TOPS

Targeted Overlay Pavement Solutions

High-Performance Thin Overlays How-To Document

April 2022

U.S. Department of Transportation

Federal Highway Administration

Every Day Counts

Innovation for a Nation on the Move

NOTICE

NON-BINDING CONTENTS

QUALITY ASSURANCE STATEMENT

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This document highlights FHWA's Every Day Counts initiative known as Targeted Overlay Pavement Solutions. TOPS integrates innovative overlay procedures into practices to improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.
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<tr><td colspan="4">16. Abstract
High-Performance Thin Overlays (HPTO) are primarily used as a pavement preservation application typically placed as a 1-inch lift. Other HPTO characteristics include highly durable aggregates, polymer-modified asphalt binder, and laboratory performance criteria to limit rutting and cracking.

The New Jersey Department of Transportation and Texas Department of Transportation have used HPTO and other similar products, including Thin Overlay Mixture-Coarse (TOM-C) to increase resistance to rutting and cracking. This document describes DOT experiences with these products, including project design and planning, mixture and material selection, and construction specifications.</td></tr>
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LIST OF ACRONYMS

APA	Asphalt pavement analyzer
AASHTO	American Association of State Highway Transportation Officials
HWTT	Hamburg Wheel Tracking Test
HPTO	High-performance thin overlay
HMA	Hot mix asphalt
IC	Intelligent compaction
JMF	Job mix formula
MTV	Material transfer vehicle
NAPA	National Asphalt Pavement Association
NMAS	Nominal maximum aggregate size
OT	Overlay test/overlay tester
PMS	Pavement management system
PMTP	Paver-mounted thermal profiler
RAS	Recycled asphalt shingles
TOM	Thin overlay mixture
VMA	Voids in mineral aggregate

INTRODUCTION

A high-performance thin overlay (HPTO) is primarily used as a pavement preservation application typically placed as a 1-inch layer in one lift (Figure 1). HPTO is designed for high resistance to rutting and cracking. The mixture consists of durable aggregates, high-quality polymer-modified asphalt binder, and laboratory performance criteria to limit rutting and cracking. The New Jersey Department of Transportation (NJDOT) calls this application HPTO, while the Texas Department of Transportation (TxDOT) calls it thin overlay mixture (TOM).

Figure 1. Finished HPTO surface. (Source: NCAT)

NJDOT defines HPTO as a fine-graded polymer-modified asphalt mixture that uses aggregate with a nominal maximum aggregate size (NMAS) of 3/8 inch. It uses a modified Superpave design methodology with restrictions on reclaimed asphalt pavement and sand. It is typically performance-tested at design and during production (including test strips).

Figure 2. Surface texture of TOM-F (left) and TOM-C (right). (Source: Texas A&M Transportation Institute)

TxDOT's version of a high-performance thin overlay is called TOM. Depending on the placement thickness, aggregate size, and gradation, TOM is further classified as TOM-C (coarse) and TOM-F (fine). These overlays can be placed at 0.5- to 1-inch thicknesses and consist of high-quality aggregate and asphalt binder materials. This document focuses on TOM-C, which is typically placed as a surface course at a thickness of 1 inch, has an NMAS of 3/8 inch, and minimum asphalt content of 6 percent. TOM-F can be used as a surface mixture but is commonly used as a hot-mix asphalt (HMA) crack attenuating layer with TOM-C on the surface. Many TxDOT districts prefer the coarser texture of TOM-C, with a surface texture that mimics stone matrix asphalt. The surface texture of each TOM mix is illustrated in Figure 2.

Other Thin Asphalt Overlays

Thin overlays used by other agencies may have similar gradations, asphalt content, and volumetric criteria. The following list describes other thin asphalt overlay products:

- New York State DOT has a 6.3-mm polymer-modified HMA for preventive maintenance. 6.3-mm polymer-modified HMA is a dense-graded mixture placed 19 mm to 25 mm thick (NYSDOT 2014).
- Mogawer et al. (2012) use the name "HPThinOL" and define it as an overlay with a thickness of 1 inch or less. They report that DOTs such as Arizona, Maryland, Michigan, New Jersey, New York, and Ohio have developed HPTO specifications. National Highway Cooperative Research Program (NCHRP) Synthesis on Thin Asphalt Concrete Overlays (Watson and Heitzman 2014), though not related to high-performance, defines surface courses typically placed at thicknesses of no more than 1.5 inches (38 mm) as thin overlays. The authors present examples of thin overlay projects in Ohio, Texas, Louisiana, Minnesota, and Georgia.

However, the performance testing during design and production differentiate HPTO as "high-performance" compared to other thin overlays. The performance testing criteria can differ one agency to another depending on their performance needs. This document focuses primarily on these products because of their laboratory performance testing and distinguishes these products from conventional thin overlays based on project development, material selection, mixture design and production, and construction.

Potential HPTO Benefits

According to NJDOT and TxDOT, there are many benefits to using HPTO as a surface lift:

- Serves as an appropriate option for State highway systems with high traffic volumes.
- Renews the road surface, provides a surface treatment, and extends pavement life.
- Minimizes impact on traffic with shorter lane closures.
- Adds service life to the pavement without a significant change in profile grade.
- Potentially improves ride quality. However, improved ride quality is dependent on pre-existing surface conditions, quality of pre-HPTO repairs, and thickness of HPTO overlay. There are limitations to how much a 1-inch lift can improve ride quality.
- Reduces noise and improves long-term skid resistance on some projects. However, these are not engineered or targeted results and depend on existing conditions.

HPTO is a critical preservation and maintenance tool for NJDOT and is considered a cost-effective, high-performance maintenance treatment by TxDOT (Figure 3).

Figure 3. Freshly placed, uncompacted HPTO.(Source: NJDOT)

PROJECT DESIGN AND PLANNING

This section describes project design and development considerations such as establishing project selection criteria, pavement evaluation, cost benefits, existing pavement structure and repair, and other project-specific considerations.

A crucial aspect of any pavement preservation treatment is application timing. A pavement preservation treatment like HPTO provides a long-term preservation strategy when the pavement is still in good condition. NJDOT research (Bennert 2016) showed that when HPTO is placed on pavement still in good condition, it has double the service life compared to HPTO placed on a pavement deteriorated to fair or poor condition (based on NJDOT definitions).

