TOPS

Targeted Overlay Pavement Solutions

Crack Attenuating Mixture

March 2022

U.S. Department of Transportation

Federal Highway Administration

Every Day Counts

Innovation for a Nation on the Move

NOTICE

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16. Abstract: Crack attenuating mixture (CAM) is a reflective crack mitigating interlayer. CAMs generally have a high asphalt content and use modified binders and fine-graded high-quality virgin aggregates. CAMs are performance-tested for crack mitigation and rut resistance and are placed as an interlayer in thin lifts (typically around an inch). Originally designed as a reflective cracking mitigation strategy for jointed plain concrete pavement (JPCP) rehabilitation, CAM interlayers can also be used for crack mitigation on asphalt and continuously reinforced concrete pavement (CRCP) surfaces. The Texas Department of Transportation (TxDOT) has used CAM since the early 2000s to reduce reflective crack mitigation. This report is a case study of TxDOT's experience and includes historical background, construction considerations, and performance of CAM products.

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CRACK ATTENUATING MIXTURE

This document is one of five case studies highlighting FHWA's Every Day Counts initiative known as Targeted Overlay Pavement Solutions (TOPS). The purpose of TOPS is to integrate innovative overlay procedures into practices to improve performance, lessen traffic impacts, and reduce the cost of pavement ownership.

Overview

Reflective cracking can be a concern for rehabilitation projects. Blankenship (2019) found that cracks typically migrate approximately one inch per year through conventional overlays. According to Blankenship's research, properly designed crack attenuating mixture (CAM) interlayers may reduce the number of reflective cracks and slow the rate of reflective cracking by up to 50 percent.

The concept of CAM interlayers was initially developed as a reflective cracking mitigation strategy for Jointed Reinforced Concrete Pavement rehabilitation. However, according to Texas Department of Transportation (TxDOT) Transportation Engineer Beata Kwater, Houston District, TxDOT has used these mixes successfully on Continuously Reinforced Concrete Pavement (CRCP) and asphalt surfaces where crack mitigation is desired.

Research

The Houston District's first overlay project with a CAM interlayer was in 2014 on a stretch of Interstate 69 (Figure 1). The 2014 design's annual average daily traffic was 300,000 vehicles per day. With the cracks spaced approximately 10 to 20 feet on the original CRCP, the Houston District worked with the Texas A&M Transportation Institute to design a CAM interlayer with athin overlay mix surface course. A seal coat layer was placed over the existing pavement to seal the surface before placing the CAM interlayer.

Figure 1. Construction of the Interstate 69 overlay system.
Source: Tom Scullion, Texas A&M Transportation Institute.

"The Houston District has several hundred lane miles of continuously reinforced concrete pavements at or near the end of their designed service life with varying levels of surface distress. Many of these old pavements are heavily trafficked and unsuitable for reconstruction due to lane closures and high costs. These are good candidates for CAM interlayers."

—TxDOT Transportation Engineer Beata Kwater, Houston District

Characteristics

According to Kwater, the CAM overlay system has performed well on Interstate 69. Today, the Houston District calls CAM interlayers TOM-F or TOM-Fine. Tom-F and CAM were developed in different TxDOT Districts around the same time during the early 2000s. Since they have similar characteristics, the two mixes were eventually integrated by TxDOT.

According to TxDOT, CAM interlayers include the following characteristics:

- High asphalt content using modified binder (typically around 7 percent).
- Quality virgin aggregate (no reclaimed products).
- Fine gradations (typical nominal maximum aggregate size of No. 4 to 3/8-inch sieve).
- Applied in thin 0.5- to 1-inch lifts. CAM is the new go-to solution for the Houston District when reflective cracking is a concern.
- Placed as an interlayer in an overlay system.
- Mixture performance tested for crack propagation and rut resistance. TxDOT uses the Hamburg Wheel Tracking Test to evaluate rutting resistance and moisture susceptibility. Reflective cracking resistance is evaluated using the Overlay Tester (OT).

Construction Considerations

According to Kwater, there are limitations to what CAM and other thin lifts can fix, and project-specific pre-overlay repairs should be considered when using CAM overlay systems. The Houston District recommends repairing cracks wider than ¼ inch and making full-depth repairs on distresses that extend through the pavement's depth, including transverse cracks, shattered slabs, and corner breaks. Good bonding to the existing surface is critical for thin lift asphalt applications. The Houston District specifies a seal coat to enhance bonding and sealing using an asphalt-rubber binder and a thin layer of aggregate.

TxDOT Houston District's current construction notes include the following construction best practices for thin lifts like CAM (Wilson et al. 2015):

- Place mixtures only when the air temperature is above 70 degrees F.
- Use Warm Mix Asphalt (WMA) when the plant to job haul distance exceeds 40 miles. When WMA is required, no reduction in temperature will be permitted (the WMA is a compaction aide).
- Use two steel wheel rollers working in tandem for breakdown rolling. Keep the rollers as close as possible to the lay-down machine. Do not use pneumatic tire rollers.
- Provide and use a paver-mounted thermal profiling system or thermal camera system.
- Establish a rolling pattern using the results from water flow measurements per test method 246.

Performance

TxDOT has found that CAM interlayer performance depends on selecting an appropriate surface mix to complement the CAM. According to TxDOT, dense-graded mixes do not perform well with CAM, and it is common for cracks to skip the CAM interlayer and appear on the surface of the stiff surface mix. The Houston District prefers a 1-inch TOM-coarse (TOM-C) surface with a TOM-F CAM interlayer. The TOM-C is a more coarse, open-graded mixture with a lower minimum asphalt content but with skid and rut-resistant properties. TxDOT also tests TOM-C mixes for reflective crack resistance using the OT. However, TxDOT's mix design specification for TOM-C requires only 300 cycles to failure, compared to 500 to 750 cycles for CAM layers.

CAM is the new go-to solution for the Houston District when reflective cracking is a concern.

INTRODUCTION

Reflective cracking is a concern for many rehabilitation projects. Generally, it is said that cracks migrate upwards approximately one inch per year through conventional overlays (Blankenship 2019). Properly designed crack attenuating interlayers can reduce the number of reflective cracks and slow the rate of reflective cracking up to 50 percent (Blankenship 2019). FHWA refers to these products as crack attenuating mixtures or CAMs.

