



Transportation Research Division



Technical Report 10-05

*Performance of a Porous Pavement System
on the Maine Mall Road in South Portland*

Construction and First Interim Report, December 2010

Transportation Research Division

Performance of a Porous Pavement System

Introduction

Porous pavements have been successfully used by developers since the mid-70's as a means to make traditional impervious facilities, such as parking lots, handle storm water in a more environmentally friendly way. Traditional pavement materials used in these facilities can create storm water run off problems such as erosion of adjacent surfaces and poor water quality of downstream watersheds. Porous pavement actually allows storm water to seep into the subsurface, typically a stone reservoir and sand filter, and dissipate into the underlying substrate. Porous pavement systems provide an effective surface for vehicle traffic while also providing storm water management that improves water quality. Some studies have shown that these systems have a high removal rate of total suspended solids, metals, oils and grease, and other harmful contaminants. Other benefits are a "cooling" effect of the storm water and a reduction in demand on the storm sewers. The surface can consist of either an asphalt pavement or concrete pavement material that meets the public expectations for smoothness while allowing excellent drainage into the underlying collection system.

Because of these benefits, in the summer of 2009, MaineDOT constructed a porous pavement system along the Maine Mall Road in South Portland. The project (PIN 17008.00), which involves the section of Maine Mall Road between Philbrook Avenue and the Maine Mall Entrance south of Gorham Road, is the first application of a porous paving system on a high-volume public road (16750 AADT in 2008) in the Northeast. The environmental benefit is the reduction of untreated runoff directly into the Long Creek watershed.

The Long Creek watershed encompasses 3.45 square miles in South Portland, Westbrook, Portland and Scarborough. Long Creek has seen a great deal of development over the last 50 years which brought new impervious surfaces (rooftops, parking lots, and roads) that increases the amount and rate of flow of storm water runoff to Long Creek, and with it, pollutants, increased water temperatures and higher flow rates. This combination has degraded the quality of Long Creek to the point it does not meet Department of Environmental Protection water quality standards.

MaineDOT developed a porous pavement system for Maine Mall Road that includes a multi-layered pavement and infiltration bed. Two layers of permeable paving material totaling nine inches rest atop a fifteen inch bed of reservoir stone, which in turn rest upon six inches of a sand filter material. Underdrain pipes capture the water after it has been filtered through the sand filter. All of this is hidden under an

asphalt surface that appears to be more coarse in texture, but otherwise looks normal. In total, the project retrofits approximately 1.5 acres of impervious surface within the watershed.

Location

Figure 1 shows the project location and begin and end points.

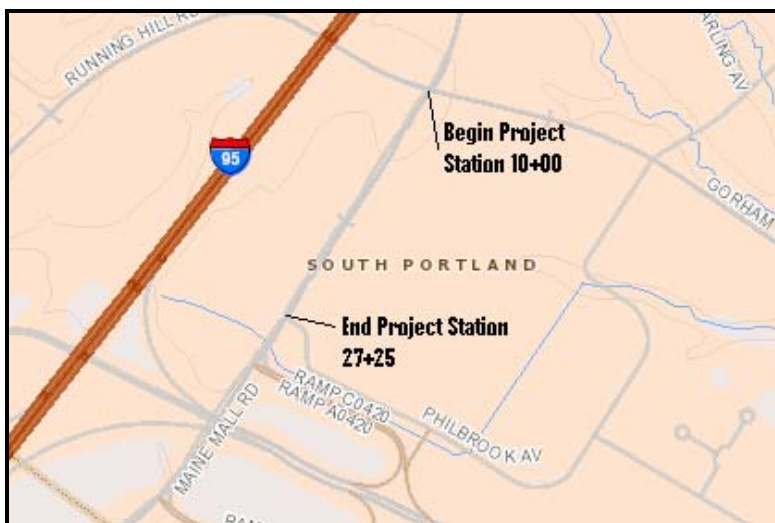


Figure 1- Location of Project, adjacent to the Maine Mall in South Portland

The highway project begins at the intersection of the Maine Mall Road and Gorham Road (Station 10+00) and extends 0.33 miles to the Philbrook Avenue intersection. The roadway is classified as a minor arterial, is posted for 25 mph and has 16750 AADT. A mill and fill treatment was applied from Station 10+00 to Station 14+96. This treatment consisted of a new conventional hot mix asphalt pavement surface. The remainder of the project is a full reconstruction treatment with porous pavement. A transition from the mill and fill to full reconstruction section ends at Station 15+36. The project vertical alignment begins at Elevation 58.88 with a slight 0.75% vertical down slope and has a low point at Station 16+25 (Elevation 55.13). A high point is at Station 19+71 (Elevation 55.44) and another low point at Station 22+43 (Elevation 54.92). The end of the project Station 27+25 has Elevation 57.08.

Construction & Materials

The typical porous pavement cross section is shown in Figure 2 and includes:

- 6" underdrain Type B pipe in variable depth pavement filter material. The filter material meets MaineDOT specification 703.22, Underdrain Backfill Material Type B.
- Variable depth reservoir stone meeting MaineDOT specification 703.31, Crushed Stone
- 6" Asphalt Treated Permeable Base (ATPB)
- 3" Open Graded Friction Course (OGFC)

Specifications for these materials are included in the appendices of this report.