The FHWA tech brief, "The Use of Thin Asphalt Overlays for Pavement Preservation," (FHWA 2019) suggests considering the typical length of time between construction and preservation treatment during project planning. The time window between construction and treatment can be significant and plays an important role in pavement preservation effectiveness. Because pavement conditions decrease over time, considering this time window can help ensure preservation treatments will occur while the pavement is still in good condition, and the full effects of preservation are received. Figure 4 shows FHWA's suggested timing.

Project Selection Criteria

Ohio DOT has been using thin overlays to maintain and preserve its highway system for many years.

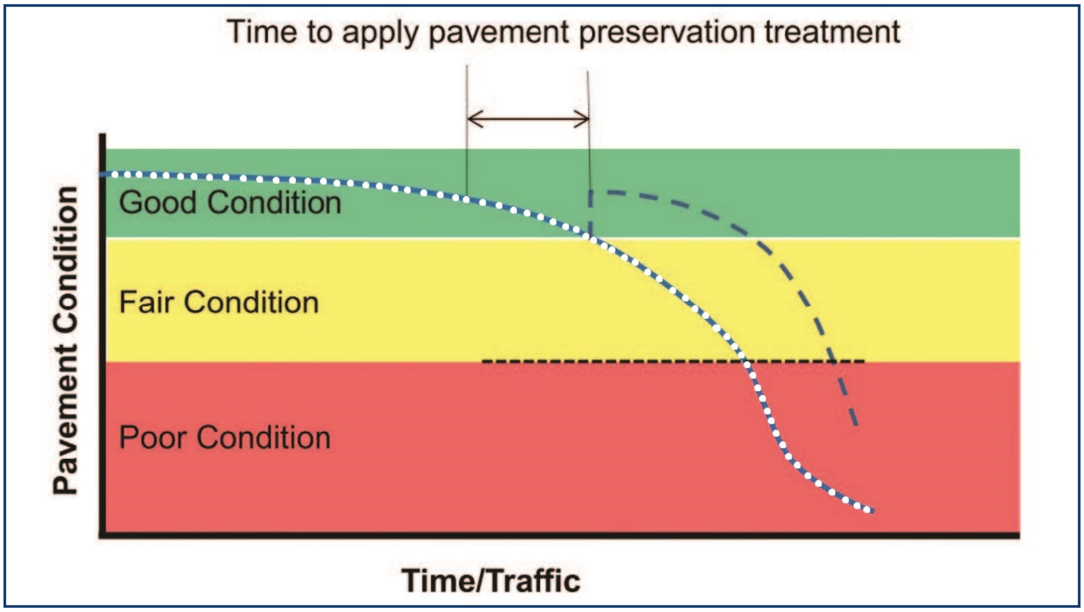

Figure 4. Pavement preservation timing. (Source: FHWA)

The agency found that one of the most significant factors in achieving the successful performance of thin overlays is project selection criteria (Watson and Heitzman 2014).

Project selection criteria depend primarily on the pavement's existing condition. However, other needs may override using HTPO as a long-term preservation strategy, such as a stopgap measure to delay a major rehabilitation. The treatment selection may also be impacted by a limited long-term budget, restricted road closures due to high traffic volumes, or other constraints.

Many DOTs have established thresholds and decision-making processes in their pavement management systems (PMS) for pavement preservation treatments, including thin overlays. These thin overlay criteria are generally applicable to HPTO treatments. In general, the pavement needs to be in good condition for the treatment to be applied. Decision-making processes and pavement condition indices vary among DOTs. For example, the NJDOT PMS threshold for pavement preservation treatments specifies an existing pavement surface distress index (scale of 0-5 with a 0-rating indicating a pavement in the poorest condition) greater than 2.4 (Bennert 2016, Blight 2018). TxDOT does not recommend using thin overlays on pavements with a structural condition index (Scale 0.0-1.0, with 0.0 rating indicating a pavement in poorest condition) of less than 0.7 (TxDOT 2014, Wilson 2015). Although the pavement condition definitions and indices are unique, the general concept remains the same—HPTO is most beneficial if applied when the pavement is still in good condition.

Figure 5 shows poor candidates for HPTO treatment, including those with deep rutting and alligator or fatigue cracking.

HPTO also can be used as an alternative to a preservation surface treatment. HPTO can delay reflective cracking on rigid pavements in good structural conditions with low-severity cracking. NJDOT reports that using HPTO as an interlayer in an overlay system is beneficial when staged construction is needed (Blight 2021).

Figure 5. Poor candidates for HPTO. (Source: TxDOT)

HPTO provides the necessary resistance to rutting and cracking and adequate surface friction. Therefore, HPTO can also be used as a superior leveling course when the interlayer is subject to traffic loads.

Other potential HPTO benefits identified by NJDOT include minimized impact on existing vertical clearance and compatibility with other infrastructures such as guardrails, curbs, and gutters. NJDOT has many roadways near stream crossings and environmental restrictions do not allow elevation changes. Therefore, HPTO is an effective solution due to its high performance and thin application thickness (Blight 2021). TxDOT reports TOM-C's suitability for pavements subject to shear forces such as turning, stopping, and accelerating traffic movements. TOM-C typically performs well on low to moderate-trafficked roads needing a crack-resistant surface mix and on roadways needing high-skid resistance. Both applications should delay future maintenance needs (TxDOT 2014, Wilson 2015).

Pavement and Asset Evaluation

A thorough pavement evaluation can identify and quantify all existing distress and structural repairs as part of a long-term pavement preservation strategy such as HPTO. Additional needs, such as improvements to ride quality, skid resistance, and drainage should be considered during the project development stage.

During pavement evaluation, identify the cause of surface distresses such as load- and non-load-related cracking, rutting, raveling, and weathering in terms of type, extent, and severity using agency guidelines. Other characteristics such as ride quality, skid resistance, and drainage may be evaluated case by case. Assets such as bridges, curbs, gutters, Americans with Disabilities Act-compliant ramps, and driveways should also be surveyed to assess their impacts on the application. Figure 6 shows a raveling seal coat classified by TxDOT as a good candidate for HPTO (TOM-C) based on the existing conditions.

The National Asphalt Pavement Association (NAPA) Information Series 135: Thin Asphalt Overlays for Pavement Preservation suggests an "investigation approach" and surface preparation based on the type and extent of the pavement distress. Use of the document is not required by Federal law or regulation.

