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Maine Department of Transportation

Transportation Research Division

Technical Report 96-25 and 97-19

Experimental Use of Sawed and Sealed Joints to Minimize Thermal Cracking

Final Report - August 2004

Transportation Research Division

Experimental Use of Sawed and Sealed Joints to Minimize Thermal Cracking

Introduction

"Saw and Seal" is the process of introducing uniformly spaced saw joints to a bituminous overlay in an attempt to eliminate or retard the formation of thermal and /or reflective cracking.

Saw and Seal technology has been experimented with for many years. Several states including Connecticut, Massachusetts, New York, Minnesota and Pennsylvania have used the Saw and Seal method. Although its primary use has been for bituminous over jointed concrete pavements, some states are using Saw and Seal on new construction and bituminous overlays of existing bituminous pavements. In the fall of 1997, the Maine Department of Transportation (MDOT) completed construction on two projects that included Saw and Seal technology in an effort to mitigate thermal and reflective cracking.

Project Location

Beddington-Deveraux Twp.

Project No. F-STP-046P(57)

This project is located in the towns of Beddington and Deveraux Twp on State Route 9. The project begins 1.36 miles easterly of the T22 MD town line and extends easterly 4.60 miles as depicted in Figure 1. This is a highway reconstruction project with 9.5 inches of hot mix asphalt (HMA) base and wearing surface. The wearing surface consists of a 0.5 inch stone C-mix with an AC-20 grade asphalt binder.

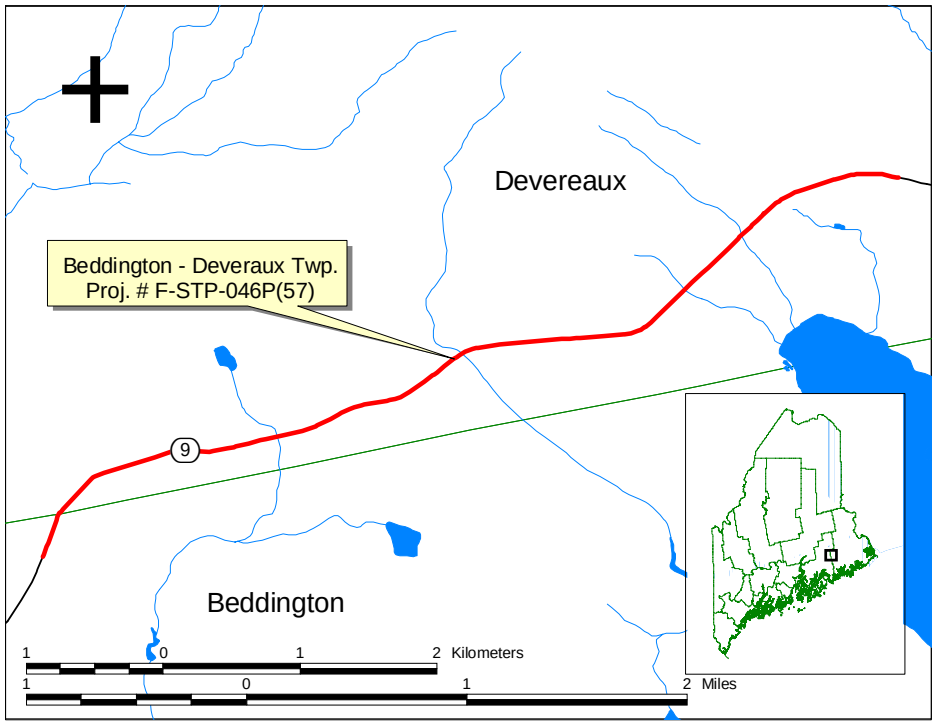

Figure 1: Beddington project location map

The experimental feature of this project consists of three 1,000-foot sections, two experimental and one control. Full width sawed joints were introduced using

a thirty foot spacing interval from station 70+00 to 80+00 and forty foot spacing interval between station 90+00 and 100+00. The control section is located between these two sections from station 80+00 to 90+00.