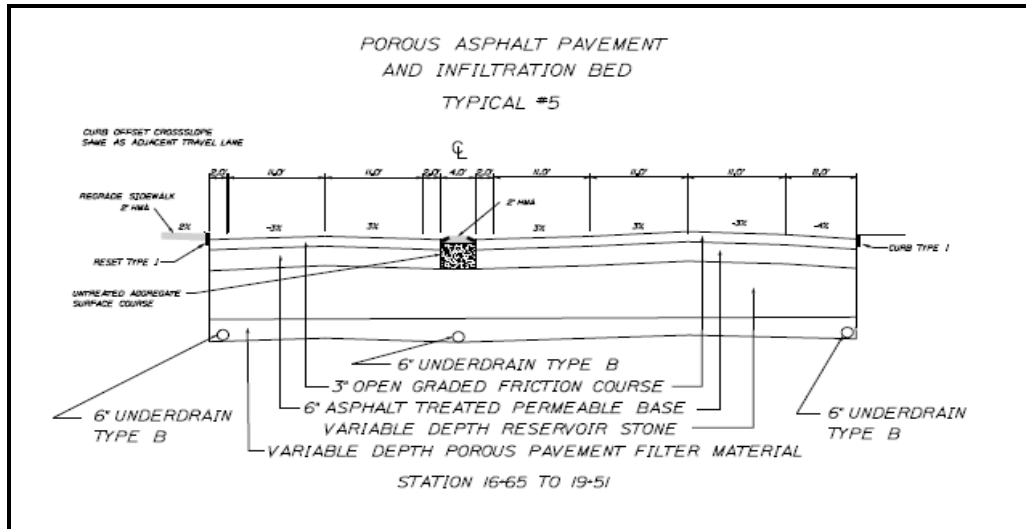


Figure 2 – Typical Section for the Porous Pavement

The construction sequence is shown below.



Figure 3 - Six inch diameter collector pipe, sand filter material and stone reservoir.

After the existing roadway was excavated to the desired grade, the 6 inch diameter, perforated underdrain pipe was installed according the plans and specifications. The pipe was installed in both transverse and longitudinal direction as can be seen in Figure 3. This pipe system will collect the storm water as it infiltrates through the porous pavement layers. The underdrain pipes are connected to catch basins that provide outlet pipes for distribution of the storm water. The outlet is located approximately 300 ft. south of the project end station into a swale area. This swale ultimately flows into Long Creek.

Next, filter material meeting MaineDOT specification 703.22, Underdrain Backfill Material Type B, was placed in 12 inch maximum lifts and compacted to a minimum 92% of maximum density. This is a variable depth layer that provides removal of total suspended solids, metals, oils and grease, and other harmful contaminants. A variable depth reservoir stone meeting MaineDOT specification 703.31, Crushed Stone, was placed over the filter layer. Gradations for both of these materials are shown in Table 1.

Filter Material		Reservoir Stone	
Sieve Designation	% by Weight Passing	Sieve Designation	% by Weight Passing
		2 ½ inch	100
		2 inch	95 -100
1 inch	95 - 100	1 inch	0 – 30
½ inch	75 - 100	¾ inch	0 – 5.0
No. 4	50 – 100		
No. 20	15 – 80		
No. 50	0 – 15		
No. 200	0 – 5.0		

Note: Percent loss shall not exceed 25, when Tested in accordance to AASHTO T96

Table 1 – Filter Material and Reservoir Stone Gradation Requirements



Figure 4 - Six inch Asphalt Treated Permeable Base placed on reservoir stone.

A six inch asphalt treated permeable base (ATPB) material was placed on the reservoir stone as shown in Figure 4. Specifications required the use of a Performance Grade Asphalt Binder (PGAB) 76-28 with a SBS polymer. This modified asphalt binder should provide better performance of the ATPB. Table 2 includes acceptance test results for gradation and asphalt content. The paving went well per the project paving reports. The ATPB special provision is included in the Appendices to this report. Because of the truck traffic, the reservoir stone was continually rolled to maintain appropriate tolerances prior to paving.



Figure 5 - Saw cutting of ATPB

A three inch lift of open graded friction course pavement was placed on the asphalt treated permeable base and serves as the roadway surface. Paving went well per the paving reports.



Figure 6 - Cross section showing sand filter, reservoir stone and ATPB



Figure 7 - Construction of 3" Open Graded Friction Course surface



Figure 8 - Demonstration of ability to pass water.

Review of the construction paving reports, contractor field and plant quality control reports and materials quality assurance data for the ATPB and OGFC shows, for the most part, the materials meet the specifications. However the % Voids average for the OGFC is slightly below the minimum target value of 18. Also the % passing the 200 sieve was higher than specification limits on average. See Tables 2 and 3 below. This information has been documented and will be available for reference as the pavement performance is evaluated over time.

Asphalt Treated Permeable Base						
Reference No.	Sublot	25.0 %	12.5 %	4.75 %	0.075 %	PGAB %
	USL		70	10	2	2.5
	Target	96	48	6	1.3	2
	LSL	95	35	2	0	1.5
227377		94	56	9	2.8	2.6
229605		94	56	7	1.5	2.4
229606		93	50	5	1.6	2.4
229607		95	45	5	1.7	2.4
	Average	94	51.75	6.5	1.9	2.4

Table 2 - Asphalt Treated Permeable Base – Quality Acceptance Test Results

Open Graded Friction Course							
Reference No.	Sublot	12.5% passing	4.75% passing	2.36% passing	0.075% passing	PGAB %	Voids %
	USL	103	27	13	4.3	6.4	22
	Target	96	20	8	2.3	6	20
	LSL	89	13	3	0.3	5.6	18
227452		92	22	11	4.6	6.1	15.4
229609		91	20	10	4.3	6.3	17.9
227459		92	21	11	4.8	6.3	16.1
227460		92	20	11	4.6	6.2	19.2
	Average	91.75	20.75	10.75	4.58	6.23	17.15

Table 3 - HMA – 12.5mm OGFC Quality Acceptance Test Results

In order to help determine the ability of the permeable layers to drain effectively through the winter months, a vertical thermocouple string was installed along the curb adjacent to the hotel near station 22+50, 39' rt. A sensor is located every foot beginning at 15 inches below finished grade, down to a six foot depth below finished grade. The lead ends are located in the visible PVC pipe behind the curb. Readings are being taken periodically, especially during the winter and spring thaw periods.

First Year Evaluation

Figure 9 shows the thermocouple readings taken through the 2010 winter. There were extended periods of freezing air temperatures. However the subsurface temperatures remained above freezing, with very few exceptions. Readings will be taken again during the 2011 winter.