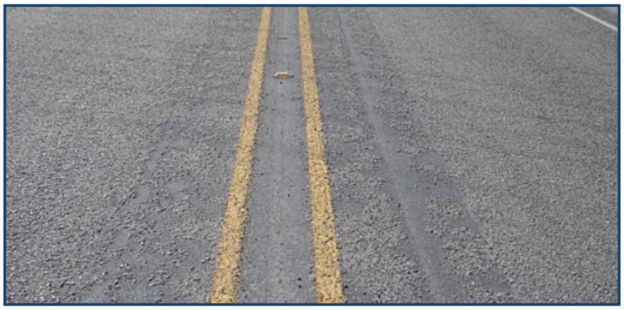

Figure 6. Raveling seal coat is a good HPTO candidate. (Source: TxDOT)

Similar suggestions are provided in the FHWA tech brief, "The Use of Thin Asphalt Overlays for Pavement

Preservation" (FHWA 2019). The suggestions include evaluating pavement conditions using coring and non-destructive testing to examine the type, extent, severity, and cause of distress. Roadway drainage, pavement cross-slope and profile, rutting, cracking, and isolated locations with severe distress should be evaluated.

Pavement Design, Thickness Criteria, and Repair Strategies

Design

Pavement preservation are treatments that are not designed to add structural capacity but are meant to simply restore overall condition of the pavement. As such, structural design is not performed when considering HPTO treatments. A small increase in structural capacity can be expected if HPTO is placed before any significant damage to the existing pavement structure.

Thickness

Typically, HPTO is placed as a 1-inch lift directly over the existing pavement. HPTO can be combined with other preservation strategies such as micro surfacing, slurry seals, or micro milling. Combined strategies may bring added potential benefits to a project (Blight 2018). For example, HPTO may be combined with micro milling when improved smoothness is desired. Micro milling before placing HPTO can also help eliminate or minimize elevation changes in the roadway.

Repairs

NJDOT and TxDOT consider minor to moderate repairs such as addressing ruts and cracks in isolated areas before placing thin overlays. NJDOT generally limits repairs to 10 percent of the preservation project (Blight 2021). Figure 7 shows an existing pavement with block cracking. According to TxDOT, this pavement has some surface distresses but is still a good candidate for HPTO (TOM-C).

Figure 7. Pavement with existing block cracking good HPTO (TOM) candidate. (Source: TxDOT)

Cost and Benefit-Cost Ratio

The higher cost ($3-5/SY) associated with HPTO when compared to other pavement preservation strategies can be offset by cost savings due to an increase in service life of the treatment by 5 to 10 years (Blight 2015, Blight 2018).

A detailed life cycle cost analysis or an analysis to determine a benefit-cost ratio on HPTO has not been performed by any agency or research institution. Most agencies may not consider it necessary for pavement preservation treatment selection. In general, the overall HPTO unit cost is higher than other pavement preservation treatments and even conventional asphalt pavement overlay products. However, comparing mixes using unit costs does not account for the fact that thin 1-inch applications may not have a comparable cost per square yard. Increased production rates may allow for shorter traffic closures and therefore reduced user delay costs. The long-term performance also contributes to the overall anticipated high benefit-cost ratio of HPTO.

Other Considerations

Other things to consider at the project planning stage, especially in urban or highly congested areas, may include but are not limited to resetting, recasting, and reconstructing inlets and manholes, curbs, and driveways as needed.

MIXTURES AND MATERIALS

HPTO is a performance-designed mixture for thin applications that provides longer service life through enhanced cracking, rutting, and durability performance (EDC-6 TOPS 2020). Compromising the quality of materials or mixture performance criteria can significantly impact the performance (TxDOT 2014, Wilson 2015).

Aggregates

HPTO mixes are generally placed in 1-inch lifts. Both NJDOT and TxDOT specify a 3/8-inch NMAS for their mixes. Like most surface course mixtures, special consideration must be given to aggregate durability to achieve the desired performance. Typically, HPTO consists of coarse aggregate, fine aggregate, and mineral filler if necessary.

For example, TxDOT specifies using sandstone, dolomite, granite, quartzite, trap rock, and limestone aggregates with a MgSO4 soundness loss of 20 or less for critical sections and 25 or less for non-critical sections (TxDOT 2014, Wilson 2015). In addition, TxDOT also specifies the aggregate to meet surface aggregate classification criteria. Table 1, Table 2, and Table 3 show some of TxDOT's aggregate quality criteria.

Table 1. Course aggregate quality criteria — TxDOT Item 347 for TOM-F.

Property	Test Method	Criteria
Surface aggregate classification	Tex-499-A (AQMP)	A[1]
Deleterious material, %, Max	Tex-217-F, Part I	1.5
Decantation, %, Max	Tex-217-F, Part II	1.5
Micro-Deval abrasion, %	Tex-461-A	Footnote[2]
Los Angeles abrasion, %, Max	Tex-410-A	30
Magnesium sulfate soundness, 5 cycles, %, Max	Tex-411-A	20
Crushed face count[3], %, Min	Tex-460-A, Part I	95
Flat and elongated particles @ 5:1, %, Max	Tex-280-F	10

Table 2. Fine aggregate quality criteria — TxDOT Item 347 for TOM-F.

Property	Test Method	Criteria
Linear shrinkage, %, Max	Tex-107-E	3

Table 3. Combined aggregate[4] quality criteria — TxDOT Item 347 for TOM-F.

Property	Test Method	Criteria
Sand equivalent, %, Min	Tex-203-F	45

[1] Surface aggregate classification of "A" is specified by TxDOT unless otherwise shown on the plans.
[2] Used to estimate the magnesium sulfate soundness loss in accordance with Section 347.2.1.1.2., "Micro-Deval Abrasion."
[3] Only applies to crush gravel.
[4] Aggregate without mineral filler or additives combined as used in the job mix formula.

The coarse aggregate, fine aggregate, and mineral filler are combined to meet job mix formula (JMF) gradation bands per the specifications. NJDOT and TxDOT specification criteria for HPTO and TOM-C are shown in Figure 8. In general, TOM-C is coarser and more gap-graded than HPTO and allows for up to 5 percent aggregates to be retained on a 3/8-inch sieve. TOM-C also allows a broader band of gradation in the fine portion of the aggregate blend (passing #16 sieve). These differences are further evidenced by observing the lower asphalt binder content criterion for TOM-C and the coarser surface texture (Figure 9).