HISTORICAL BACKGROUND

The development of CAM at TxDOT dates to the early 2000s. Reflective cracking was an increasing problem, particularly with the rehabilitation of aging Jointed Plain Concrete Pavements (JPCP). The rehabilitation of JPCP was problematic for many TxDOT Districts because many JPCPs in the State had exceeded their design life. The need for statewide guidelines for rehabilitating JPCP is summarized in a research problem statement (Scullion and Von-Holdt 2004):

> *Reflective cracking continues to be a major problem in the rehabilitation of JPCP…The proposed investigation will focus on why a particular approach (for mitigating reflective cracking) worked well, and others did not…This project will include studies of past pilot projects using reflective cracking construction techniques and evaluations of similar types of treatments in different areas of the State. The objective is to develop statewide methods for rehabilitating JPCP to avoid joint reflective cracking.*

This 2004 research project, titled *Performance Report on JPCP Repair Strategies in Texas*, evaluated several JPCP rehabilitation approaches. One of the approaches was a proprietary CAM-like product designed for use on structurally sound JPCPs with doweled joints in good condition (Bischoff 2007). TxDOT evaluated the product and reported it had excellent reflective cracking mitigation properties based on laboratory and field results (Scullion and Von Holdt 2004).

However, the highly flexible mix had poor rut-resisting properties, according to laboratory results. According to the report, poor rut resistance may not have been a problem if placed underneath a 3- to 4-inch HMA surface lift. However, many TxDOT Districts had an urgent need for an overlay solution with a maximum total overlay thickness of 3 inches (including the CAM interlayer). Additionally, staged construction often involves opening intermediate lifts to traffic before the surface lift is placed. Rutting concerns during staged construction were exacerbated by hot Texas weather. Therefore, the idea to develop a similar mix with superior rut performance was conceived.

The concept for CAM interlayers was initially developed as a reflective cracking mitigation solution for JPCP rehabilitation. However, TxDOT has used these mixes successfully on Continuously Reinforced Concrete Pavement (CRCP) and asphalt surfaces where crack mitigation is desired. The following case study describes TxDOT use of a CAM interlayer on CRCP. CAM - Bryan District Efforts

The first TxDOT CAM specification was developed as a one-time-use Special Specification for Ultra-Thin Overlays (SS1309) in the Bryan District. TxDOT worked with the Texas A&M Transportation Institute (TTI) to develop the CAM specification. The specification included several innovative features:

- The optimum asphalt content was selected based on volumetric principles to provide 98 percent maximum theoretical density with 50 gyrations in the Superpave Gyratory Compactor.
- The mix was performance-tested for resistance to rutting and cracking using the Hamburg Wheel Tracking Test (HWTT) and OT.
- The asphalt and aggregate mix components were paid separately, allowing Districts to vary the amount of binder required without the need for change orders or redesigns.
- The aggregate quality requirements were enhanced consistent with TxDOT's performance mixes as compared to conventional mixes.
- No reclaimed asphalt pavement or river sand was permitted.
- Stringent requirements were placed on the temperature at placement.
- Only polymer-modified binders were allowed (typically a PG 76-22).

CAM was originally being developed as a surface layer. Performance and experience have proven that CAM is more successful as a crack mitigating interlayer in an overlay system (Scullion 2021). However, a CAM interlayer should be paired with the right surface mix to optimize benefits (Bennert 2015).

TOM – Austin District Efforts

Around the same time the CAM specification was being developed in Bryan, another TxDOT District needed a solution for its growing surplus of high-quality aggregate screenings. A local supplier in the Austin District had a large stockpile of leftover Surface Aggregate Classification (SAC) A sand. The larger size aggregate particles had been scalped and sold as SAC A coarse aggregate. SAC is used by TxDOT to classify aggregate quality. Aggregate can be classified as SAC A, B, or C. Frictional and durability indicators such as polish value, soundness, acid insolubility, and Micro Deval tests are used to classify the aggregates. SAC A has the highest frictional and durability properties. Therefore, the surplus stockpile of SAC A screenings came from high-quality rock, so TxDOT considered finding a use for it to be a worthwhile endeavor. With a fine gradation, it made sense to use in a Thin Overlay Mix (TOM). The result was the first edition of a TxDOT TOM.

TxDOT has another TOM product, known as TOM-C, or TOM-Coarse. As the naming convention suggests, TOM-C is coarser than TOM-F and is primarily used as a surface lift. TxDOT Districts prefer the coarser texture of TOM-C for a surface course on heavily trafficked roads. TOM-C works well with crack attenuating interlayers like TOM-F or CAM. Selecting the right surface mix to top a crack attenuating mix is critical to the success of the overlay system.

From CAM to TOM

TTI was integral in developing both the Bryan District CAM specification and the Austin District TOM specification. These specifications were being developed as the benefits of performance testing were becoming prevalent in the industry. Both mixes were being evaluated for rutting and cracking resistance and used similar materials. These factors contributed to the development of CAM and TOM in separate Texas Districts.

Houston District Case Study

The Houston District has found success using CAM interlayers. In TxDOT's experience, the performance and benefit of CAM interlayers are dependent on the entire overlay system and the preparation of the existing surface. This means the CAM interlayer cannot be evaluated without looking at the entire overlay system. Therefore, the characteristics of each overlay component and the pre-overlay repairs are described below.

Project Background

A project completed in 2014 on Interstate 69 (IH-69) (formerly US-59) was the first project to use CAM as an interlayer in the Houston District. At that time, the Houston District called the lift CAM, but uses TOM-F terminology today. The existing roadway surface was the original CRCP placed in the 1960s, and it was severely cracked and spalled. This stretch of IH-69 is heavily trafficked. In 2012, the design annual average daily traffic was 300,000 vehicles per day (Kwater 2021). The Houston District needed an overlay solution to hold up to the heavy traffic and allow the original concrete to remain in place.

"Reconstruction was not an option," said Kwater. "It would have been too expensive, and the traffic disruptions would have been a nightmare."

CAM is not unique to TxDOT as NJDOT has a similar product called BRIC

The New Jersey DOT (NJDOT) has a CAM-like product called the binder-rich intermediate course (BRIC). There are many similarities between TxDOT and NJDOT specifications. Notable differences include a finer master gradation band and higher minimum asphalt content of 7.4 percent (NJDOT 2018). The same performance testing theory applies, and the mix is evaluated for resistance to rutting and reflective cracking. However, NJDOT prefers the asphalt pavement analyzer (APA) for rut resistance testing. The APA is another wheel tracking device that works similarly to the HWTT. A significant difference is the loading mechanism since the APA uses a pressurized tube between the sample surface and wheel.

However, the District needed to reduce the maintenance costs of repairing the deteriorated CRCP surface and protect the original concrete from further deterioration. The Houston District worked with TTI to develop an overlay solution to prevent crack migration. The resulting overlay design included sealing the existing surface with an asphalt-rubber seal coat, followed by a 1-inch CAM interlayer, and finished with a 1-inch TOM-C surface course.

Pre-overlay repairs

The first critical step in the rehabilitation process was to repair significant distresses. The existing surface of the original CRCP concrete was severely cracked and spalled. “There were transverse cracks every 10 to 20 feet,” said Kwater.