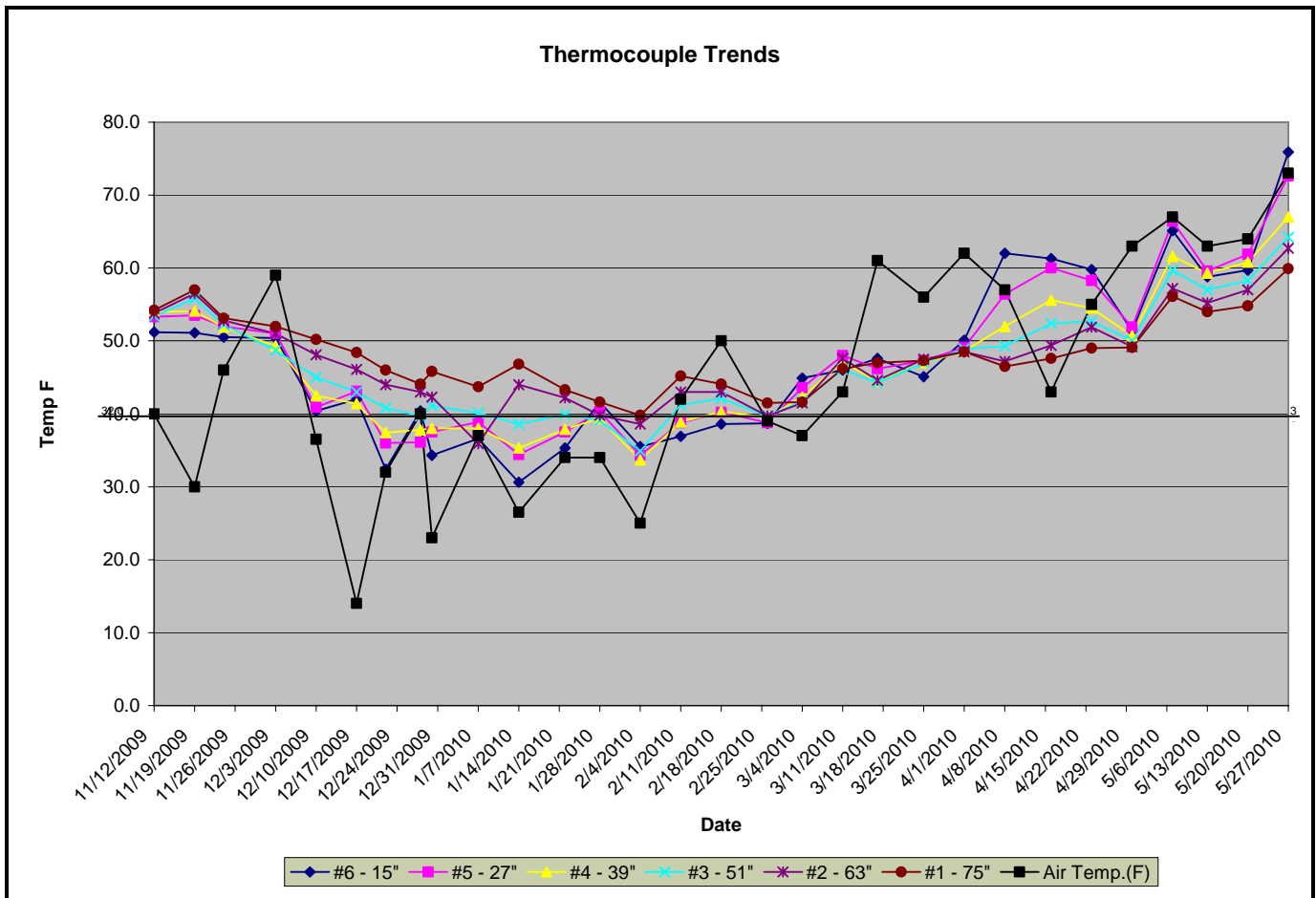


Figure 9 - Thermocouple Trends – Sensor located at depths indicated below finished grade

The site was inspected for pavement distresses in September 2010. There are some areas of the OFGC surface showing loss of material or raveling. Aside from this, the pavement appears to be in good condition. The following photos were taken during the September visit.



Figure 10 - Material loss in OGFC Surface



Figure 11 - OGFC Surface defects



Figure 12 - Note difference between OGFC and Conventional HMA Surface



Figure 13 - OGFC Surface - Note wheel path discoloration.

Conclusions

The porous pavement appears to be performing well from a rutting and cracking perspective. However there are areas of raveling in the OFGC surface that are a concern. Thermocouple readings during the 2010 winter indicate the subsurface maintains above freezing temperatures, for the most part, even during extended periods of cold weather.

Pavement performance will be evaluated and results reported for at least five years.

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Appendices

Special Provision Section 404, Asphalt Treated Permeable Base

Special Provision Section 404, Open Graded Friction Course

SPECIAL PROVISION
SECTION 404
ASPHALT TREATED PERMEABLE BASE

Description The Contractor shall furnish and place one or more courses of Asphalt Treated Permeable Base (ATPB) on an approved base in accordance with the contract documents and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the plans or established by the Resident.

MATERIALS

Materials shall meet the following requirements:

- Performance Graded Asphalt Binder PGAB 76-28, modified with SBS polymer
and section 702.01
- Aggregates for ATPB Table 2 of this Special Provision

COMPOSITION OF MIXTURES

The Contractor shall compose the Asphalt Treated Permeable Base with aggregate, Performance Graded Asphalt Binder (PGAB), and mineral filler if required. The Contractor shall size, uniformly grade, and combine the aggregate fractions in proportions that provide a mixture meeting the grading requirements specified, and the requirements in Table 1.