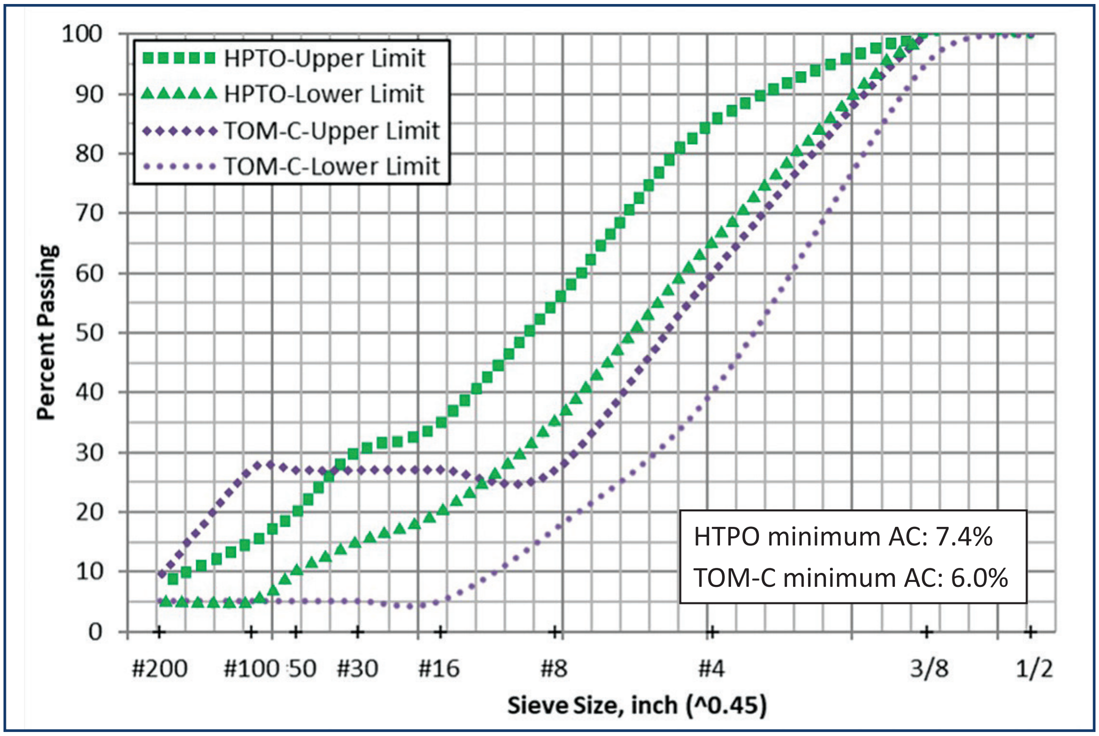

Figure 8. Typical HPTO and TOM-C gradations. (Data Source: NJDOT, TXDOT)

Asphalt Binders

Both NJDOT and TxDOT require polymer-modified binders for use in HPTO mixtures, per their TxDOT Item 347 and NJDOT standard specifications Section 902, respectively. Polymer-modified binders are critical for achieving the performance testing criteria for HPTO. Per NJDOT standard specifications Section 902, NJDOT specifies a polymer-modified asphalt binder graded continuously for performance (AASHTO R 29), typically PG 64E-22, and specifies a certificate of analysis to be submitted with the mix design (TxDOT Item 347 and NJDOT standard specifications Section 902). PG 76-22 is the preferred binder type for TxDOT on high-volume roadways or roadways with significant truck traffic.

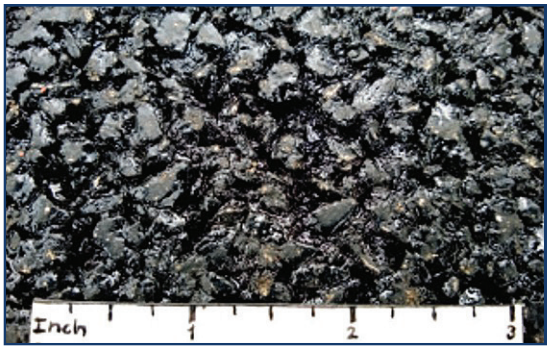

Figure 9. TOM-C surface texture.
(Source: Texas Transportation Institute)

Recycled Materials

In the current NJDOT and TxDOT specifications, the use of recycled materials such as reclaimed asphalt pavement and recycled asphalt shingles in HPTO is not permitted per NJDOT standard specifications Section 902 and TxDOT Item 347. In addition, NJDOT prohibits the use of remediated petroleum-contaminated soil aggregate or crushed recycled container glass (NJDOT 2018).

Additives

Using a warm mix additive in HPTO can help with placement in slightly cooler ambient air temperatures by reducing the rate of heat loss from the mix and allowing more time for compaction. A warm mix additive can also minimize bumps in the new surface associated with paving over crack sealing material (Newcomb 2015).

For example, TxDOT specifications Item 347 requires using Department-approved warm mix additives or processes to facilitate compaction when the surface temperature is below 60 degrees F or when the air temperature is 60 degrees F and falling.

Mixture Design and Performance Testing

The mixture design methodology for HPTO can be agency-dependent. Modified mixture design criteria are generally based on observed field performance and research results. Current national mixture design criteria for 9.5- and 4.75-mm mixtures, similar to the sizes used in HPTO, can be found in AASHTO M 323.[5]

NJDOT designs HPTO using the Superpave gyratory compactor with Ndes of 50 gyrations with a target laboratory density of 96.5 percent (percent of maximum theoretical specific gravity).

TxDOT also allows the use of the Texas gyratory compactor (TGC) with a target laboratory density of 97.5 percent (percent of maximum theoretical specific gravity) instead of Ndes of 50. The TGC uses a greater internal angle to compact the harsh angular materials used by TxDOT. Doing this eliminates rounded field sands and dirty screenings in their approved mix designs (TxDOT 2014a).

Volumetric criteria for both NJDOT and TxDOT are shown in Table 4. Watson and Heitzman (2014) recommend that an agency determine the locking point of the aggregate structure in its mixtures and use that number of gyrations for its Ndes level while keeping the binder type the same, especially for thin asphalt overlays. The locking point is defined by Watson et al. (2008) as the first time that the specimen height remains the same for three successive gyrations.

The volumetric criteria for the design and control of TxDOT and NJDOT HPTO mixes are summarized in Table 4.

Table 4. Volumetric criteria for design and control of HPTO — NJDOT Section 902.08 and TxDOT 347.

Mix Property	HPTO (NJDOT Section 902)	TOM-F (TxDOT 347)
Binder content (total weight of mix), min. %	7.4	6.0
Design VMA, %	≥18.0	16.0 Min.
Design gyrations	50	50

5 AASHTO specifications referenced are not required by Federal law or regulations unless they are explicitly incorporated by reference into FHWA regulations.