Figure 2. Punchouts require FDR.
Source: TxDOT Pavement Manual 2021

Severe cracks and other distresses need to be repaired before implementing a CAM overlay. According to the TxDOT Pavement Manual (TxDOT 2021), CRCP distresses that involve full-depth repair (FDR) before rehabilitation include punchouts (Figure 2) and deep spalling (Figure 3).

FDR procedures include identifying the repair limits, saw-cutting the perimeters, removing the concrete slab, removing the damaged base (if needed), drilling holes for longitudinal and transverse tie bars or dowel bars, providing longitudinal and transverse steel continuity of tie bars, and placing and finishing concrete.

Figure 3. Deep spalling is typically rehabilitated using FDR.
Source: TxDOT Pavement Manual 2021

Figure 4. Existing surface repairs were made before rehabilitation. Source: Tom Scullion, TTI

According to TxDOT, repairing the surface was tedious but more feasible than reconstruction. Satellite imagery from before 2014 (Figure 4) shows the condition of the concrete surface and examples of partial repairs of spalling and cracking (smaller and darker concrete repairs) and FDR patches (lighter colored patches) (Scullion 2021).

Overlay System

The overlay system includes three components including a bonding mechanism (for example, seal coat), an interlayer (CAM), and a surface course (TOM-C). Each component contributes to the success of the CAM interlayer.

Bonding Mechanism

Bonding is the number one issue in thin overlay construction for TxDOT (TxDOT 2014). According to an FHWA Technical Brief (FHWA 2016), 60 to 75 percent loss of life could be expected if a pavement displayed no bonding within its layers. This report states that even a bond loss of 10 percent could reduce fatigue life by 50 percent. If adequate bond strength is not achieved in an overlay system, the benefits of the overlay system are significantly reduced. Therefore, emphasis is placed on the bonding mechanism under the CAM interlayer.

The 2014 IH-69 project specified a seal coat according to TxDOT Item 316, which describes the seal coat as a single layer of asphalt-rubber binder with a single layer of aggregate. The seal coat layer promotes bonding and waterproofing (TxDOT 2014). The seal coat also served as a crack sealant for the existing surface on cracks up to ¼ inch wide (Kwater 2021) and reduced repair efforts.

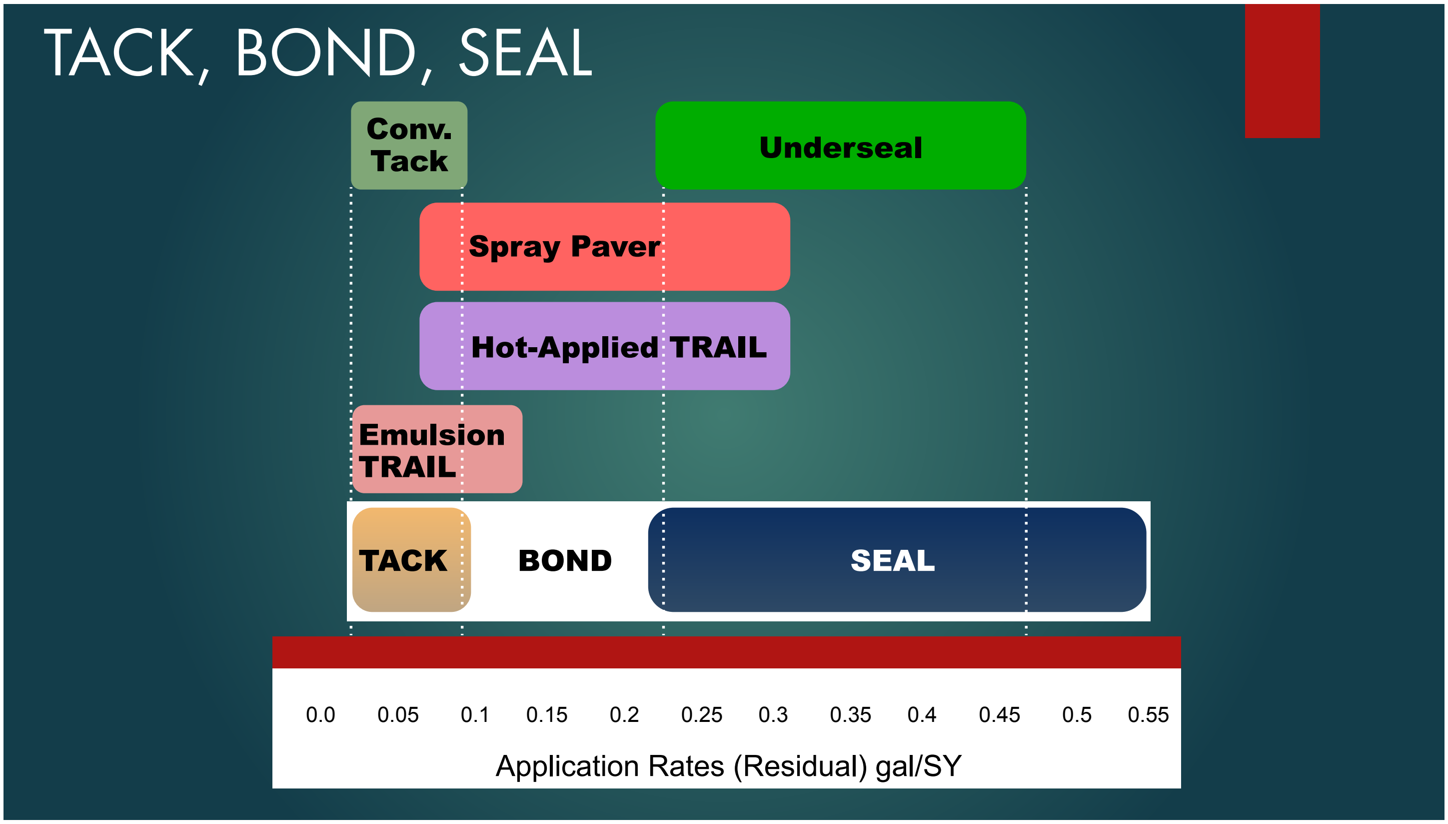

Figure 5. TxDOT guidance for interlayer bonding application rates. Source: Hilbrich n.d.

Today, the Houston District specifies a bonding course (SS3084) or underseal course (SS3085) instead of a seal coat. These courses are typically specified on the existing pavement before overlays, while tack is still used for new construction (TxDOT 2019). According to TxDOT specifications, these courses use a tracking-resistant asphalt interlayer (TRAIL) or spray-applied underseal membrane. The significant difference between the bonding and underseal courses is using an aggregate surface on the underseal. Districts that need assistance with selection of bonding layers can refer to the TxDOT Interlayer Material Guide (TxDOT 2019). The bonding course is used to improve bonding between the layers as compared to conventional tack products. The underseal provides additional sealing of the underlying surface if needed. Depending on the application equipment, temperatures, and rates, some bonding and sealing results overlap among these products. This information is illustrated in Figure 5 and shown in Table 1. Research (Senadheera and Vignarajh 2007) shows that underseals may provide some crack attenuating properties, similar to a stress-absorbing membrane interlayer. These interlayers can also be used as crack attenuating products. However, TxDOT does not characterize the underseal course as such in its 2019 guidance document.

