts no greater than 8-inches (20 cm). Lightly compact each lift with equipment, keeping equipment movement over storage bed subgrades to a minimum. Install aggregate to grades indicated on the drawings.
- e. Install choker base course (see Materials section) aggregate evenly over surface of filter course bed, sufficient to allow placement of pavement, and notify Engineer for approval. Choker base course thickness shall be sufficient to allow for even placement of the porous asphalt but no less than 4-inches (10 cm) in depth.
- f. The infiltration rate of the compacted filter course shall be determined by ASTM D3385 or an approved alternate at the discretion of the supervising engineer. The infiltration rate shall be no less 5-30 ft/day or 50% of the hydraulic conductivity (D2434) at 95% standard proctor compaction (refer to section 2.1.A.5).
- g. Following placement of bed aggregate, the sideslope geotextile shall be folded back along all bed edges to protect from sediment washout along bed edges. At least a four-foot (1.2 m) edge strip shall be used to protect beds from adjacent bare soil. This edge strip shall remain in place until all bare soils contiguous to beds are stabilized and vegetated. In addition, take any other necessary steps to prevent

sediment from washing into beds during site construction. When the site is fully stabilized, temporary sediment control devices shall be removed.

5. QC/QA requirements for Porous Media Bed Construction.

QC/QA activities are summarized in Table 8.

Table 8: QC/QA requirements for porous media bed construction.

Activity	Schedule
Contractor to notify engineer for approval	24 hours in advance of start of work
Contractor to employ soil inspector acceptable to engineer	NA
Contractor to employ staking and layout control inspector acceptable to engineer	NA
Contractor to employ site grading inspector acceptable to engineer	NA
Contractor to employ pavement work inspector acceptable to the engineer	NA
Contractor to notify engineer for approval	after subgrade preparation, before construction of porous media bed
Contractor to notify engineer for approval	after filter course placement, before placement of choker course and pavement to verify proper compaction of filter course by ASTM D3385

6. Resurfacing

In cases where a porous asphalt system was constructed and the asphalt needs to be replaced, it is recommended to mill the older asphalt and to resurface on the choker course rather than to use a tackifier and pave over the older asphalt. While there is little documented experience with partial milling and resurfacing it has been done with success for porous asphalt pavements. Attention to cleaning milled surface is critical.

1. Mill older asphalt down to specified depth or to choker course
2. Restore the infiltration capacity with low angle pressure washing or air to a vacuum (for example the 15" vacuum attachment hose of a Tymco regenerative air vac)
3. Level and compact choker course

7. Porous Asphalt Pavement Installation

1. The mixing plant, hauling and placing equipment, and construction methods shall be in conformance with NAPA IS 131 and applicable sections of the state DOT's specification for asphalt mixes.
2. The use of surge bins shall not be permitted.
3. Hauling Equipment. The open graded mix 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 bodies. Mineral filler, fine aggregate, slag dust, etc. shall not be used to dust truck beds. The open graded mix shall be covered during transportation with a suitable material of such size sufficient to protect the mix from the weather and also minimize mix cooling and the prevention of lumps. When necessary, to ensure the delivery of material at the specified temperature, truck bodies shall be insulated, and covers shall be securely fastened. Long hauls, particularly those in excess of 25 miles (40 km), may result in separation of the mix and its rejection.
4. Placing Equipment. The paver shall be a self-propelled unit with an activated screed or strike-off assembly, capable of being heated if necessary and capable of spreading and finishing the mixture without segregation for the widths and thicknesses required. In general, track pavers have proved superior for Porous Asphalt placement. The screed shall be adjustable to provide the desired cross-sectional shape. The finished surface shall be of uniform texture and evenness and shall not show any indication of tearing, shoving, or pulling of the mixture. The machine shall, at all times, be in good mechanical condition and shall be operated by competent personnel.

Pavers shall be equipped with the necessary attachments, designed to operate electronically, for controlling the grade of the finished surface.

The adjustments and attachments of the paver will be checked and approved by the Engineer before placement of asphalt material.

5. Rollers. Rollers shall be in good mechanical condition, operated by competent personnel, capable of reversing without backlash, and operated at speeds slow enough to avoid displacement of the asphalt mixture. The mass (weight) of the rollers shall be sufficient to compact the mixture to the required density without crushing of the aggregate. Rollers shall be equipped with tanks and sprinkling bars for wetting the rolls.

Rollers shall be two-axle tandem rollers with a gross mass (weight) of not less than 7 metric tons (8 tons) and not more than 10 metric tons (12 tons) and shall be capable of providing a minimum compactive effort of 44 kN/m (250 pounds per inch) of width of the drive roll. All rolls shall be at least 1.1 m (42 inches) in diameter.

A rubber tired roller is not required on the open graded asphalt friction course surface.

6. Conditioning of Existing Surface. Contact surfaces such as curbing, gutters, and manholes shall be painted with a thin, uniform coat of Type RS-1, or equivalent emulsified asphalt immediately before the asphalt mixture is placed against them.
7. Temperature Requirements. The temperature of the asphalt mixture, at the time of discharge from the haul vehicle and at the paver, shall be between 135-163°C (275 to 325°F), within 6 °C (10 °F) of the compaction temperature for the approved mix design.