T1R6-Sherman

Project No. IM-95-6594(00)E

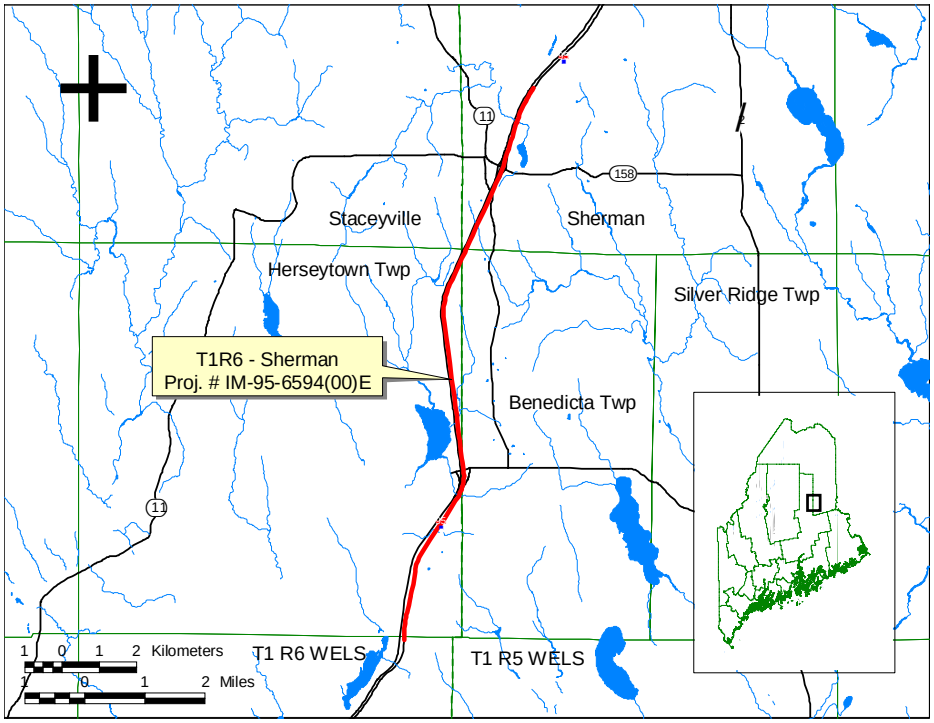

Figure 2: T1R6 project location map

This project is located on the northbound lane of Interstate 95 in the towns of T1R6, Herseytown Twp., Benedicta Twp. and Sherman. Figure 2 contains a location map of the project. The project begins 0.06 miles southerly of the Herseytown Twp. town line and extends northerly 9.72 miles. This highway pavement rehabilitation project includes grinding and stockpiling of the existing three inch wearing surface, full depth reclamation of the remaining eight inches of existing HMA then surfacing with 4.5 inches of HMA. The wearing surface is a 0.5 inch stone Superpave mix with an AC-20 grade asphalt binder.

The experimental portion of this project consists of two 2,000-foot sections, one experimental and one control section. Full width sawed joints were introduced using a 30-foot spacing interval from station 4150+00 to 4170+00. The control section was established from station 4170+00 to 4190+00.

Materials

Sawed joints on each project were sealed with Product # 9005, Hot Applied Joint Sealant, manufactured by KOCH Materials Company, Northumberland, Pennsylvania. The material meets the following specifications:

ASTM D3405
AASHTO M-301-85
Federal Specification SS-S-1401C
FAA Specification P-605, Type III

Construction

Beddington-Deveraux Twp.

Project No. F-STP-046P (57)

The construction process, including the bituminous wearing surface was completed in the experimental area on September 10, 1997. The contractor arrived on October 2, 1997 with a “wet cut” pavement saw to cut the joints. Special Provision Section 419, subsection Sawing Joints, states ‘Only dry cutting will be allowed’. A decision was made by the resident engineer to proceed with the “wet cut” pavement saw if the contractor thoroughly cleaned all slurry from the joint and dried the joint and sidewalls completely. The Saw and Seal process began at station 70+00. Joints were cut in a single pass across both lanes and a foot into each shoulder to a depth of 2.5 inches as illustrated in Photo 1. Dimensions of a typical saw joint are displayed in Figure 3. The joints were flushed with water and air (Photo 2) then dried (Photo 3). Bond breaker tape was installed on the bottom of each reservoir (Photo 4), in some instances a double layer was applied, to assure the sealant remained in the reservoir. The joints were then sealed with a shoeless wand (Photo 5). The shoeless wand applied either too much or too little sealant and couldn’t fill the joint properly. Hand work was necessary to finish the level of sealant to acceptable levels (Photo 6). Cutting was halted at station 72+40 after 9 joints had been sawed and sealed. It was determined that the contractor didn’t have the proper heat lance and shoe applicator to clean, dry, and seal the joints as specified in the Special Provision. Cutting resumed on October 21, 1997 using the proper heat lance and shoe applicator. Although air temperatures during this second phase of installation was below the 50°F minimum, installation was allowed to continue. The experimental feature was successfully completed October 23, 1997 at a cost of $3.00 per lineal foot.