Table 1. Interlayer bonding guidance for Texas districts Source: TxDOT 2019.[1]

Category	Tack (TxDOT 2014 Standard Specification)[2]	Bonding Course (TxDOT Special Specification 3084)	Underseal Course (TxDOT Special Specification 3085)
Intended Use	• New Construction. • Rehabilitation with Multiple Lifts. • Overlaying New HMA Layers. • Existing Pavement Is in Good Condition. • Patching and Level-Up.	• Where Improved Bonding Is Needed. • Existing Pavement Is in Good Condition. • Thin Lifts (Typically Less Than 2”). • Milled Surfaces with Very Minimal to No Visible Cracking.	• Where Sealing of Underlying Surface Is Needed. • PFC Overlays. • Notch and Widen Projects. • Moderate to Severe Cracking. • Milled Surfaces with Visible Cracking.
Materials	• Emulsions (e.g., CSS-1H, SS-1H) Applied to Minimize Tracking. • PG (Minimum High-Temp Grade of PG58). • Tracking-Resistant Asphalt Interlayers (TRAIL); MPL Approved; Use Designated as “Tack” and Is Typically Emulsion.	• Spray Paver (Low Application Rate). • Tracking-Resistant Asphalt Interlayer (TRAIL); MPL Approved; Use Designated as “Tack” and Is Emulsion or Hot-Applied.	• Seal Coat Binders and Aggregate (Item 316). • Spray Paver (High Application Rate). • Tracking-Resistant Asphalt Interlayer (TRAIL); MPL Approved; Use Designated as “Seal” and Is Hot-Applied.
Residual Rates[3] (gal. per square yard)	0.04 to 0.10 (gal. per square yard): • Use Manufacturer’s Recommendations for TRAIL Application Rates.	0.04 to 0.14 (gal. per square yard): • Unless Specification Item has Different Rate (e.g., Item 348 (for Spray Paver). • Use Manufacturer’s Recommendation for TRAIL Application Rates	0.12 to 0.35 gal. per square yard: • Rate for Seal Coat Is Based on Embedment of Aggregate Grade (Size), and Existing Surface Conditions. Ensure Proper Rock Application of “Salt and Pepper” Appearance. • Per Item 348 (Spray Paver) and Adjust for Existing Surface Conditions. • Use Manufacturer’s Recommendation for TRAIL Application Rates.
Typical Application Rates[4] (gal. per square yard)	The Engineer Will Set the Rate: • Use Manufacturer’s Recommendations for TRAIL Shot Rates. • Adjust for Existing Surface Conditions.	Typical Application Rates (gal. per square yard): • 0.10 to 0.22 for Spray Paver. • 0.06 to 0.14 for TRAIL – MPL Listed as “Tack” (Emulsion TRAIL) • 0.08 to 0.12 for TRAIL – MPL Listed as “Tack” (Hot-Applied TRAIL). • Adjust for Existing Surface Conditions.	Typical Application Rates (gal. per square yard): • 0.30 to 0.45 for Seal Coat (Emulsion). • 0.20 to 0.35 for Seal Coat (AC). • 0.22 to 0.40 for Spray Paver. • 0.12 to 0.20 for TRAIL – MPL Listed as “Seal” (Hot-Applied TRAIL). • Adjust for Existing Surface Conditions.
Payment ($)[5]	Pay Item[6]	Pay Item	Pay Item
Bond Strength (psi)[7] For Information Only	40 min.	50 min.	50 min.

Note 1 The information provided in this document is intended for guidance and the application rate will need to be adjusted for existing surface conditions. The District will determine the appropriate application rate. It is recommended to seek guidance from the manufacturer prior to determining the application rate used for the project.

Note 2 Items 341 and 344 in the 2014 Standard Specifications are replaced with Special Specifications 3078, 3079, 3080, 3081, and 3082.

Note 3 The residual asphalt is defined as the remaining asphalt binder after the emulsion cures.

Note 4 The application rate is defined as the actual shot rate used to apply the asphalt binder to the existing surface.

Note 5 Emulsion is paid by the gallon of emulsion used on the project, not by the asphalt binder residual rate.

Note 6 Special Provisions to Items 340, 341, 342, 344, 346, and 347 have tack coat as a pay item beginning with the October 2019 letting.

Note 7 Measured in accordance with Tex-249-F, “Shear Bond Strength Test.”

TxDOT pays for tack, bonding course, and underseal course as individual pay items. TxDOT's bonding layer quality assurance procedures require a test strip and Shear Bond Strength Tests, according to Tex-249-F (Figure 6). This test determines the shear strength between two bonded layers, typically 6-inch field cores. This test uses a device with one fixed sleeve and one sliding sleeve. The sleeves are placed on either side of the bonding layer. A vertical force on the sliding sleeve evaluates the shear strength of the bond.