Lab-molded density, %	96.5	97.5 (Applicable only when using Texas Gyratory Compactor)
Tensile strength ratio, %	85	Not specified
Dry tensile strength, PSI	Not specified	85-200
Dust to asphalt ratio	0.6-1.2	Not specified
Drain down, %	≤1.0	0.20 max.
Hamburg Wheel Test, min. passes at 12.5 mm rut depth	Not applicable	20,000 (high grade - PG 76)
Overlay Tester, min. cycles	600	300
Asphalt Pavement Analyzer (APA), 8,000 cycles	4 mm (max.)	Not applicable

The volumetric properties such as minimum voids in mineral aggregate (VMA) and minimum asphalt content can be prescribed to ensure a durable mixture. NJDOT specifies a minimum VMA of 18 percent with a minimum asphalt content of 7.4 percent in the HPTO mixtures (Table 4). TxDOT specifies a minimum design VMA of 16 percent and a minimum asphalt content of 6 percent. The differences in asphalt content between NJDOT and TxDOT mixes can be attributed to the difference in aggregate gradation (Figure 8).

The high-performance characteristics are evaluated based on laboratory performance testing. The rutting performance of the mixture may be evaluated using tests such as the Hamburg Wheel Tracking Test (HWTT) or the asphalt pavement analyzer (Figure 10).

NJDOT uses gyratory specimens compacted down to an air void content of 5.0 ± 0.5 percent for APA testing. Getting an approved mix design corresponds to APA rut depth results of less than 4 mm using 8,000 loading cycles when tested at 64 degrees C with a hose pressure of 100 psi and 100-pound wheel load (NJDOT 2018). In comparison, TxDOT specifies a maximum rut depth of 12.5 mm at 20,000 passes of the HWTT.

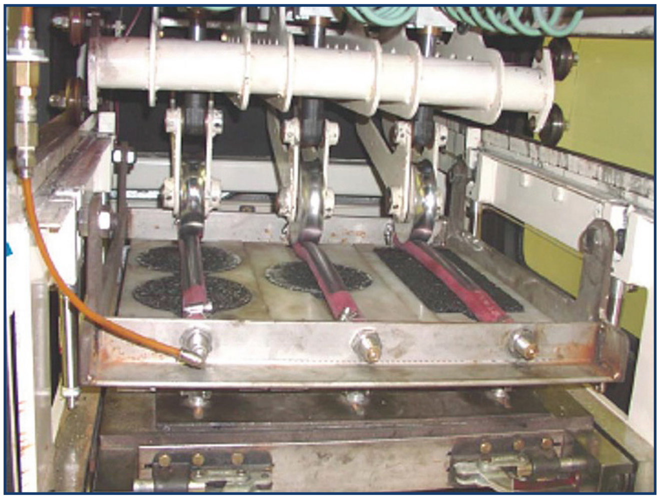

Figure 10. Asphalt pavement analyzer. (Source: Dr. Tom Bennert)

The performance criteria for both NJDOT and TxDOT during mixture design are shown in Table 4.

Cracking performance may be evaluated using the flexural beam fatigue test, the Texas Overlay Tester (Figure 11), or other cracking index tests such as the Indirect Tensile Asphalt Cracking Test.

NJDOT and TxDOT both use the OT for cracking performance evaluation. Laboratory test specimens are prepared using standard procedures outlined in the agency (NJDOT or TxDOT) specifications, including mixing, aging, and compaction. Due to its sensitivity to sample preparation and technician training, NJDOT tests five OT specimens during the mix design process and discards the high and low results to minimize errors.

The average of the middle three samples must reach 600 cycles before failure to meet mix design criteria. TxDOT also specifies OT to evaluate cracking resistance of the mixture and a minimum of 300 cycles to failure.

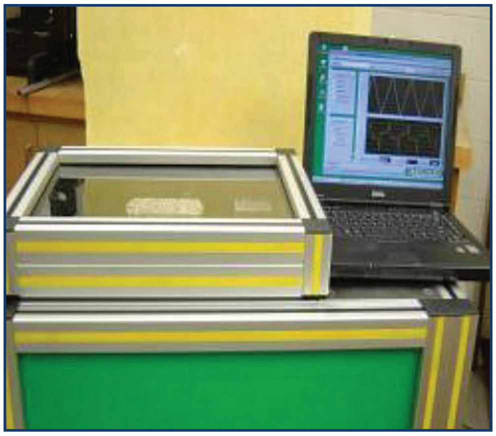

Figure 11. Texas overlay tester. (Source: TxDOT)

TxDOT mix design specifications include a dry tensile strength range of 85 to 200 psi tested according to Tex-248. HMA tensile strength is another indicator of cracking potential.

NJDOT limits drain down of HPTO mixes to 1 percent when tested according to AASHTO T 305.[6] Similarly, TxDOT specifies a maximum drain down of 0.20 percent when tested according to Tex-235. These test procedures evaluate the amount of drain down of an uncompacted asphalt mixture when the sample is held at elevated temperatures comparable to those encountered during production, storage, transport, and placement of the mixture.

CONSTRUCTION SPECIFICATIONS

HPTO construction specifications typically include requirements for materials, production, storage and transportation, surface preparation, placement, and compaction and generally follow the specifications for thin overlay mixtures. Standard quality acceptance and quality control procedures, such as contractor quality control plans, also apply to HPTO construction.

Materials

High-quality aggregates and asphalt binders should be included in the specification's materials section. The aggregate qualities and properties are discussed in the Mixtures and Materials section of this document.

A polymer-modified asphalt binder is important. Non-polymer-modified binders are not likely to pass laboratory performance test criteria. Agencies can use their standard requirements for classification of performance grading of the binder without having to develop special provisions.

Typically, a high-quality tack coat, either emulsion or liquid asphalt, is specified. Specifying the use of non-tracking tack coat material or polymer-modified emulsions can help improve bond strength, which is particularly important in thin lifts. Minimum bond strength can be evaluated using a bond strength tester (shown in Figure 12). Bond strength can also be measured on field cores. Tack application rates can be field verified using absorbent pads or other methods. TxDOT includes tack coat as a pay item in the specifications, and therefore the application is monitored during the quality assurance process. Neither TxDOT nor NJDOT specifies a bond strength requirement.

[6] AASHTO specifications referenced are not required by Federal law or regulations unless they are explicitly incorporated by reference into FHWA regulations.