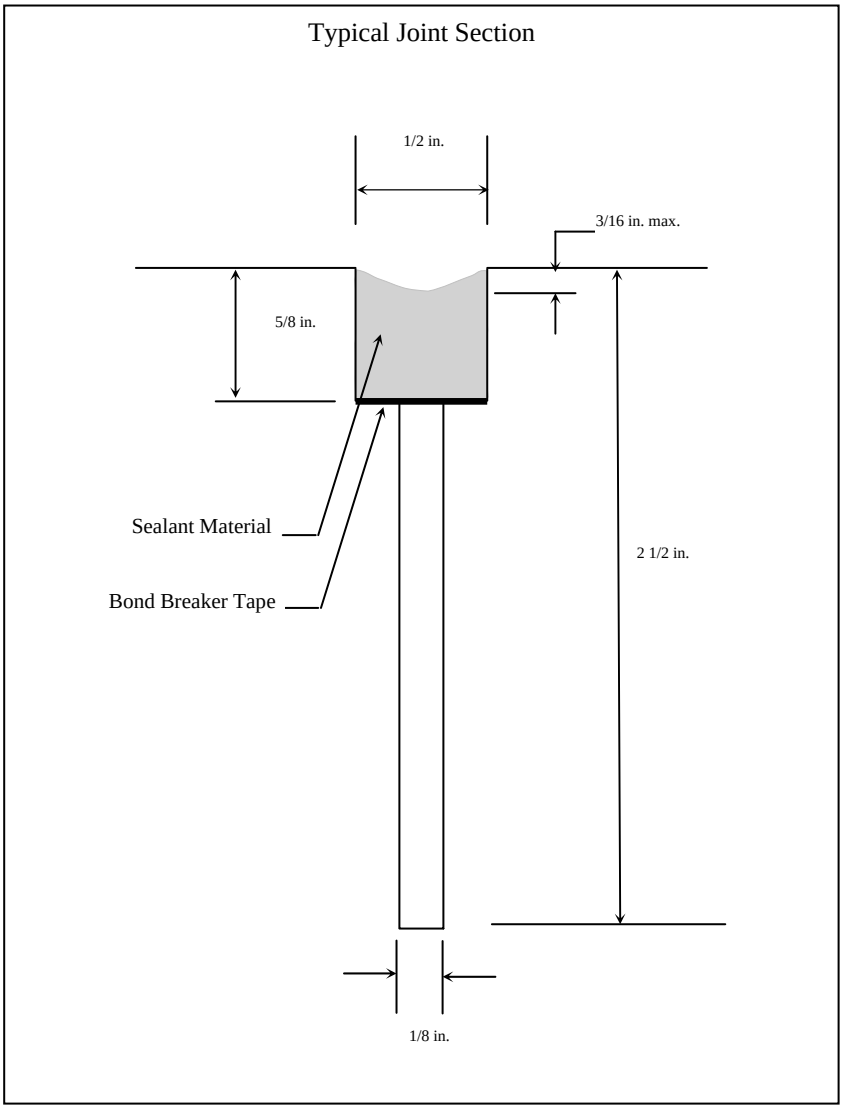

Figure 3: Saw and seal joint details.

Photo 1: “Wet Cut” pavement saw


Photo 2: Cleaning and flushing the joint

Photo 3: Drying the joint


Photo 4: Bond breaker tape application


Photo 5: Rubber sealant application


Photo 6: Sealant hand work

The Special Provision for Sawing and Sealing Joints in Bituminous Pavement for the Beddington – Devereaux project is as follows:

Beddington-Devereaux
046P(57)
March 28, 1996

SPECIAL PROVISION
SECTION 419
SAWING AND SEALING JOINTS IN BITUMINOUS PAVEMENT

Description: This work shall consist of sawing a cut transversely across the newly finished bituminous concrete pavement as shown on the plans or as directed, and in accordance with this Special Provision. Upon the satisfactory completion of each cut, it shall be sealed with hot rubber asphalt joint sealer. The work is to establish a weakened plane joint to control thermal cracking in the newly placed bituminous concrete pavement.

MATERIALS

Joint Sealer. Joint sealer shall be an asphalt rubber compound of the hot poured type conforming to AASHTO M301 and ASTM D3405.

CONSTRUCTION REQUIREMENTS

Weather. Joint sealer shall not be applied on a wet surface, after sunset or before sunrise, or when the atmospheric temperature is below 10°C (50°F) in a shaded area at the job site, or when weather conditions are otherwise unfavorable to proper construction procedures.

Equipment. Equipment used in the performance of the work shall be subject to the Engineer's approval and shall be maintained in a satisfactory working condition at all times.

(a) Air Compressor: Air compressors shall be portable and capable of furnishing not less than 3.0 m3 (100 cu. ft.) of air per minute at not less than 600 kPa (90 psi) pressure at the nozzle. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water.