8. Spreading and Finishing. The Porous Asphalt should be placed in two lifts at 1.5 to 2 inches (4 - 6 cm). One lift is not recommended because uniform compaction is difficult to achieve. Great care must be taken to insure that the porous asphalt layers join completely. This means: keeping the time between layer placements minimal; keeping the first layer clear from dust and moisture, and minimizing traffic on the first layer. However care should be taken to allow sufficient time for the asphalt placement to set, generally the following day or when the surface temperature of the first lift cools to 38°C (100 °F). Two lifts affords better compaction of the entire lift, especially in colder weather and for large sites. It also provides access to the site for finish work such as curbing. Care must be taken to not damage or impair permeability of the base course if a multiple lift scenario is chosen. If significant site work will take place between placement of base and wearing courses higher durability mixes should be used for both layers.

The Contractor shall protect all exposed surfaces that are not to be treated from damage during all phases of the pavement operation.

The asphalt mixture shall be spread and finished with the specified equipment. The mixture shall be struck off in a uniform layer to the full width required and of such depth that each course, when compacted, has the required thickness and conforms to the grade and elevation specified. Pavers shall be used to distribute the mixture over the entire width or over such partial width as practical. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture shall be spread and raked by hand tools.

No material shall be produced so late in the day as to prohibit the completion of spreading and compaction of the mixture during daylight hours, unless night paving has been approved and established for the project.

No traffic will be permitted on material placed until the material has been thoroughly compacted and has been permitted to cool to below 38 °C (100 °F). The use of water to cool the pavement is not permitted. The Engineer reserves the right to require that all work adjacent to the pavement, such as guardrail, cleanup, and turf establishment, is completed prior to placing the wearing course when this work could cause damage to the pavement. On projects where traffic is to be maintained, the Contractor shall schedule daily pavement operations so that at the end of each working day all travel lanes of the roadway on which work is being performed are paved to the same limits.

9. Compaction. Immediately after the asphalt mixture has been spread, struck off, and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. The compaction objective is 16% - 19% in place void content (Corelock).

Breakdown rolling shall occur when the mix temperature is between 135-163°C (275 to 325°F). This is typically achieved with 1-2 passes with a 7.5 – 10 ton vibratory roller.

Finish rolling shall occur when the mix temperature is between 66-93°C (150 to 200°F). This is typically achieved with a 1-ton roller with no vibratory compaction. Finish rolling is largely aesthetic and done for a smooth finished surface. Care should be taken so as to not continually roll the same location for instance back and forth to a water source.

The cessation temperature occurs at approximately 79°C (175°F), at which point the mix becomes resistant to compaction. If compaction has not been performed at temperatures

greater than the cessation temperature, the pavement will not achieve adequate durability. The temperatures referenced here are guidelines and have been used in the field to oversee successful porous asphalt installations.

The surface shall be rolled when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking, or shoving.

Rollers or oscillating vibratory rollers, ranging from 7.5 – 10 tons, shall be used for breakdown compaction. 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.

To prevent adhesion of the mixture to the rollers, rollers shall be kept moist with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted.

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.

Other combinations of rollers and/or methods of compacting may be used if approved in writing by the Engineer, provided the compaction requirements are met.

The speed of the roller shall be slow and uniform to avoid displacement of the mixture, and the roller should be kept in as continuous operation as practical. Finish rolling shall continue below the threshold temperature until all roller marks and ridges have been eliminated.

Rollers will not be stopped or parked on the freshly placed porous asphalt.

It shall be the responsibility of the Contractor to conduct whatever process control the Contractor deems necessary. Acceptance testing will be conducted by the Engineer using cores provided by the Contractor.

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. Any area showing an excess or deficiency of binder shall be removed and replaced. These replacements shall be at the Contractor's expense.

If the Engineer determines that unsatisfactory compaction or surface distortion is being obtained or damage to highway components and/or adjacent property is occurring using vibratory compaction equipment, the Contractor shall immediately cease using this equipment and proceed with the work in accordance with the sixth paragraph of this subsection.

10. Joints. Joints between old and new pavements or between successive day's 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.

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 3 m (10 feet) long. The butt joint shall be thoroughly coated with Type RS-1 or equivalent emulsified asphalt just prior to depositing the pavement mixture when pavement resumes.

Longitudinal joints that have become cold shall be coated with Type RS-1 or equivalent 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 emulsion.