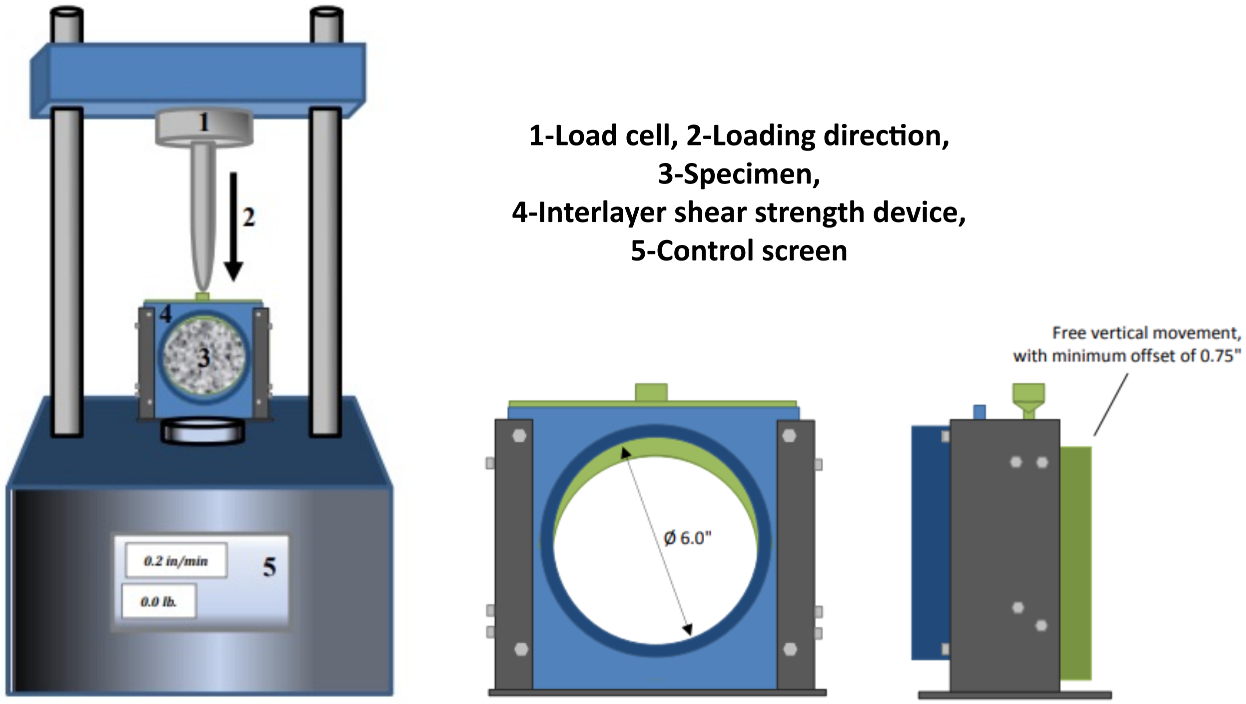

Figure 6. Shear Bond Strength Test. Source: TxDOT 2019

CAM Interlayer

The CAM interlayer used on IH-69 was designed according to TxDOT SS3000. Today, the Houston District uses TOM-F as the CAM interlayer. The specifications are similar, but not identical. Figure 7 compares the CAM SS3000 specification master gradation band against the TOM-F master gradation band (specification Item 347). The TOM-C gradation band, often used as a surface layer on CAM or TOM-F interlayers, is also shown in Figure 7.

CAM and TOM-F gradations have identical lower limits. The upper limits vary slightly, where the TOM-F runs finer. Additional mix properties are compared in Table 2. One notable difference between CAM and TOM-F is the minimum required asphalt content of 7 percent and 6.5 percent, respectively. Laboratory minimum voids in the mineral aggregate (VMA) requirements for CAM are 17 percent compared to TOM-F's requirement of 16.5 percent.

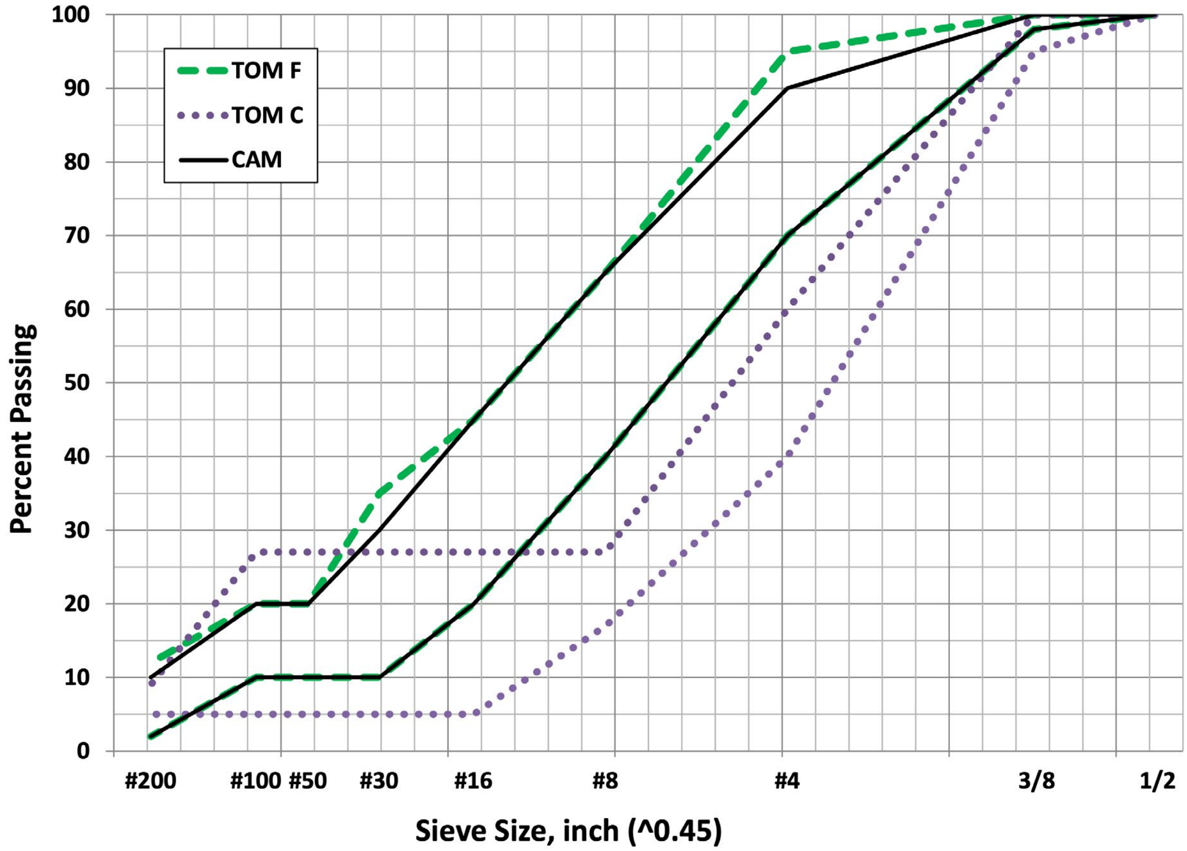

Figure 7. CAM and TOM master gradation bands. Source: TxDOT S347, SS300

Table 2. CAM and TOM design properties for TxDOT.

Test Property	Test Method	CAM Requirement	TOM-F Requirement	TOM-C Requirement
Minimum Binder Content, percent	N/A	7.0	6.5[1]	6.0[1]
Design VMA, percent	N/A	17.0	16.5	16.0
Plant Produced VMA, percent	N/A	16.5	16.0	15.5
Design Gyrations	Tex-241-F	50[2]	50[3,4]	50[3,4]
Target Laboratory Molded Density, percent	Tex-207-F	98.0	97.55	97.5[5]
Tensile Strength, dry, psi	Tex-226-F	85-200[6]	85-200	85-200
Dust/Asphalt Ratio[7]	N/A	1.4 Max	N/A	N/A
Boil Test[8]	Tex-530-C	N/A	N/A	N/A
Drain-down, percent	Tex-235-F	N/A	0.20 Max	0.20 Max

[1] Unless shown otherwise on the plans or approved by the engineer.
[2] May be adjusted within a range of 50-100 gyrations when shown on the plans or allowed by the engineer.
[3] May be adjusted within a range of 35-100 gyrations when shown on the plans or allowed by the engineer.
[4] Texas Gyratory Compactor, TEX-207-F.
[5] Unless shown otherwise on the plans or approved by the engineer.
[6] May exceed 200 psi when approved and may be waived when approved.
[7] Defined as % passing #200 sieve divided by the asphalt content.
[8] Used to establish baseline for comparison to production results. May be waived when approved.