(b) Hot Air Lance: Should operate with propane and compressed air in combination at 1100°C – 1650°C (2000°F - 3000°F), exit air heated at 300 m/sec (1000 ft/sec). The lance should draw propane from no smaller than a 45 kg (100 lb.) tank using separate hoses for propane and air draw. The hoses shall be wrapped together with reflectorized wrap to keep them together and to protect workers in low light situations.

(c) Hand Tools: Shall consist of brooms, shovels, metal bars with chisel shaped ends, and any other tools which may be satisfactorily used to accomplish this work.

(d) Melting Kettle: The unit used to melt the joint sealing compound shall be a double boiler, indirect fired type. The space between inner and outer shells shall be filled with a suitable heat transfer oil or substitute having a flash point of not less than 315°C (600°F). The kettle shall be equipped with a

satisfactory means of agitating and mixing the joint sealer at all times. This may be accomplished by mixing the joint sealer at all times. This may be accomplished by continuous stirring with mechanically operated paddles and/or a continuous circulating gear pump attached to the heating unit. The kettle must be equipped with thermostatic control calibrated between 90°C and 290°C (200°F and 550°F).

Sawing Joints. The bituminous concrete shall be in place for a minimum of 48 hours prior to sawing to allow a clean cut to be made and to withstand the eroding effects of the saw or other cutting device.

The joint shall be cut with an abrasive blade or blades of such size and configuration that the resulting depth and reservoir shape are in accordance with the plans. Sawed joints will be made using a single pass. Only dry cutting will be allowed.

The completed cut shall extend in a straight line transversely across the travel way and shall extend 300 mm (12 inches) onto the paved shoulder.

Sealing Joints. The sawed joints shall be sealed as soon as possible after the cut has been made. Traffic shall not be allowed to knead together or damage the sawed joint. Each joint shall be clean and dry prior to the placement of the sealing compound by blowing out all dirt, dust and deleterious matter that may have accumulated in the saw joints, and heated with the hot air lance five minutes prior to the joint being sealed.

The joint seal shall be applied with an applicator shoe and have a flow control valve which allows all cracks to be filled to refusal, so as to eliminate all voids or entrapped air, and not leave surplus crack sealer on pavement surface. Any depression in the seal greater than 5 mm (3/16 inch) below the pavement surface shall be brought up to the specified limit by the further addition of hot seal. The recommended application temperature of the sealer shall be furnished to the Contractor by the manufacturer and the actual temperature of the material in the melting kettle shall not fluctuate from this recommended temperature by more than 5.5°C (10°F).

Workmanship. All workmanship shall be of the highest quality. Excess of spilled sealer shall be removed from the pavement by approved methods and discarded. Any workmanship determined to be below normal acceptable standards will not be accepted, and will be corrected and/or replaced as directed by the Engineer.

Method of Measurement. This work shall be measured for payment by the number of linear feet of joint sawed and sealed in the 'bituminous concrete surface, measured in place and accepted.

Basis of Payment. Payment for this work shall be at the contract unit price per linear foot for sawing and sealing joints in bituminous concrete pavement, complete in place.

Payment will be made under:

Pay Item	Pay Unit
419.20 Sawing, Sealing Joints in Bituminous Concrete Surface	Meter (Linear Foot)

T1R6-Sherman

Project No. IM-95-6594(00)E

The bituminous wearing surface in the experimental section of this project was completed October 1, 1997. The Saw and Seal procedure began October 16, 1997 at station 4150+00 and was completed October 17, 1997. Sawed and sealed joints were introduced using similar methods as the Beddington-Deveraux project with two exceptions. The contractor was not required to use a heat lance or bond breaker tape for acceptable completion of the experimental feature. Joints were cut in one pass using a wet cut pavement saw (Photo 7). Notice the one eighth inch cut centered in the one half inch cut in Photo 8, this photo was taken prior to drying the joint. The joints were then dried using a propane torch (Photo 9) and sealed with a pressurized applicator fitted with a shoe (Photo 10). A decision was made to allow the contractor to continue with joint construction even though air temperatures were below the 50°F minimum. Cost to saw and seal the joints was $3.00 per lineal foot.