The Contractor shall submit for Department approval a Job Mix Formula (JMF) to the Central Laboratory in Bangor. The JMF shall state the original source, gradation, and percentage to be used of each portion of the aggregate. It shall also state the proposed PGAB content, proposed mixing and compaction temperatures, the name and location of the refiner, the supplier, the source of PGAB submitted for approval, the type of PGAB modification if applicable, and the location of the terminal if applicable. The Department shall then have 15 calendar days in which to process the design before approval. At the time of JMF submittal, the Contractor shall identify and make available the stockpiles of all proposed aggregates at the plant site. There must be a minimum of 135 Mg [150 ton] for stone stockpiles before the Department will sample. The Department shall obtain samples for laboratory testing. The Contractor shall also make available to the Department the PGAB proposed for use in the mix in sufficient quantity to test the properties of the asphalt and to produce samples for testing of the mixture.

Performance Graded Asphalt Binder Unless otherwise noted in Special Provision 403 - Hot Bituminous Pavement, PGAB shall be 76 – 28, modified with SBS polymer. The PGAB shall meet the applicable requirements of AASHTO M320 - Standard Specification for PGAB. The Contractor shall provide the Department with an approved copy of the Quality Control Plan for PGAB in accordance with AASHTO R 26-01 Certifying Suppliers of PGAB. The Contractor shall request approval from the Department for a change in PGAB supplier or source by submitting documentation stating the new supplier or source a minimum of 24 hours prior to the change. In the event that the PGAB supplier or source is changed, the Contractor shall make efforts to minimize the occurrence of PGAB co-mingling.

Sufficient PGAB shall be used in the mixture such that at least 95 percent of the aggregate particles are completely coated with binder as determined by AASHTO T 195. In addition, when compacted in a gyratory compactor for 35 gyrations, the resulting specimen shall be stable and must not fall apart under its own weight.

Table 1 – ASPHALT TREATED PERMEABLE BASE DESIGN CRITERIA

PGAB content	2.0 percent minimum
Mixing temperature range	290°F – 350°F Or as per PGAB supplier
PGAB Grade	PG 76-28

Table 2: AGGREGATE REQUIREMENTS

GRADATION REQUIREMENTS	
Sieve Designation	Percentage by Weight Passing Square Mesh Sieves (Combined Aggregate)
37.5 mm	100
25 mm	95 – 100
19 mm	80 – 95
12.5 mm	35 – 70
4.75 mm	2 – 10
2.36 mm	0 – 5
0.075 mm	0 – 2.0
AGGREGATE QUALITIES	
AASHTO T 327 Micro-Deval	18.0 maximum
ASTM D5821 Coarse Aggregate Angularity (Minimum)	85/80
ASTM D4791 (8.4) Flat and Elongated Particles (Maximum)	10

ASTM D5821 - “85/80 denotes that 85% of the coarse aggregate has one fractured face and 80% has two fractured faces.

ASTM 4791 - Criteria are presented as maximum percent by weight of flat and elongated particles (5:1 ratio).

EQUIPMENT

The Asphalt Treated Permeable Base shall be produced and placed with equipment meeting the following requirements of Section 401 of the Special Provisions:

Hot Mix Asphalt Plant	401.07
Hauling Equipment	401.08
Pavers	401.09
Rollers	401.10

WEATHER LIMITATIONS

Asphalt Treated Permeable Base shall only be placed between the dates of May 1st and the Saturday following October 1st provided that the air temperature as determined by an approved thermometer (placed in the shade at the paving location) is 10°C [50°F] or higher and the base to paved upon is 60°F or higher..

CONSTRUCTION REQUIREMENTS

Test Strip A test strip shall be constructed prior to the placement of ATPB on the project. The test strip will be constructed offsite to establish the proper mix design, production, placement, and compaction procedures for this contract prior to full plant production and placement on the project site.

The test strip shall consist of a 20 ton minimum quantity. The Contractor shall work cooperatively with the Department to develop the mix gradation and asphalt content, and shall notify the Department within 48 hours prior to their intent to construct the test strip. The Contractor shall provide the Department with two mix samples from the test strip produced material for mix verification. The samples shall be tested for conformance to the contract requirements before further production. In addition to the mix samples, a minimum of three cores will be sampled from the test strip, and shall be evaluated for density, porosity, and asphalt coating.

The mix samples, when compacted in a gyratory compactor for 35 gyrations, shall result in a specimen that is porous, and stable, and not fall apart under its own weight when removed from the gyratory compactor. Sufficient PGAB shall be used in the mixture such that at least 95 percent of the aggregate particles are completely coated with binder as determined by AASHTO T 195. In the event that the cores or gyratory compacted samples do not meet the requirements set forth in this specification, mixture gradation and asphalt contents will be adjusted and new test strips will be required until the requirements are met. Any modifications to the mixture shall be submitted as a change to the JMF by contract modification.

There will be no separate payment for material placed in a offsite test strip, but shall be considered incidental to the 404.30 - Asphalt Treated Permeable Base item.

ATPB mix production will not resume unless the Department is confident material meeting the contract requirements can be produced.

Preparation of Existing Surface The Contractor shall thoroughly clean the surface upon which Asphalt Treated Permeable Base is to be placed of all objectionable material. When the surface of the existing base is irregular, the Contractor shall bring it to uniform grade and cross section.

Preparation of Aggregates The Contractor shall dry and heat the aggregates for the ATPB to the required temperature. The Contractor shall properly adjust flames to avoid physical damage to the aggregate and to avoid depositing soot on the aggregate.

Mixing The Contractor shall combine the dried aggregate in the mixer in the amount of each fraction of aggregate required to meet the JMF. The Contractor shall measure the amount of PGAB and introduce it into the mixer in the amount specified by the JMF. The Contractor shall produce the ATPB at the temperature established by the JMF. Once mixed, the ATPB must be placed as soon as possible. Storage of Asphalt Treated Permeable Base in surge hoppers or storage silos for a period exceeding 2 hours will not be allowed.

Spreading and Finishing On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the Contractor shall spread, rake, and lute the ATPB with hand tools to provide the required compacted thickness. Solvent based agents developed to strip asphalts from aggregates will not be allowed as release agents.

On roadways with adjoining lanes carrying traffic, the Contractor shall place each course over the full width of the traveled way section being paved that day, unless otherwise directed by the Department.