Performance Testing

TxDOT laboratory mixture performance test requirements distinguish CAM interlayers from other asphalt mixes. TxDOT uses the HWTT to evaluate rutting performance and moisture susceptibility, and the OT evaluates resistance to reflective cracking.

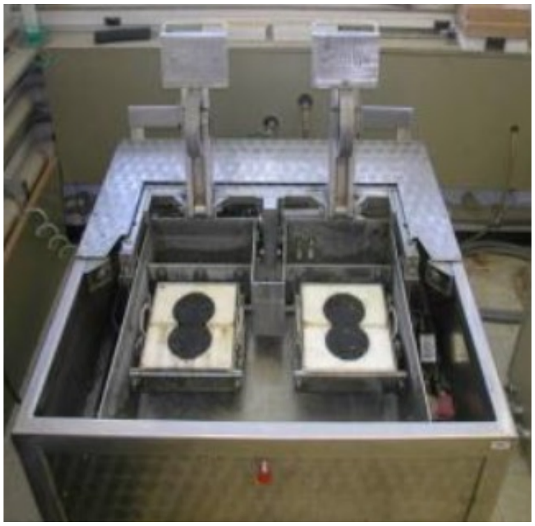

Figure 8. HWTT apparatus and specimens. Source: TxDOT 2014

Hamburg Wheel Tracking Test

TxDOT uses the HWTT to evaluate rut resistance according to the procedures outlined in Tex-242. This test method determines the premature failure susceptibility of asphalt mixtures due to weak aggregate structure, inadequate binder stiffness, moisture damage, and other factors, including inadequate adhesion between the asphalt binder and aggregate (TxDOT 2019). The HWTT apparatus is an electronically powered temperature-controlled device with an 8-inch diameter, 1.85-inch-thick steel wheel that makes repeated passes over the surface of the 6-inch gyratory or core specimens (Figure 8). The wheel applies a load of 158±5 pounds and makes 52 passes (plus or minus 2) per minute at a speed of approximately 1 foot per second. TxDOT performs the test in a water bath of 77 to 158 degrees F. Tex-242 runs the test at 122 degrees F. TOM and CAM samples after HWTT are shown in Figure 9.

Figure 9. TOM and CAM samples after HWTT. Source: Tom Scullion, TTI

Overlay Tester

TxDOT uses the OT according to Tex-248 to evaluate the susceptibility of asphalt mixtures to fatigue cracking or reflective cracking (TxDOT 2019). The device is an electro-hydraulic system that applies repeated direct tension loads to specimens. The apparatus features two blocks – one is fixed, and the other slides horizontally (Figure 10). The sliding block applies a tension force (in a cyclic triangular waveform to a constant maximum displacement of 0.025 inches). One load cycle takes 10 seconds. Sample preparation for the OT includes saw cutting 6-inch gyratory specimens, or cores, to extract only the innermost middle portion (Figure 11). This specimen gets epoxied to the fixed and sliding blocks. Placing a 10-pound weight on the blocks (Figure 12) promotes a good bond while the epoxy cures, which generally takes 8 hours.