Photo 7: T1R6 Pavement saw

Photo 8: Freshly cut joint

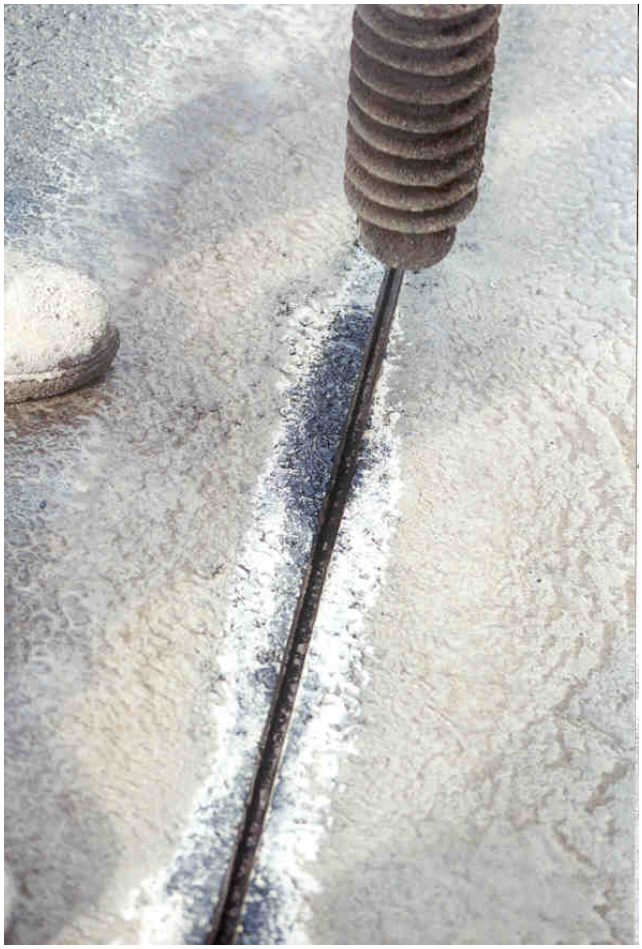

Photo 9 Drying the joint

Photo 10: Sealing the joint

The Special Provision for Sawing and Sealing Joints in Bituminous Pavement for the T1R6 – Herseytown Twp. – Benedicta Twp. - Sherman project is as follows:

TIR6-Herseytown Twp.-Benedicta Twp.-Sherman
6594.00
March 4, 1997

SPECIAL PROVISION
SECTION 419
SAWING AND SEALING JOINTS IN BITUMINOUS PAVEMENT

Description: This work shall consist of sawing a cut transversely across the newly finished bituminous concrete pavement as shown on the plans or as directed, and in accordance with this Special Provision. Upon the satisfactory completion of each cut, it shall be sealed with hot rubber asphalt joint sealer. The work is to establish a weakened plane joint to control thermal cracking in the newly placed bituminous concrete pavement.

MATERIALS

Joint Sealer. Joint sealer shall be an asphalt rubber compound of the hot poured type conforming to AASHTO M301 and ASTM D3405.

CONSTRUCTION REQUIREMENTS

Sawing Joints. The bituminous concrete shall have aged sufficiently to allow a clean cut to be made and to withstand the eroding erects of the saw or other cutting device.

The joint shall be cut with an abrasive blade or blades of such size and configuration that the resulting depth and reservoir shape are in accordance with the plans. Sawed joints will be made using a single pass. Either dry or wet cutting will be allowed.

The completed cut shall extend in a straight line transversely across the travel way and shall extend 300 mm (12 inches) into the paved shoulder.

Sealing Joints. The sawed joints shall be sealed immediately after the cut has been made. Traffic shall not be allowed to knead together or damage the sawed joint. Each joint shall be clean and dry prior to the placement of the sealing compound by blowing out all dirt, dust and deleterious matter that may have accumulated in the saw joints. Sufficient air pressure shall be provided to insure thorough cleaning and drying.

A combined melter and pressure applicator shall be used to place the joint seal. The melter shall be either oil or gas-fired double walled, oil bath type with power driven mechanical agitator and circulating pump shall be equipped with a thermostat control to maintain the sealing compound within the range of temperatures specified by the manufacturer with a suitably mounted thermometer to indicate the temperature of the sealing compound in the melter.

The joint seal shall be applied with a mobile carriage and rubber shoe and have a flow control valve which allows all cracks to be filled to refusal, so as to eliminate all voids or entrapped air, and not leave surplus crack sealer on pavement surface. Any depression in the seal greater than 3 mm (1 /8 inch) below the pavement surface and any depression in the seal greater than 5 mm (3/16 inch) shall be brought up to the specified limit by the further addition of hot seal. The recommended melting temperature of the sealer shall be furnished to the Contractor by the manufacturer and the actual temperature of the material in the melter shall not exceed this recommended temperature by more than 8°C (15°F).

Method of Measurement. This work shall be measured for payment by the number of linear feet of joint sawed and sealed in the bituminous concrete surface, measured in place and accepted.

Basis of Payment. Payment for this work shall be at the contract unit price per linear foot for sawing and sealing joints in bituminous concrete pavement, complete in place.