Joints shall be fully coated with PGAB 64-28 just prior to the placement of the adjoining course. Areas that become contaminated or stripped of asphalt coating will be retreated with asphalt prior to placement of the adjoining course.

Compaction The actual methods and equipment utilized to compact the ATPB will be determined during the placement and compaction of the offsite test strip. In general, the following shall be required unless otherwise authorized by the Department:

Immediately after the Asphalt Treated Permeable Base has been spread, struck off, and any surface irregularities adjusted, the Contractor shall thoroughly and uniformly compact the ATPB by rolling. The ATPB shall be compacted by a minimum of three complete passes of a steel roller having a minimum weight of 12 tons operated in static mode, or 10 tons if equipped with oscillatory compaction and operated in low frequency, low amplitude mode, unless otherwise directed by the Department. When allowed by the Resident, a light application of water may be applied to the ATPB during compaction. Pneumatic rollers will not be used to compact the ATPB.

The Contractor shall roll the surface when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking, or shoving. The Contractor shall prevent adhesion of the ATPB to the rollers or vibrating compactors without the use of fuel oil or other petroleum, or solvent based release agents. Solvents designed to strip asphalt binders from aggregates will not be permitted as release agents on equipment, tools or ATPB surfaces. The Contractor shall immediately correct any displacement occurring as a result of the

reversing of the direction of a roller or from other causes to the satisfaction of the Department. Any operation that results in breakdown of the aggregate shall be discontinued.

Traffic. After a 24 hour curing period of the ATPB, limited traffic may be routed over the ATPB surface. Unless otherwise authorized by the Department, construction equipment, and traffic shall be prohibited from traveling over the ATPB surface until the entire pavement structure is in place, including the surface course. Damage to the ATPB layer caused by construction equipment or traffic shall be remedied by complete removal replacement of the damaged area to the limits determined by the Department. There will be no additional payment for repairs, or associated work.

Table 3. ACCEPTANCE LIMITS

Gradation	Table 2 Limits
PGAB content	JMF Target +/- 0.5 %

Acceptance The quantity of ATPB placed on the project shall be evaluated by Quality Level Analysis as described in Section 106 of the Standard Specifications, Revision of December 2002, using the gradation limits established in Table 3. A Lot shall consist of the entire quantity placed, and will be divided into four equal sublots. The Department will obtain samples of ATPB in conformance with AASHTO T168 Sampling Bituminous Paving Mixtures, and the MDOT/ ACM Sampling Policy, which will then be transported by the contractor in approved transport containers to the designated acceptance laboratory within 48 hours. The Department will take two (2) full sample boxes randomly within each subplot. At this time, the contractor may obtain splits of the sample for testing. The mix will be tested for gradation and PGAB content. Disputes will be allowed for PGAB content only, as provided for in Section 401 of the Standard Specifications or special Provision 400. If the Percent within Limits for PGAB Content and percent passing the nominal maximum, 12.5 mm, 4.75 mm and 0.075 mm sieves are equal to or greater than a 90 PWL, the Department will pay 100% of the unit price. If any of these properties are less than 90 Percent within Limits, the following deductions shall apply to the Lot.

Nominal max., 12.5 mm, and 4.75 mm sieves	- 1 % each
0.075 mm sieve	- 2 %
PGAB content	- 2 %

Method of Measurement

The Department will measure Asphalt Treated Permeable Base by the Ton [Mg] in accordance with Section 108.1 – Measurement of Quantities for Payment.

Basis of Payment

The accepted quantity of asphalt treated permeable base will be paid for at the contract unit price per Ton [MG] complete in place, minus any deductions based on Quality Level Analysis.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
404.30 Asphalt Treated Permeable Base	Ton [MG]

SPECIAL PROVISION
SECTION 404
Open Graded Friction Course

404.01 Description The Contractor shall furnish and place one or more courses of open-graded friction course (OGFC) on an approved base in accordance with the contract documents and in reasonably close conformity with the lines, grades, thickness, and typical cross sections shown on the plans or established by the Resident. The Department will accept this work under Quality Assurance provisions, in accordance with the requirements of Section 106 – Quality, Section 401 – Hot Mix Asphalt Pavement, and this Special Provision.

404.02 Materials Materials shall meet the following requirements:

Performance graded asphalt binder 702.01
 Aggregates for HMA Pavement 703.07, except as noted in Table 1.

Mineral Filler Mineral filler shall consist of finely divided mineral matter such as rock or limestone dust or other suitable material. At the time of use it shall be sufficiently dry to flow freely and essentially free from agglomerations. Filler shall be free from organic impurities and have a plasticity index not greater than 4. Filler material for the mix shall meet AASHTO M17, except that the gradation requirements of M17 shall not apply.

Stabilizing additive Stabilizing additive shall consist of a fiber stabilizer, either cellulose or mineral fiber. The dosage rate for cellulose shall be approximately 0.3 percent by total mixture mass and sufficient to prevent draindown. Cellulose fibers shall conform to the properties outlined in Table 2. For mineral fibers, the dosage rate shall be approximately 0.4 percent by total mixture mass and sufficient to prevent draindown. Mineral fibers shall conform to the properties of Table 3.

TABLE 1 - AGGREGATE REQUIREMENTS

Criteria	Test Method	Specified Minimum	Specified Maximum
Micro-Deval	AASHTO TP 58-99	-	18.0
Flat and Elongated, % 3 to 1 5 to 1	ASTM D4791	-	20
	ASTM D4791	-	5
Fractured Faces, %			
One face	ASTM D5821	100	-
Two faces		90	-
Sand equivalent	AASHTO T176	50	-
Uncompacted Void Content of Fine Aggregate	AASHTO T304	45	-

TABLE 2 – Cellulose Fiber Properties

Property	Requirements
Method A - Alpine Sieve ¹ Analysis	
Fiber Length	6 mm (0.25 in.) maximum
Passing 0.150mm (No. 100) sieve	70 ± 10%
Ash Content ²	18 ± 5% non-volatiles
PH ³	7.5 ± 1.0
Oil Absorbtion ⁴	5.0 ± 1.0 (times fiber mass)
Moisture Content ⁵	Less than 5.0% (by mass)

¹ Alpine Sieve Analysis. This test is performed using an Alpine Air Jet Sieve (Type 200 LS). A representative five gram sample of fiber is sieved for 14 minutes at a controlled vacuum of 75 kPa (11 psi). The portion remaining on the screen is weighed.