Allowing warm mix technology may help with placement during colder months and extend the time available for compacting the thin lift.

Production, Storage, and Transportation

General agency requirements for production, storage, and transportation of HMA should apply to HPTO. Production tolerances of approved mix design should be specified for aggregate gradation, asphalt content, and laboratory density. For example, JMF production tolerances for HPTO in NJDOT's specifications are shown in Table 5.

Figure 12. Pull-off bond strength tester. (Source: TxDOT)

Table 5. JMF criteria for HPTO - NJDOT Section 902.08.

Sieve Sizes	Percent Passing[7]	Production Control Tolerances[8]
3/8"	100	±0.0%
No. 4	65-85	±4.0%
No. 8	33-55	±4.0%
No. 16	20-35	±3.0%
No. 30	15-30	±3.0%
No. 50	10-20	±2.0%
No. 100	5-15	±2.0%
No. 200	5.0-8.0	±1.0%
Asphalt Binder Content (Ignition Oven)[9]	7.4% minimum	±0.30%

Due to the use of polymer-modified binders in HPTO mixtures, materials stored for extended periods in silos should be evaluated to ensure the quality is not affected. TxDOT's Item 347 does not allow storing the mixtures for a period long enough to affect the quality of the mixture or beyond 12 hours. NJDOT specifies that the mixture's temperature during discharge at the asphalt plant remain 10 degrees F. higher than the manufacturer's laydown temperature recommendations and below 330 degrees F. The use of trucks with clean beds free of contaminants will also result in a higher quality mixture and is specifically required by TxDOT's Item 347.

7 Aggregate percent passing to be determined based on dry aggregate weight.

8 Production tolerances are for the approved JMF and may not fall outside wideband gradation limits.

9 The asphalt binder content may not be lower than the minimum after the production tolerance is applied.

Surface Preparation

Surface preparation includes spot repairs, milling, crack sealing, or other repairs dictated by existing pavement evaluation. For example, in areas with severe oxidation of asphalt or on roadways with restrictions on raising pavement profiles, NJDOT employs a micro-mill before placing HPTO.

A critical aspect of surface preparation is sweeping and cleaning the surface and correctly applying the tack coat. A high-quality tack coat should be applied with 100 percent coverage at the appropriate residual rate recommended by the manufacturer or based on the agency's experience and specification. An example of a poor application is shown in Figure 13, and a more desired uniform application with adequate coverage is shown in Figure 14.

Additional information on successful tack coat application and practices may be found in an FHWA tech brief on Tack Coat Best Practices (FHWA 2016).

NJDOT specifications require the contractor and resident engineer to perform a joint inspection before placement to ensure the existing conditions of the underlying surface were adequately addressed (NJDOT 2019).

Figure 13. Inadequate tack coat application. (Source: FHWA)

Figure 14. Uniform application of tack coat. (Source: FHWA)

Placement and Compaction

HPTO placement in wet and cold weather conditions should be evaluated for impacts on performance before commencing paving operations. NJDOT specifications enforce strict weather limitations and state that HPTO should not be placed if the National Weather Service forecasts a 50 percent or greater chance of rain. TxDOT requires the roadway surface temperature to be 60 degrees F. or above. However, TxDOT specification Item 347 permits paving on a roadway with a thermal imaging system if the surface is dry and the temperature at least 32 degrees F.

Figure 15. Use of MTV and spray-paver with a hopper insert. (Source: NJDOT)

Based on practices followed by NJDOT and TxDOT, HPTO may be placed using a conventional paver or spray paver (also called an ultra-thin paver). Considering the rapid loss of temperature during the placement of thin application, the specification will benefit from requiring the use of a material transfer vehicle (MTV) for HPTO. The noted results of using an MTV include reducing physical and thermal segregation, providing a smoother pavement by allowing continuous (non-stop) paving, and more uniform compaction of the mat. The onboard storage capacity (surge capacity) approaching 25 tons, plus the 15 tons held in the paver hopper insert, allows the MTV to virtually eliminate gaps between delivery trucks to keep the paving operations moving continuously. The use of an MTV and spray-paver with a hopper insert is shown in Figure 15.

Specifying a paver-mounted thermal profiler (PMTP) for thin applications, such as HPTO, pinpoints areas with thermal segregation and allows the contractor to monitor the temperature across the width of the mat being placed. Using a PMTP may allow the agency to place thresholds on temperature differentials that direct the contractor to take corrective actions to solve the problem.

Using a test strip may provide an opportunity for crews and DOT personnel to understand the behavior of the mixture during production, placement, and compaction in the field. It also provides an opportunity to establish optimal rolling patterns. NJDOT standard specifications Section 902 requires an approved test strip for HPTO, including passing performance testing results, before production can commence.

Compaction on HPTO may be performed with standard double drum vibratory rollers. However, if an aggregate breakdown or asphalt binder bleeding is observed, TxDOT and NJDOT specify compaction to be performed in static mode only. Pneumatic rollers were observed to pick up excessive materials by contractors in both New Jersey and Texas and are not used by either agency. The use of pneumatic rollers on HPTO could be evaluated during test strips along with optimal rolling patterns. Additional information on density is provided in the next section.

Acceptance and Quality Control

Standard acceptance and QC requirements should be included. These requirements may include acceptance of both the materials produced at the plant and of the finished mat. As an example, Table 6 shows the testing specified by TxDOT for TOM-C.

Table 6. Testing responsibilities in TxDOT Item 347.

Test Description	Test Method	Contractor	Engineer	Level[10]
1. Aggregate Testing				
Sampling	Tex-221-F	✓	✓	1A
Dry sieve	Tex-200-F, Part I	✓	✓	1A
Washed sieve	Tex-200-F, Part II	✓	✓	1A
Deleterious material	Tex-217-F, Part I	✓	✓	1A
Decantation	Tex-217-F, Part II	✓	✓	1A
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	2
Crushed face count	Tex-460-A	✓	✓	2
Flat and elongated particles	Tex-280-F	✓	✓	2
Linear shrinkage	Tex-107-E	✓	✓	2
Sand equivalent	Tex-203-F	✓	✓	2
Organic impurities	Tex-408-A	✓	✓	2
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B

[10] Levels 1A, 1B, and 2 are certification levels provided by the HMA Center certification program.