Payment will be made under:

Pay Item	Pay Unit
419.20 Sawing and Sealing Joints in Bituminous Concrete Pavement	Meter (Linear Foot)

Field Inspection

Beddington-Deveraux Twp.

Project No. F-STP-046P(57)

This project was inspected on September 30, 2002. The ambient temperature was 53°F with partly cloudy skies. Overall, the project and pavement is in good shape after five years exposure to traffic. Annual average daily traffic count is 2980 for year 2003.

Section 1, 30 Foot Spacing

The joint sealant is pliable and well adhered to the sidewalls. There are no transverse cracks but there is a small amount of shoulder and centerline joint separation plus a small amount of initial load cracking.

Twenty nine of the thirty three sawed joints have cracks extending from the end of the joint halfway across the shoulder. Photo 11 shows a typical crack at the end of a joint.

Section 2, Control

The Control Section has no transverse cracks. There is a longitudinal crack six feet in length located between wheel paths in the west bound lane. Fifty percent of the centerline joint has separated and forty percent of the shoulder joint has separated. Pavement looks very good with no ravel.

Section 3, 40 Foot Spacing

Sealant is pliable and adherence is good except at the roadway centerline on six of the joints where it has separated from the sidewall (Photo 12).

There are no transverse cracks but there is a small amount of initial load cracking in the wheel path. A longitudinal crack 35 feet in length is located between wheel paths in the west bound lane. Centerline joint separation has occurred in fifty five percent of the section. Shoulder joint separation is evident along seventy percent of the section. Eighteen of the twenty five joints have cracks extending beyond the saw cut halfway into the shoulder.

Photo 11: Typical shoulder crack

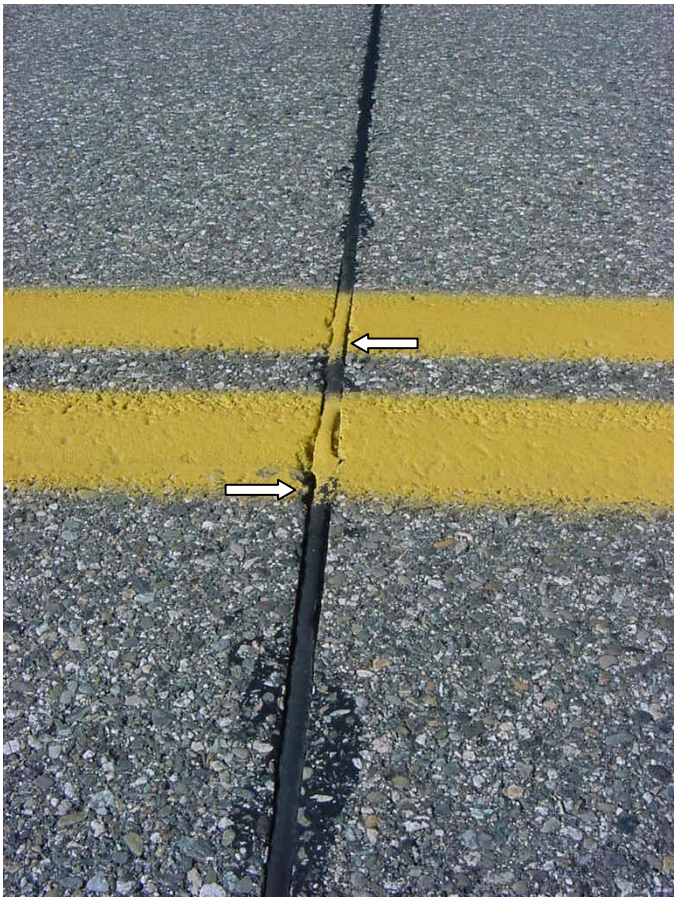

Photo 12: Sealant delaminating

T1R6-Sherman

Project No. IM-95-6594(00)E

This project was inspected on September 25, 2002. The ambient temperature was 37°F with sunny skies and annual average daily traffic count is 2642 in year 2003.

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Section 1, 30 Foot Spacing

There are no transverse cracks. Centerline and shoulder longitudinal joints have separated the entire length of the section. There are isolated areas of initial load cracking in the passing lane only and longitudinal cracks between wheel paths on both lanes. Cracks are extending from the ends of each sawed joint into the left shoulder and break down lane (Photo 13).

Sealant is pliable and adherence is good in most of the joints. Sealant has dropped approximately one inch or more below the pavement surface in eight of the sixty six joints. This could be attributed to the exclusion of Bond Breaker tape to seal the bottom of the reservoir. The joint edge has raveled in these areas due to winter snow removal (Photo 14). Two joints had missing sealant between wheel paths (Photo 15).