11. Surface Tolerances. The surface will be tested by the Engineer using a straightedge at least 3 m (10 feet) in length at selected locations parallel with the centerline. Any variations exceeding 9.5 mm (3/8 inch) between any two contact points shall be satisfactorily eliminated. A straightedge at least 3 m (10 feet) in length may be used on a vertical curve. The straightedges shall be provided by the Contractor.
 12. Work shall be done expertly throughout, without staining or injury to other work. Transition to adjacent impervious asphalt pavement shall be merged neatly with flush, clean line. Finished pavement shall be even, without pockets, and graded to elevations shown on drawing.
 13. Repair of Damaged Pavement. Any existing pavement on or adjacent to the site that has been damaged as a result of construction work shall be repaired to the satisfaction of the Engineer without additional cost to the Owner.
 14. Striping Paint
 - a. Vacuum and clean surface to eliminate loose material and dust.
 - b. Paint 4-inch wide (10 cm) parking striping and traffic lane striping in accordance with plan layouts. Apply paint with mechanical equipment to produce uniform straight edges. Apply in two coats at manufacturer's recommended rates. Provide clear, sharp lines using white traffic paint. Paint should conform with Federal Specification TT-P-85.
 - c. Color for Handicapped Markings: Blue
8. QC/QA for Paving Operations (optional as part of an installation contract).
1. The full permeability of the pavement surface shall be tested by application of clean water at the rate of at least 5 gpm (23 lpm) over the surface, using a hose or other distribution devise. Water used for the test shall be clean, free of suspended solids and deleterious liquids and will be provided at no extra cost to the Owner. All applied water shall infiltrate directly without large puddle formation or surface runoff, and shall be observed by the Engineer.
 2. Testing and Inspection: Employ at Contractor's expense an inspection firm acceptable to the Engineer 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. All test reports must be signed by a licensed Engineer.
 3. 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 Engineer.

4. Surface Smoothness: Test finished surface for smoothness using a 3 m (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 9.5mm (3/8 inch).
5. Porous pavement beds shall not be used for equipment or materials storage during construction, and under no circumstances shall vehicles be allowed to deposit soil on paved porous surfaces.
6. QC/QA requirements during paving are summarized in Table 9 **Error! Reference source not found..**

Table 9: QC/QA requirements during paving.

Activity	Schedule/Frequency	Tolerance
Inspect truck beds for pooling (draindown)	every truck	NA
Take temp of asphalt in truck	every truck	> 135°C (275°F)
Take temp of PA mix in the paver	each pull	within 6°C (10°F) of the recommended compaction temp
Consult with engineer to determine locations of butt joints	As needed	NA
Test surface smoothness and positive drainage with a 10' straightedge	after compaction	9.5 mm (3/8")
Consult with engineer to mark core locations	after compaction	NA
House test with at least 5 gpm water	after compaction	immediate infiltration, no puddling

PART 4. REFERENCES

1. Brown, S. A, and E. S. Clyde, 1989, Design of Rip Rap Revetments, USDOT, FHWA Hydraulic Engineering Circular 11, Publication Number FHWA-IP-89-016, McLean, VA.
<http://isddc.dot.gov/OLPFiles/FHWA/009881.pdf>
2. CalTrans, January 2003, California Stormwater BMP Handbook 3 of 8 New Development and Redevelopment, California Dept. of Transportation, Sacramento, CA www.cabmphandbooks.com
3. NH DOT, 2010, NHDOT Standard Specifications - 2010 Edition, Concord, NH.
<http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/specifications/>
4. USEPA, September, 1999, Storm Water Technology Fact Sheet: Infiltration Drainfields, Number: 832F99018 USEPA, Office of Water, Washington, DC
http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_infltdrn.pdf

5. USEPA, September 2004, Stormwater Best Management Design Guide: Volume 1 General Considerations, Office of Research and Development, EPA/600/R-04/121, Washington, D.C. <http://www.epa.gov/nrmrl/pubs/600r04121.html>
6. Vermont Agency of Transportation, 2011, 2011 Standard Specifications for Construction Book, Division 700, Section 708, Montpelier, VT. <http://vtranscontracts.vermont.gov/construction-contracting/2011-standard-specifications>
7. Wisconsin Department of Natural Resources, Feb. 2004, Site Evaluation for Stormwater Infiltration(1002), Wisconsin Department of Natural Resources Conservation Practice Standards Madison, WI <http://dnr.wi.gov/topic/stormwater/documents/dnr1002-Infiltration.pdf>

Note on Multiple Stress Creep Recovery Grading

Multiple Stress Creep Recovery (MSCR) Implementation

North East Asphalt User Producer Group (NEAUPG) States have agreed to launch MSCR grading for modified binders for the 2013 season. This only affects polymer modified products for now. NHDOT will be accepting either grade designation from suppliers this year.

MSCR grading measures binder properties at the local environment temperature. Stiffness properties above those of the standard grade are determined by applying traffic parameters, as follows.

S Standard
H Heavy
V Very Heavy
E Extremely Heavy

<u>Environmental Grade</u>	<u>Old Modified Grade</u>	<u>New Modified Grade</u>
NH 58°	PG 76-28	PG 64V-28, or PG 64E-28
Maine 58°	PG 70-28	
Mass 64°	PG 64-28 (w/latex or tire rubber)	
RI 64°	PG 76-28	

Binder suppliers can currently supply NH with PG 76-28 with > 3% SBS

PG 64E-28 can be produced with about 2.2% SBS

The PG 64E-28 being shipped to RI meets the MSCR testing and has 60% elastic recovery at 10° C. ER test is normally run at 20° C.