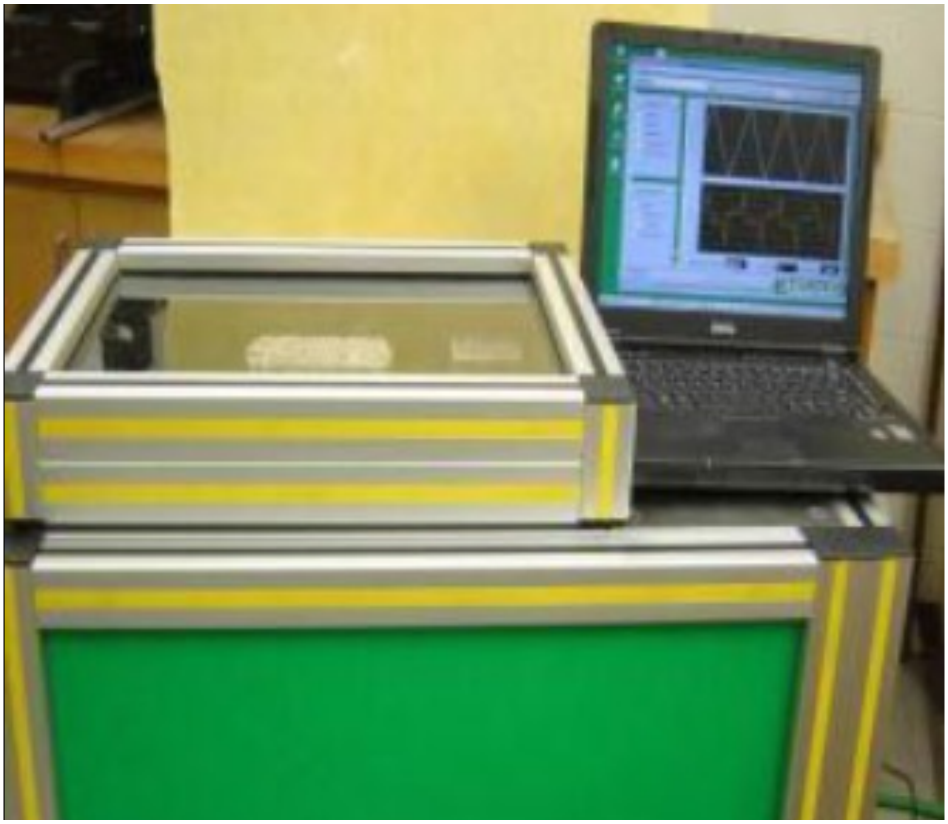

Figure 10. Overlay Tester. Source: TxDOT 2014

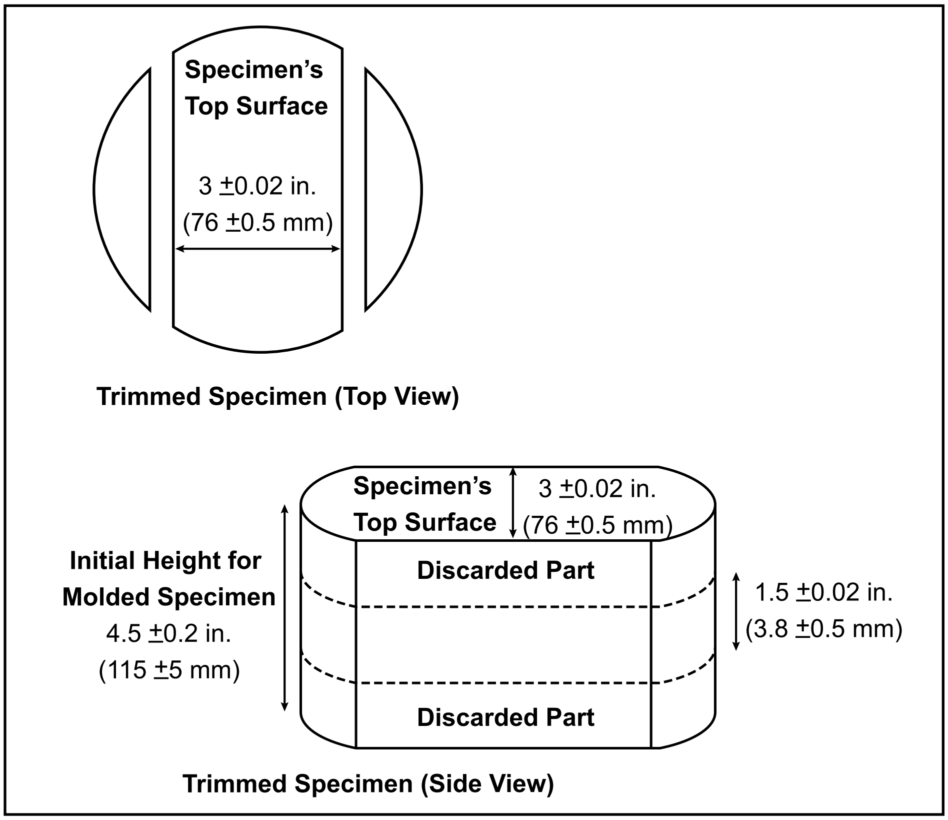

Figure 11. Using the middle portion of a 6-inch gyratory sample or core. Source: TxDOT 2017

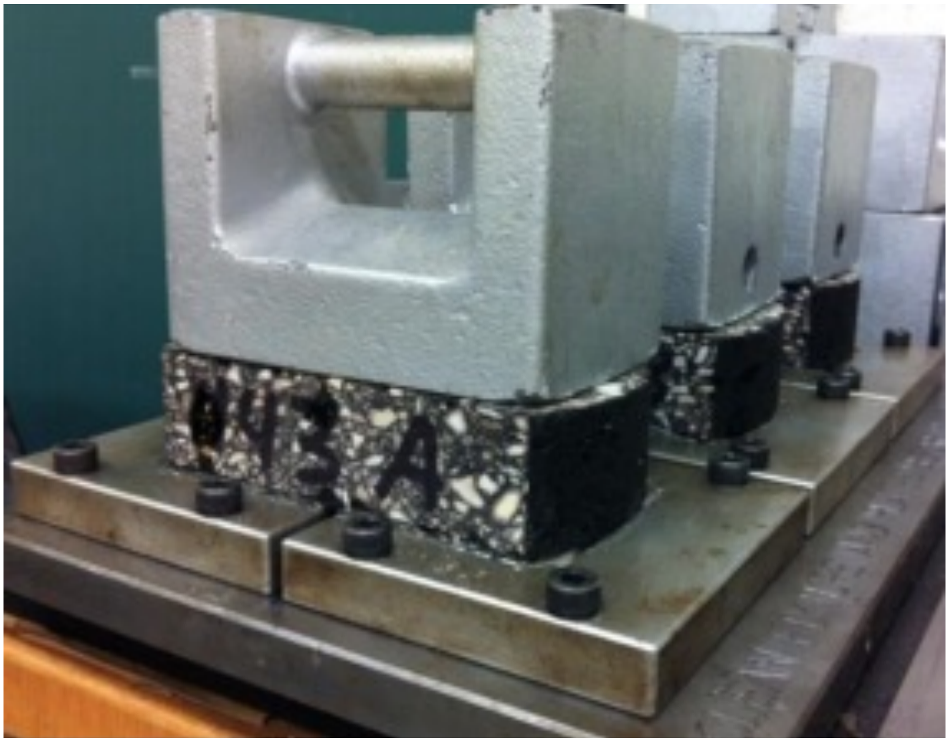

Figure 12. Weighted specimens after being epoxied to blocks. Source: TxDOT 2017

SS3300 CAM HWTT and OT criteria are summarized in Table 3. The specifications allow the thresholds to be decreased when shown on plans or as directed by the Project Engineer.

Table 3. HWTT and OT criteria for CAM according to TxDOT SS3300.

High-Temperature Binder Grade	HWTT Requirements Minimum passes at 0.5” (12.5-mm) rut depth tested at 122 degrees F	OT Requirements Minimum number of cycles to failure
PG 64 or lower	10,000	750
PG 70	15,000	750
PG 76 or higher	20,000	750

The contractor submitted two potential CAMs for trial batching during the 2014 IH-69 project. TxDOT performance tested both mixes. The first CAM had an asphalt content of 6.8 percent, and the second CAM had an asphalt content of 7.3 percent. Both mixes passed HWTT and OT criteria. All mixes passed the maximum rut depth threshold with comparable measurements. However, the CAM interlayer samples show a smoother rut texture overall.

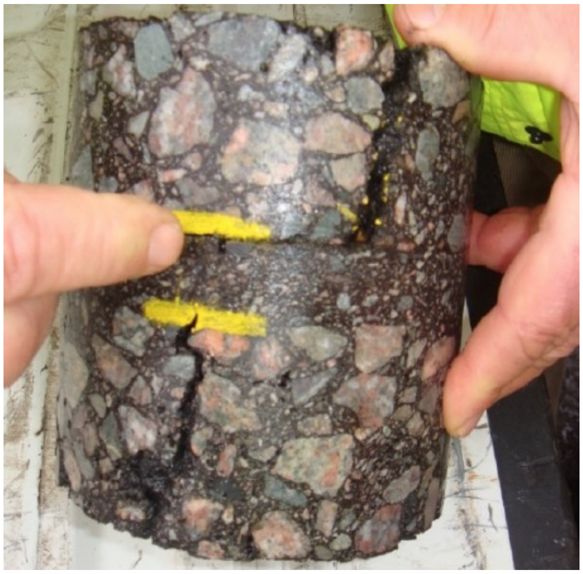

Figure 13. Crack jumping over a crack attenuating layer with a stiff surface mix. Source: Bennert 2021

TOM Surface

Research indicates improved performance when the surface mix used on top of a CAM interlayer also has some crack attenuating properties (Bennert 2015). In TxDOT's experience, recycled materials such as reclaimed asphalt pavement or recycled asphalt shingles can contribute to stiffer mixes. Even a high-quality flexible crack attenuating layer cannot prevent stiff mixes from cracking. A phenomenon known as "crack jumping" can occur in an overlay system where the surface mix is much stiffer than the crack attenuating layer (Figure 13).