Twenty five joints have initial cracking parallel to the joint in each travel lane wheel path (Photo 16). This type of cracking was reported in the Fourth Interim report and severity has remained the same after one

year. Sealant appears to be well adhered to the sidewalls in these areas and there is no apparent reason for this to occur. There have been reports of the sawed joints “tenting” during the past two winter seasons. Tenting is when both edges of the joint rise higher than the surrounding pavement to form a tent that is noticeably rough when traveling at highway speeds. The reason for this tenting is unsure. There is speculation that this started during the 1999-2000 winter season when the department stopped utilizing sand on the roadway as an abrasive approach to improve winter driving conditions and switched to salt to liquefy snow creating salt brine that flows from the roadway and aids in drying the surface. The salt brine may be seeping into and settling on the bottom of the joint or between the HMA and base material if cracks extend below the sawed joint thru the HMA. When the temperature drops below 15 degrees Fahrenheit the brine could freeze and expand causing the HMA on either side of the joint to lift, relieving pressure on the sidewalls. When the pavement and frozen joint warms, traffic loads may be forcing the raised HMA on either side of the joint down causing cracks parallel to the sawed joint. Although the joint appears to be sealed, all it takes is one or two small openings in the sealed joint to allow salt brine to penetrate.

Photo 13: Crack extension into shoulder

Photo 14: HMA ravel at joint edge

Photo 15: Missing sealant

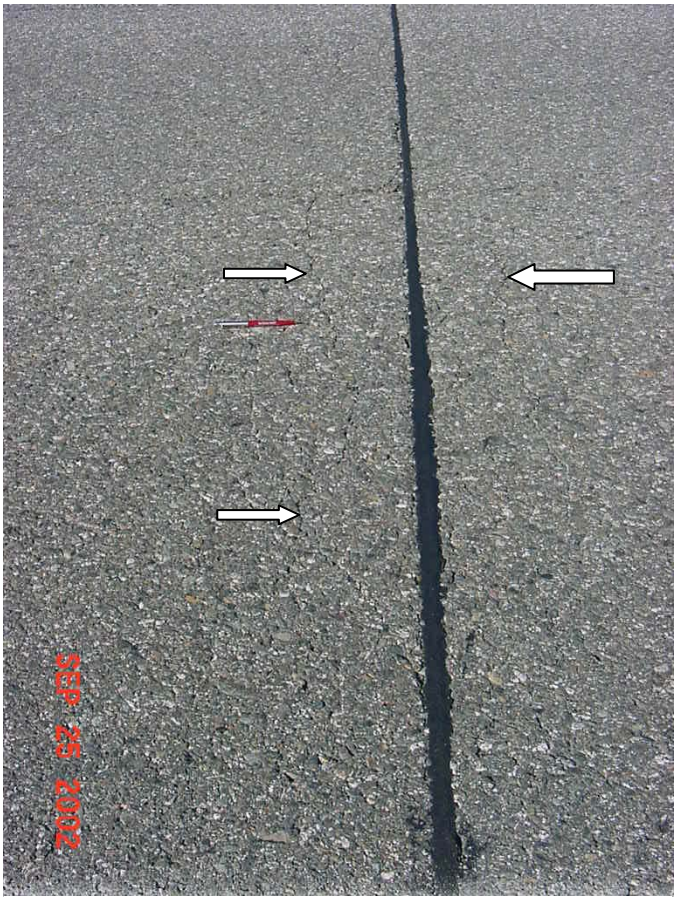

Photo 16: Parallel cracking

Section 2, Control

Centerline and shoulder joints have separated the entire length of this section. There is a small amount of longitudinal cracking between wheel paths in both lanes and a small amount of initial load cracking in the passing lane. Eleven transverse cracks, ranging in length from 1 to 2 feet, are located between wheel paths in both lanes. A number of them are originating from longitudinal and load cracking mentioned earlier (Photo 17 and 18). There are a total of six transverse cracks that are crossing from either centerline to quarter point or from shoulder to quarter point in both lanes (Photo 19).

Photo 17: Migrating transverse cracks

Photo 18: Transverse crack from load cracking

Photo 19: Control section transverse crack

Summary

Each project has completely different results. Beddington is void of transverse cracking, has a reduced amount of cracks extending into the shoulder, and the sealed joints are not “tenting” during the winter season. T1R6 has transverse cracking in the control section, cracks extending into the shoulder are extensive, and the sawed joints are “tenting”.

Beddington-Deveraux Twp.

Reduced cracking on the Beddington project is most likely attributed to HMA thickness. Beddington has a total thickness of 9.5 inches whereas T1R6 has 4.5 inches. The additional HMA distributes traffic load more efficiently and is less susceptible or delays the formation of thermal transverse cracks.