² Ash Content. A representative 2-3 gram sample of fiber is placed in a tared crucible and heated between 595° and 650°C (1100° and 1200° F) for not less than two hours. The crucible and ash are cooled in a desiccator and reweighed.

³ pH Test. Five grams of fiber is added to 100 ml of distilled water, stirred and let sit for 30 minutes. The pH is determined with a probe calibrated with pH 7.0 buffer.

⁴ Oil Absorption Test. Five grams of fiber is accurately weighed and suspended in an excess of mineral spirits for not less than five minutes to ensure total saturation. It is then placed in a screen mesh strainer (approximately 0.5 square millimeter hole size) and shaken on a wrist action shaker for ten minutes (approximately 1-¼ inch motion at 240 shakes/minute). The shaken mass is then transferred without touching, to a tared container and weighed. Results are reported as the amount (number of times it's own weight) the fibers are able to absorb.

⁵ Moisture Content. Ten grams of fiber are weighed and placed in a 121° C (250 °F) forced air oven for two hours. The sample is then reweighed immediately upon removal from the oven.

TABLE 3 – Mineral Fiber Properties

Mineral fibers ¹	
Sieve Analysis	
Fiber Length ²	6 mm (0.25in.) maximum mean test value
Thickness ³	0.050 mm (0.0002 in.) maximum mean test value
Shot Content ⁴	
0.250 mm (No. 60) Sieve	90 ± 5% passing
0.063 mm (No. 230) Sieve	70 ± 10% passing

¹ The European experience and development of the above criteria are based on the use of basalt mineral fibers.

² The fiber length is determined according to the Bauer McNett fractionation.

³ The fiber thickness is determined by measuring at least 200 fibers in a phase contrast microscope.

⁴ Shot content is a measure of non-fibrous material. The shot content is determined on vibrating sieves. Two sieves, the 0.250 mm (No. 60) and the 0.063 mm (No. 230) are typically utilized. For additional information, see ASTM C612.

404.03 Composition of Mixtures The Contractor shall compose the open-graded friction course with aggregate, Performance Graded Asphalt Binder (PGAB), stabilizing fibers and mineral filler if required. OGFC shall be designed and tested according to AASHTO R35 and the requirements listed in Tables 4 and 5. The Contractor shall size, uniformly grade, and combine the aggregate fractions in proportions that provide a mixture meeting the grading requirements of the Job Mix Formula (JMF).

The Contractor shall submit for Department approval a JMF to the Central Laboratory in Bangor for each mixture to be supplied. The Department shall then have 15 calendar days in which to process a new design before approval. The JMF shall establish a single percentage of aggregate passing each required sieve size within the limits shown in

Table 4. The general composition limits given in Table 4 indicate the control points of mixtures permissible under this specification. The JMF shall state the source, gradation, and percentage to be used of each portion of the aggregate and mineral filler if required. It shall also state the proposed PGAB content, the name and location of the refiner, the supplier, the source of PGAB submitted for approval, the type of PGAB modification if applicable, and the location of the terminal if applicable.

In addition, the Contractor shall provide the following information with the proposed JMF:

- Properly completed JMF indicating all mix properties (Gmm, VMA, VFB, etc.)
- Stockpile Gradation Summary
- Design Aggregate Structure Consensus Property Summary
- Design Aggregate Structure Trial Blend Gradation Plots (0.45 power chart)
- Trial Blend Test Results for at least three different asphalt contents
- Design Aggregate Structure for at least three trial blends
- Test results for the selected aggregate blend at a minimum of three binder contents
- Specific Gravity and temperature/viscosity charts for the PGAB to be used
- Recommended mixing and compaction temperatures from the PGAB supplier
 - Material Safety Data Sheets (MSDS) For PGAB
 - Asphalt Content vs. Air Voids trial blend curve
 - Test report for Contractor's Verification sample
 - Test reports for PG binder content and gradation of RAP when used in the JMF
 - Supplier's recommended mixing and compaction temperatures for PGAB

TABLE 4. Aggregate Gradation Control Points

Sieve Designation	Nominal Maximum Aggregate Size---Control Points - Percentage by Weight Passing Square Mesh Sieves (Combined Aggregate)	
	12.5 mm OGFC	9.5 mm OGFC
19 mm	100	
12.5 mm	85 – 100	100
9.5 mm	55 – 75	85 – 100
4.75 mm	10 – 25	20 – 40
2.36 mm	5 – 10	5 – 10
0.075 mm	2.0 – 4.0	2.0 – 4.0

At the time of JMF submittal, the Contractor shall identify and make available the stockpiles of all proposed aggregates at the plant site. There must be a minimum of 135 Mg [150 ton] for stone stockpiles, 70 Mg [75 ton] for sand stockpiles, and 45 Mg [50 ton] of blend sand before the Department will sample. The Department shall obtain samples for laboratory testing. The Contractor shall also make available to the Department the PGAB and stabilizing fibers proposed for use in the mix in sufficient quantity to test the properties of the asphalt and to produce samples for testing of the mixture. Before the start of paving, the Contractor and the Department shall split a production sample for evaluation. The Contractor shall test its split of the sample and determine if the results meet the requirements of the Department's written policy for mix design verification (See Maine DOT Policies and Procedures for HMA Sampling and Testing available at the Central Laboratory in Bangor). If the results are found to be acceptable, the Contractor will forward their results to the Department's Lab, which will test the Department's split of the sample. The results of the two split samples will be compared and shared between the Department and the Contractor. If the Department finds the mixture acceptable, an approved JMF will be forwarded to the Contractor and paving may commence. The first day's production shall be monitored, and the approval may be withdrawn if the mixture exhibits undesirable characteristics such as checking, shoving

or displacement. The Contractor shall be allowed to submit aim changes within 24 hours of receipt of the first Acceptance test result. Adjustments will be allowed of up to 2% on the percent passing the 2.36 mm sieve through the 0.075 mm and 3% on the percent passing the 4.75 mm or larger sieves. Adjustments will be allowed on the %PGAB of up to 0.2%. Adjustments will be allowed on GMM of up to 0.010.