Test Description	Test Method	Contractor	Engineer	Level[8]
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA[11] (calculation only)	Tex-204-F	✓	✓	2
Rice gravity	Tex-227-F	✓	✓	1A
Drain-down	Tex-235-F	✓	✓	1A
Ignition oven correction factors[12]	Tex-236-F	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	2
Overlay test	Tex-248-F	✓	✓	TxDOT
Hamburg Wheel test	Tex-242-F	✓	✓	2
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A
Molding (Texas Gyratory Compactor)	Tex-206-F	✓	✓	1A
Molding (Superpave Gyratory Compactor)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA (calculation only)	Tex-204-F	✓	✓	1A
Rice gravity	Tex-227-F	✓	✓	1A
Gradation & asphalt binder content	Tex-236-F	✓	✓	1A
Drain down	Tex-235-F	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F	✓	✓	1A
Hamburg Wheel Test	Tex-242-F	✓	✓	2
Overlay test	Tex-248-F	✓	✓	TxDOT
Micro-Deval abrasion	Tex-461-A	✓	✓	2
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
5. Placement Testing				
Establish rolling pattern	Tex-207-F	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Footnote[13]
Thermal profile	Tex-244-F	✓	✓	1B
Water flow	Tex-246-F	✓	✓	1B

[11] Voids in mineral aggregates.

[12] Refer to Section 347.4.9.2.3, “Production Testing” for exceptions to using an ignition oven.

[13] The profiler and operator must be certified at the Texas A&M Transportation Institute.

Rutting and cracking performance requirements for HPTO mixtures should be specified using test methods preferred by the agency. The NJDOT criteria and percent pay adjustment for HPTO are shown in Table 7. NJDOT performs APA and overlay tests for every lot, where a lot is generally considered one day of paving.

Table 7. Performance test criteria and percent pay adjustment for HPTO in NJDOT Section 902.08.

Test	Criteria	Test Result	PPA
APA at 8,000 loading cycles, mm (AASHTO T 340)	5.0 maximum	t ≤ 5.0 5.0 < t ≤ 12.0 t > 12.0	0 -50(t-5)/7 -100 or remove and replace
Overlay Tester, cycles (NJDOT B-10)	600 minimum	t ≥ 600 600 > t ≥ 400 t < 400	0 -(600-t)/4 -100 or remove and replace

Measuring the density of very thin layers by extracting cores may not always be possible. Some agencies estimate in-place air voids by requiring surrogate test methods such as permeability tests. Figure 16 shows the Texas water flow test being performed on a finished surface. Alternatively, technologies such as intelligent compaction can help monitor compaction efforts in real-time by providing proof of the required roller coverage established by the test strip.

Figure 16. Texas water flow test. (Source: TxDOT)

For more information, the NJDOT HPTO specification can be found in Section 406 in the Updated NJDOT Standard Specification for Road and Bridge Construction (2007). Significant revisions were made to these specifications in 2018, including Section 902.08 for HPTO. Item 347 of TxDOT asphalt binder. Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges (2014) include TOM-C and TOM-F specifications.

EXAMPLE CONSTRUCTION PRACTICES

The construction practices followed for thin overlay or conventional HMA applications apply to HPTO. Some additional considerations are included in this section. TxDOT and NJDOT stress the importance of educating and training plant personnel and construction crews.

Stockpile Management and Quality Control

Thin applications such as HPTO use a limited number of aggregate stockpiles and bins at the plant. Stockpile management is critical to avoid contamination and segregation. Regular checks made on gradations and moisture can help ensure the quality of the mixture is not being affected.

Mixture Production and Productivity

The use of multiple bins or complete recalibration of cold feed bins should be considered when higher feed rates are needed during HPTO production. On new mixtures, trial batches and tests strips paved in the contractor's yard or another off-project site will provide opportunities to understand the impact of the mixture type on production and productivity.

Due to the number of fine aggregates in HPTO, the overall plant production may be slower as additional time will be needed to remove moisture. Maintaining dry stockpiles can help speed up production and contribute to the efficiency and economics of the plant operation.

Storage and Transportation

Long periods of storage time in silos should be avoided as that may affect mixture quality.

Transportation of the material to the construction site should be done using trucks with clean beds. Beds that are insulated and tarped help reduce temperature loss in the mixture during transport. The use of solvents to clean truck beds should not be allowed as it can contaminate the mixture, resulting in a poor-quality material.

Surface Preparation

Proper surface preparation before HPTO placement is important. Preparation includes repairs such as milling or crack sealing. Excess crack sealant on the existing surface, especially sealant less than a year old and not properly cured, should be addressed prior to overlay to keep it from swelling or migrating up into the finished surface and causing bumps. Removing excess sealant or using warm-mix asphalt to pave at a lower temperature may be considered to reduce crack sealant bumps. Any unaddressed or outstanding repairs not required in the contract that might affect the overall quality of construction must be brought to the agency's attention in advance to give adequate time for resolution.

Inadequate HPTO bonding with the existing surface will lead to rapid overlay deterioration. Therefore, consider applying a quality tack coat with 100 percent coverage at the proper application rate on a clean surface.

Test Strip

Specifying on-site test strips can help the construction team understand the mixture during production, placement, and compaction on the existing project surface. The test strip will help establish plant production balance, establish rolling patterns, ensure adequate density, and help identify any issues in the construction process that might need to be addressed before full-scale production begins.

Placement and Compaction

Typically, density may be achieved using static rolling. However, local NJDOT and TxDOT contractors have reported that some mixes need a vibratory pass or two to achieve density. If vibratory passes are necessary, they should be made during the initial breakdown rolling and evaluated along with mix behavior using a test strip. Using dual steel wheel rollers (Figure 17) in tandem following closely behind the paver

Figure 17. HPTO compaction. (Source: NCAT)

can help ensure proper compaction. NJDOT allows the use of warm-mix asphalt as a compaction aid to help with both placement and compaction.

Tools for Quality Construction

Intelligent Construction Technologies

Intelligent construction technologies, such as intelligent compaction and PMTP, are a combination of modern science and innovative construction technologies. They allow contractors to measure real-time temperature and compaction operations during paving, track progress visually, record measured data and machine settings digitally, and report everything from the field using technically advanced equipment.

Balanced Paving Applications

Contractors should ensure proper trucking and compaction efforts are available to balance paving operations. Thin-lift paver speed may be faster compared to conventional, thicker asphalt lifts. Also, compaction efforts may differ from conventional thicker lifts due to shorter compaction windows. Several free tools can help balance paving operations. These tools consider plant production, number and capacity of trucks, haul times, paver speed, roller parameters, and other variables.