The extra HMA combined with Bond Breaker tape may also be preventing or delaying “tenting”. The tape appears to keep the sealant in place while curing, facilitating sidewall adherence and preventing or reducing salt brine intrusion and the additional HMA may be reducing the likelihood of cracks extending from the bottom of the sawed joint to the aggregate subbase material.

The only noticeable difference between the thirty foot and forty foot joint spacing sections is the amount of longitudinal cracking and sealant delaminating at centerline. The forty foot spacing section has thirty five feet of longitudinal cracking between wheel paths and six joints have sealant separation at midpoint of each joint whereas the thirty foot spacing section has a very small amount of longitudinal cracking and the joints are well sealed. The longitudinal crack could generate transverse cracking similar to what is occurring on the T1R6 project.

T1R6-Sherman

The T1R6 project has a number of transverse cracks, all in the control section. It appears the saw and sealed joints has eliminated or delayed the formation of transverse cracks. Shoulder cracking at the joint ends are more severe on this project than in Beddington. The cracks extend across the entire shoulder. This could be attributed to thinner HMA.

A number of joints experienced sealant failure. Types of failure include sealant delaminated from the sidewall, sagging into the joint, or missing sealant. Bond breaker tape was not utilized on this project and may be the cause of many sealant failures. Construction temperatures below 50 degrees Fahrenheit may also contribute to poor sidewall adhesion.

Saw joint "tenting" is prevalent during the winter season. As a result of this, initial cracks are forming parallel to the joint in each wheel path. Severity and number of joints affected by this type of cracking has not increased from last year's evaluation. It's possible these cracks may develop into load cracks in the future.

Traffic loads are similar for both projects and can be ruled out as a contributing factor for "tenting."

Conclusions / Recommendations

Sawing and sealing bituminous joints appear to reduce the formation of transverse cracks on roadways with an HMA layer thickness of 4.5 inches or less. Roadways with heavier HMA layers also delay the formation of transverse cracks. Extending the saw joint into the shoulder slows but does not eliminate the formation of cracks extending into the shoulder. States that utilize salt for snow removal may experience saw joint deformation when temperatures drop below 15 degrees Fahrenheit. The use of Bond Breaker tape prior to sealing joints will assure a successful bond to sidewalls reducing the likelihood of sagging or missing sealant and may help prevent joint "tenting."

Recommendations include:
1. Pavement temperature should be 50 degrees Fahrenheit and rising before joint construction begins.
2. Use thirty foot spacing between joints.
3. Joints should be cut in one pass.
4. Extend the joints into the shoulder to slow formation of shoulder cracking.
5. Air clean and thoroughly dry cut joints with heat wands prior to sealing.
6. Bond Breaker tape should be utilized.
7. Monitor sealing procedures to assure proper application and sealant adherence to sidewalls.

Although sawing and sealing bituminous joints does reduce and control thermal cracking, should it be used on all bituminous projects? Are there specific circumstances when it should or should not be used? Is it cost effective? State transportation literature on experimental saw and seal projects were reviewed to answer these questions. Minnesota Department of Transportation published a report that gave recommendations. David W. Janisch and Curtis M. Turgeon authored Report No. MN/PR-96/27, "Sawing and Sealing Joints in Bituminous Pavements to Control Cracking," March 1996. The report reviews more than 50 projects that were constructed since the 1960's, identifying problems and making recommendations for the use of saw and seal on three types of projects; bituminous overlays of jointed concrete pavements, bituminous overlays of bituminous pavements, and new bituminous pavements. The following recommendations were given for projects that should <u>not</u> be considered for saw and seal;

- Overlays on Jointed Concrete Pavements with a high frequency of midpanel cracks (> 20%) or badly deteriorated cracks.

- Overlays on Jointed Concrete Pavements with badly deteriorated joints and/or lots of patching at or near the joints.

- Overlays on bituminous pavements with meandering transverse cracks.

- Overlays on previously overlaid concrete pavements where the cracks at the depth to be milled are badly deteriorated or stripped.

- Overlays on bituminous pavements with severe load related distress such as alligator cracking, potholes or severe stripping related distress.

The report also states that project maintenance costs have been reduced. The formation of cracks are delayed and the severity of cracking is reduced which extends the length of time between crack sealing and reduces the amount of time and crack sealing material used on the project.

Contractor bid prices for both saw and seal projects in Maine were $3.00 per lineal foot. This equates to $12672.00 per mile for a 24 foot wide project with 30 foot spacing or $9504.00 per mile on the same project with 40 foot spacing. The cost of constructing saw and seal joints may be offset by the reduced amount of maintenance on the project.

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