The Contractor shall submit a new JMF for approval each time a change in material source or materials properties is proposed. The same approval process shall be followed. The cold feed percentage of any aggregate may be adjusted up to 10 percentage points from the amount listed on the JMF, however no aggregate listed on the JMF shall be eliminated.

TABLE 5: VOLUMETRIC DESIGN CRITERIA

Air Voids @ N_{Design}	20.0 percent
Binder Content	6.0 percent minimum
VCA_{mix}	Less than VCA_{DRC}
Draindown	0.3 percent maximum (AASHTO T 305)
Gyrations @ N_{Design}	50

404.04 Temperature Requirements After the JMF is established, the temperature of the mixture shall conform to the PGAB supplier's recommended mixing sand compaction temperature, with the following tolerances:

In the truck at the mixing plant	+/- 25°F
At the Paver	+/- 25°F

The JMF and the mix subsequently produced shall meet the requirements of Tables 1, 4 and 5. Under no circumstances will the Department accept HMA (unless the binder has been modified) that has been heated to temperatures over 179°C [340°F].

404.05 Performance Graded Asphalt Binder Unless otherwise noted in Special Provision 403 - Hot Bituminous Pavement, PGAB shall be 76 – 28, modified with SBS polymer. The PGAB shall meet the applicable requirements of AASHTO M320 - Standard Specification for PGAB. The Contractor shall provide the Department with an approved copy of the Quality Control Plan for PGAB in accordance with AASHTO R 26-01 Certifying Suppliers of PGAB. The Contractor shall request approval from the Department for a change in PGAB supplier or source by submitting documentation stating the new supplier or source a minimum of 24 hours prior to the change. In the event that the PGAB supplier or source is changed, the Contractor shall make efforts to minimize the occurrence of PGAB co-mingling.

404.06 Weather and Seasonal Limitations Section 401.06 shall apply, with the following change: The atmospheric temperature must be 16°C [60°F] or higher for placement of OGFC.

404.07 Hot Mix Asphalt Plant Section 401.07 shall apply.

401.08 Hauling Equipment Section 401.08 shall apply.

404.09 Pavers Section 401.09 shall apply.

404.10 Rollers Section 401.10 shall apply, with the following exceptions: Pneumatic rollers will not be required. Steel wheel rollers shall have a minimum weight of 10 tons.

404.101 Surface Tolerances Section 401.101 shall apply.

404.11 Preparation of Existing Surface Section 401.11 shall apply, with the following requirements:

The surface where the OGFC is to be placed shall be cleaned of all foreign and loose material. Immediately before beginning paving operations, ensure that the surface is dry. Do not place tack coat

unless the weather restrictions are met. When precipitation has occurred within 24 hours before application, the Department will determine when the surface is completely dry.

Apply a tack coat of PGAB 64-28 to curbs, gutters, manholes, and other similar structures. Clean the exposed surfaces of these structures and apply a uniform coating to contact surfaces before paving.

In areas inaccessible to distributor spray bars, use hand spraying equipment for tack coat. Do not allow traffic or construction vehicles on tack coated surfaces.

Only apply tack coat that can be paved over in the same day. Apply a tack coat of PGAB 64-28 at a rate of 0.10 to 0.14 gallons per square yard and at a spraying temperature of 325 °F. Adjust the spraying temperature and application rate to produce a uniform coating, with no excess material.

404.12 Hot Mix Asphalt Documentation Section - 401.12 shall apply.

404.13 Preparation of Aggregates Section - 401.13 shall apply.

404.14 Mixing Section - 401.14 shall apply.

404.15 Spreading and Finishing Section - 401.15 shall apply.

404.16 Compaction Section - 401.16 shall apply, with the following exceptions: Pneumatic rollers will not be used to compact the OGFC. The OGFC shall be compacted by a minimum of three complete passes of a steel roller operated in static mode, unless otherwise directed by the Department. If the OGFC is unstable during compaction, it may be allowed to cool until rolling can be completed without excessive displacement. Following compaction, no traffic will be allowed on the OGFC for a period of 24 hours.

404.17 Joints Section - 401.17 shall apply.

404.18 Quality Control Method A, B & C Section 401.18 shall apply, with the following exceptions:

Quality Control Plan, Item m: Maximum silo storage time shall be two hours.

Reasons for the Contractor to cease paving, Item d. Revise to read, "The Fractured Faces value falls below the requirements of Special Provision 404, Table 1 - Aggregate Requirements."

Reasons for the Contractor to cease paving, Item f. Revise to read, "The Flat and Elongated value exceeds the requirements of Special Provision 404, Table 1- Aggregate Requirements"

404.19 Quality Control Method D Section - 401.19 shall apply.

404.20 Acceptance Sections - 401.201, 401.202 and 401.203 shall apply, with the following exceptions:

Replace Table 5 - Method A Acceptance Limits with the following:

TABLE 6 - METHOD A ACCEPTANCE LIMITS

Property	USL and LSL
Passing 4.75 mm [No. 4] and larger sieves	Target +/-7%
Passing 2.36 mm [No. 8] to 1.18 mm [No. 16] sieves	Target +/-4%
Passing 0.60 mm [No. 30]	Target +/-3%
Passing 0.30 mm [No. 50] to 0.075 mm [No. 200] sieve	Target +/-2%
PGAB Content	Target +/-0.4%
Air Voids	20.0 % +/- 2.0 %

Replace Table 6 - Method B Acceptance Limits with the following:

TABLE 7: METHOD B ACCEPTANCE LIMITS

Property	USL and LSL
Percent Passing 4.75 mm and larger sieves	Target +/-7
Percent Passing 2.36 mm to 1.18 mm sieves	Target +/-5
Percent Passing 0.60 mm	Target +/-4
Percent Passing 0.30 mm to 0.075 mm sieve	Target +/-3
PGAB Content	Target +/-0.5
Air Voids	20.0 % +/-2.5

Replace Table 7 - Method C Acceptance Limits with the following:

TABLE 8: METHOD C ACCEPTANCE LIMITS

Property	USL and LSL
Passing 4.75 mm and larger sieves	Target +/-7%
Passing 2.36 mm to 1.18 mm sieves	Target +/-5%
Passing 0.60 mm	Target +/-4%
Passing 0.30 mm to 0.075 mm sieve	Target +/-2%
PGAB Content	Target +/-0.4%
Air Voids	20.0% +/-2.0%

404.21 Method of Measurement The Department will measure Open-graded friction course by the Mg [ton] in accordance with Section 108.1 - Measurement of Quantities for Payment.

404.22 Basis of Payment The Department will pay for the work, in place and accepted, in accordance with the applicable sections of this Section, for each type of OGFC specified.

The Department will pay for the work specified in Section 404.11, for the OGFC used, except that cleaning objectionable material from the pavement and furnishing and applying bituminous material to joints and contact surfaces is incidental.

Payment for this work under the appropriate pay items shall be full compensation for all labor, equipment, materials, and incidentals necessary to meet all related contract requirements, including design of the JMF, implementation of the QCP, obtaining core samples, transporting cores and samples, filling core holes, applying emulsified asphalt to joints, and providing testing facilities and equipment.

The Department will make a pay adjustment for quality as specified below.

404.221 Pay Adjustment for the Quality of Open-graded friction course The Department will sample, test, and evaluate Open-graded friction course in accordance with Section 106 - Quality and Section 404.20 - Acceptance.

404.222 Pay Factor (PF) (Methods A, B & C) Section 401.222 shall apply, with the following changes:

For HMA evaluated under Acceptance Method C, the Department will determine a pay factor using acceptance limits from Table 8: Method C Acceptance Limits.

The following variables will be used for pay adjustment:

- PA = Pay Adjustment
- Q = Quantity represented by PF in Mg [ton]
- P = Contract price per Mg [ton]
- PF = Pay Factor

Pay Adjustment Method A

The Department will use the following criteria for pay adjustment: Performance Graded Asphalt Binder content, voids @N_d, and the percent passing the nominal maximum, 4.75 mm, 2.36 mm and 0.075 mm sieves for the type of HMA represented in the JMF. If the pay factor for PGAB content falls below 0.80, then the PGAB pay factor shall be 0.55.

PGAB Content, Air Voids and Gradation: The Department will determine a pay adjustment using Table 6: Method A Acceptance Limits as follows:

$$PA = (\text{voids @ } N_d \text{ PF} - 1.0)(Q)(P)x0.10 + (\text{PGAB PF} - 1.0)(Q)(P)x0.15 + (\% \text{ Passing Nom. Max PF} - 1.0)(Q)(P)x0.05 + (\% \text{ passing } 4.75 \text{ mm PF} - 1.0)(Q)(P)x0.05 + (\% \text{ passing } 2.36 \text{ mm PF} - 1.0)(Q)(P)x0.05 + (\% \text{ passing } 0.075 \text{ mm PF} - 1.0)(Q)(P)x0.10$$

Pay Adjustment Method B

The Department will use the following criteria for pay adjustment: density, Performance Graded Asphalt Binder content, voids @N_d, and the percent passing the nominal maximum, 4.75 mm, 2.36 mm and 0.075 mm sieves for the type of HMA represented in the JMF. If the pay factor for PGAB content falls below 0.86, then the PGAB pay factor shall be 0.70.

PGAB Content, Air Voids and Gradation: The Department will determine a pay adjustment using Table 7: Method A Acceptance Limits as follows:

$$PA = (\text{voids @ } N_d \text{ PF} - 1.0)(Q)(P)x0.10 + (\text{PGAB PF} - 1.0)(Q)(P)x0.15 + (\% \text{ Passing Nom. Max PF} - 1.0)(Q)(P)x0.05 + (\% \text{ passing } 4.75 \text{ mm PF} - 1.0)(Q)(P)x0.05 + (\% \text{ passing } 2.36 \text{ mm PF} - 1.0)(Q)(P)x0.05 + (\% \text{ passing } 0.075 \text{ mm PF} - 1.0)(Q)(P)x0.10$$

Pay Adjustment Method C

The Department will use Performance Graded Asphalt Binder content, and the percent passing the nominal maximum, 4.75 mm, 2.36 mm and 0.075 mm sieves for the type of HMA represented in the JMF. If the PGAB content falls below 0.80, then the PGAB pay factor shall be 0.55.

PGAB Content and Gradation The Department will determine a pay factor using Table 8: Method C Acceptance Limits. The Department will calculate the price adjustment for Mixture Properties as follows:

$$PA = (\% \text{ Passing Nom. Max PF-1.0})(Q)(P)X0.05+(\% \text{ passing 4.75 mm PF-1.0})(Q)(P)X0.05+(\% \text{ passing 2.36 mm PF-1.0})(Q)(P)X0.05+(\% \text{ passing 0.075 mm PF-1.0})(Q)(P)X0.10+(PGAB \text{ PF-1.0})(Q)(P)X0.25$$

Air Voids The Department will determine a pay factor (PF) using Table 8: Method C Acceptance Limits. The Department will not make price adjustments for Air Voids but will monitor voids as shutdown criteria.

404.223 Process for Dispute Resolution (Methods A, B & C only) Section 401.223 shall apply.

Payment will be made under:

<u>Pay Item</u>	<u>Pay Unit</u>
404.31 Open-Graded Friction Course 12.5 mm Nominal Maximum Size	Megagram [Ton]
404.32 Open-Graded Friction Course 9.5 mm Nominal Maximum Size	Megagram [Ton]