TROUBLESHOOTING

The following sections include some known potential issues with HPTO (and thin lift pavements in general) and troubleshooting information.

Blistering

Crews have seen blistering in NJDOT projects caused by trapped water vapor (Figure 18).

Water can occasionally get trapped beneath the impervious HPTO and previous surface layer. Blistering then occurs post-construction when the warming daytime temperatures convert the entrapped water into vapor. These blisters are more prevalent in lower elevations, milled areas of questionable quality (scabbing), and when HPTO is placed outside optimal paving temperatures or after a rain event. Some other causes include trapped moisture in porous HMA, contamination of paving equipment and haul trucks, insufficient sweeping on the surface, and moisture from improperly cured emulsified tack coat or tack coat applied too soon after a rain event.

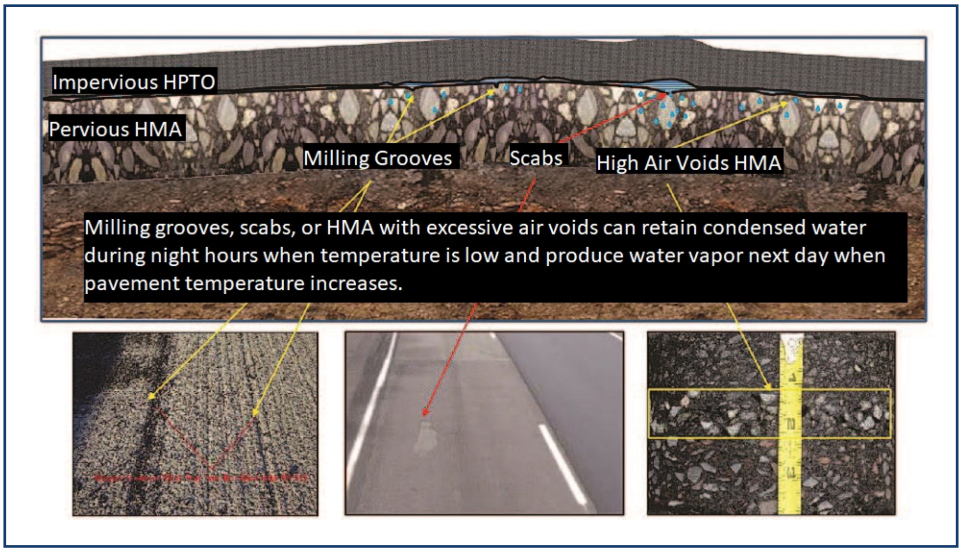

Figure 18. Blistering illustration. (Source: NJDOT)

Further investigation by NJDOT revealed that most areas with blistering had a higher dust content in the mixture, which reduced the permeability and prevented the escape of moisture (vapor). Quality control test results showed over-compaction in these areas, which further reduced permeability and led to blistering. Figure 19 compares typical NJDOT mixture permeability values with the lowest permeability measured on HPTO.

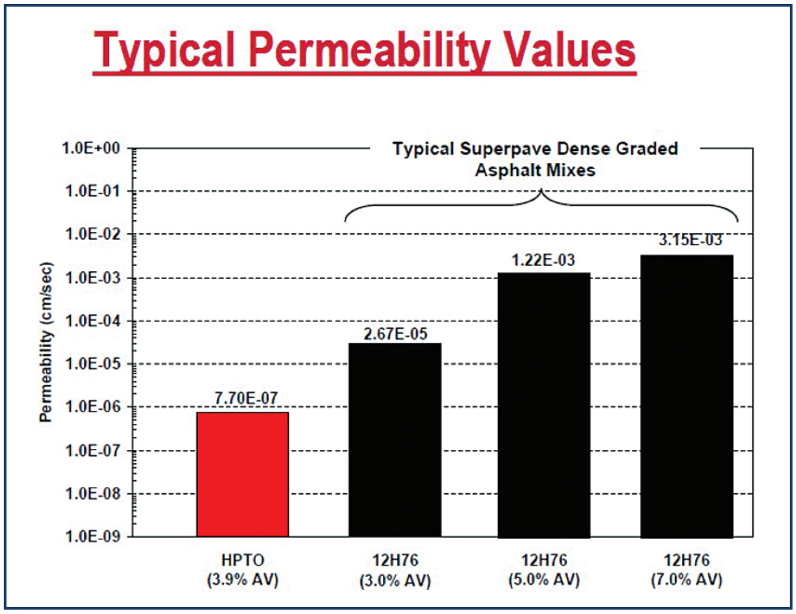

Figure 19. Typical NJDOT mixture permeability values. (Source: Dr. Tom Bennert)

NJDOT suggestions to reduce the potential for blistering include improved quality control procedures during milling, production, and placement. Successful practices include proper sweeping, cleaning, and drying of pavement, and ensuring the tack coat material breaks and cures before the overlay process begins. NJDOT is considering the implementation of intelligent compaction to monitor compaction efforts in real-time and document construction quality. Mix design changes that increase permeability without compromising beneficial HPTO characteristics may be considered in future NJDOT research efforts.

Low Initial Skid Resistance

With the high asphalt content and a relatively thicker asphalt film coating the aggregate, a newly constructed HPTO surface may have a lower initial skid resistance until subject to surface wear due to traffic. In such cases, a light application of sand on the newly placed surface to improve initial skid numbers may be a solution (Blight 2018). The application rate, gradation, and other quality aspects of the sand must be evaluated based on available sources and the agency's local experience. When necessary, NJDOT uses a spread rate of approximately 0.5 pounds per square yard of sand that meets the requirements for fine aggregate in Section 901.07.02 of NJDOT's standard specifications.

SUMMARY

This document considers HPTO and TOM-C as high-performance thin overlays. It focuses on the distinguishing aspects of project development, material selection, mixture design, production, and construction best practices for HPTO compared to conventional thin overlays. HPTO can be placed as a pavement preservation application, typically 1-inch thick, using a high-quality 3/8-inch NMAS aggregate and a polymer-modified asphalt to provide high resistance to rutting and cracking. HPTO may be considered a cost-effective tool used on State highway systems with high traffic volumes as a long-term pavement preservation strategy and can also help improve ride quality. NJDOT and TxDOT's experiences show that the key to successful performance includes selecting the proper treatment at the right location, using high-quality materials in construction, incorporating performance requirements in the specification, and following successful construction practices for conventional thin overlays. A well-bonded, properly constructed HPTO placed at the right time can result in extended pavement life.

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TOPS

Targeted Overlay Pavement Solutions

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