Reflective cracking and crack jumping are less frequent when the surface mix also has flexible crack attenuating properties (Bennert 2018). The Houston District prefers using TOM-C for the surface course. TOM-C uses high-quality SAC A aggregate, does not allow reclaimed asphalt pavement or recycled asphalt shingles, and must meet TxDOT skid requirements for surface mixes. TOM-C is also performance-tested for rutting and cracking, and has the same HWTT requirements as CAM (Table 3). However, the binder grade of PG 64 or lower is not permitted. The TOM specification for the OT only requires 300 cycles when used as a surface layer compared to CAM's requirement of 750 cycles. However, when used as an interlayer, the requirement can be increased to get the desired crack attenuating properties. The Houston District typically specifies 500 OT cycles for its new TOM-F interlayers (Kwater 2021).

In 2014, two TOMs were evaluated for use on the surface of the IH-69 project. The TOM specimens after the HWTT are shown alongside the CAM interlayer specimens in Figure 9. Figure 14 shows laboratory slabs of the CAM/TOM, and Figure 15 shows the construction surfaces.

Figure 14. Slab samples of CAM and TOM. Source: Tom Scullion, TTI

Figure 15. Construction surfaces of TOM (left) and CAM interlayer (right). Source: Tom Scullion, TTI

Figure 16. IH-69 overlay system construction. Source: Tom Scullion, TTI

Construction

TxDOT stresses the importance of placement techniques to improve construction quality and success of the CAM overlay system. According to TxDOT guidelines, bonding is the most critical issue with thin construction overlays (TxDOT 2014). Today, TxDOT recommends trackless bonding products between the existing pavement and overlay. During the 2014 construction of IH-69, the contractor used a material transfer vehicle offset in an adjacent lane (Figure 16) to prevent construction traffic from picking up tack material.

Compaction windows for a 1-inch lift are much shorter than a 2-inch or 1.5-inch overlay. Houston District construction notes require that thin lifts like CAM are placed when the air temperature is above 70 degrees F. Asphalt temperatures during placement should be between 315 to 330 degrees F for CAM lifts (Kwater 2021). Paver-mounted thermal profiling (PMTP) systems measure and report temperatures behind the screed. TxDOT's Houston District requires the use of PMTP systems or thermal camera systems to monitor temperature uniformity for CAM and TOM pavements.

TxDOT recommends using tandem breakdown rollers for CAM compaction. A good practice is to keep the tandem breakdown rollers within 100 feet from the back of the paver (Kwater 2021). The Houston District's CAM interlayer construction notes make tandem breakdown roller operations mandatory during construction (Figure 17).

Figure 17. Water flow test.
Source: TxDOT Austin District

The Houston District requires Warm Mix Asphalt (WMA) when the plant to job haul distance exceeds 40 miles. When WMA is required, no reduction in temperature is permitted (the WMA is a compaction aide).

According to SS3000, CAMs are evaluated using core samples to ensure adequate compaction efforts. The mixture compaction requirements are 2 to 6 percent air voids. TOMs (both surface mixes and interlayers) use a different test method for evaluating compaction efforts. TOMs are evaluated using water flow testing according to Tex-246-F. This method evaluates the impermeability of the mixture. Houston District construction notes require rolling patterns for TOM-F interlays and TOM-C surface courses be established using the water flow test.

CAMs have high AC and polymer modified binder. Therefore, additional compaction considerations include avoiding over compaction, leading to bleeding. Additionally, proper release agents in the rollers can mitigate the pick-up of the sticky mixtures (TxDOT 2014).

Performance

The Houston District is pleased with the performance of the IH-69 CAM overlay system. The District reports that the performance has been noticeably better compared to conventional overlays. The conventional 2-inch Type-D (3/4-inch maximum aggregate) mixes had not been performing well in the District. Houston District engineers recall that 2-inch conventional overlays only lasted 2 to 3 years before deteriorating rapidly with cracking, raveling, and aging. The expected design life of these overlays is a minimum of 7 years, which left the roads in rough condition while awaiting funding for further rehabilitation (Kwater 2021).

The cost per square yard for a 1-inch lift is less than the cost of a conventional 2-inch lift, which reduced costs 30 percent in the Austin District (TxDOT 2014). This cost information does not directly reflect a CAM overlay system since a surface course is recommended, and the overlay system depth is generally a minimum of 2 inches. However, according to the Houston District, there are clear cost savings when considering the increased service life and reduced maintenance costs.

Overall, the Houston District is impressed by the performance of the CAM overlay system. The hybrid of a CAM interlayer, now called TOM-F, and TOM-C surface course is the new go-to solution for rehabilitation, including an appropriate bonding course, when reflective cracking is a concern. The Houston District has not developed exact thresholds to trigger the use of CAM. The Houston District has plenty of original CRCPs, which are candidates for CAM interlayers. “If it’s iffy whether or not to use CAM, we’ll usually consult with TTI for advice and a full investigation,” says Brett McLeod, Houston District Assistant Area Engineer.

SUMMARY

TxDOT has nearly 20 years of experience using CAM interlayers. Today, TxDOT typically refers to these mixes as TOM-F. Some of TXDOT's takeaways for using CAM interlayers are as follows:

- CAM interlayers should be paired with the right surface mix for best performance. Surface mixes should have some crack attenuating properties to mitigate crack jumping.
- Performance testing is what ensures CAM interlayers have adequate crack mitigation properties without compromising rut resistance. Performance testing ensures only high-quality materials are used and that the desired CAM characteristics are met.
- According to TxDOT, bonding is the number one issue in thin overlay construction (TxDOT 2014). Therefore, using superior bonding products and using quality assurance procedures to ensure bonding is paramount.
- Properly designed crack attenuating interlayers can reduce the number of reflective cracks and slow the rate of reflective cracking up to 50 percent (Blankenship 2019). However, there are limitations to thin lift overlays, and pre-overlay repairs should be included in the design.
- CAM interlayers and other thin lift overlays have short compaction windows. Close attention should be paid to placement and compaction temperatures. Tandem breakdown rollers operated close to the paver, and PMTP equipment have proven successful in Texas.

LIST OF ACRONYMS

- **BRIC** Binder-rich intermediate course
- **CAM** Crack attenuating mixture
- **CRCP** Continuously reinforced concrete pavements
- **FDR** Full-depth repair
- **FHWA** Federal Highway Administration
- **HWTT** Hamburg Wheel Tracking Test
- **IH-69** Interstate Highway 69
- **JPCP** Jointed plain concrete pavement
- **NJDOT** New Jersey Department of Transportation
- **OT** Overlay tester
- **PMTP** Paver-mounted thermal profiling
- **SMA** Stone matrix asphalt
- **TOM** Thin overlay mix
- **TOPS** Targeted overlay pavement solutions
- **TRAIL** Tracking-resistant asphalt interlayer
- **TSM** Thin surface mix
- **TTI** Texas A&M Transportation Institute
- **TxDOT** Texas Department of Transportation
- **VMA** Voids in the mineral aggregate

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TOPS
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