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CRACK REDUCTION STRATEGIES ON A PAVEMENT WARRANTY PROJECT (INTERSTATE 25 AT FOUNTAIN, COLORADO)

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DEPARTMENT OF TRANSPORTATION RESEARCH

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16. Abstract
As part of a mandated pavement warranty pilot program, a four-mile segment of I-25 south of Fountain, Colorado was rehabilitated during the summer of 1998. The north and southbound lanes were overlaid with five inches of HBP under a warranty contract. Prior to the overlay, the roadway was milled to a depth of 1 inch over the entire project, with the exception of the first nine test section locations (approximately 3,600 feet) where the driving lane was milled an additional 1-1/2 inch depth (trench section) and after the specific treatments were applied, the trench was overlaid with HBP.

Treatments consisted of eight crack prevention methods over the 2-1/2 inch (1-1/2 inch trench in a 1-1/2 inch milled section of the driving lane) as well as the standard 1-inch milled surface. Although a specially assigned Pavement Evaluation Team (PET) evaluated the project's performance, Research became involved in the performance evaluation for the three-year warranty period. The evaluation consisted of project inspection prior to construction, crack prevention treatments during construction, and the three -year post-construction evaluation.

Findings confirmed that the least recurrence of cracks was noticed in the "trenched" section that had the additional 1-1/2 inch hot mix pavement. Furthermore, the majority of the recurrent cracking was observed after the first year, with additional cracking becoming visible after the third year.

Implementation
CDOT will continue to track warranty projects to determine cost benefit and performance of warranties. Innovation will continue to be encouraged; however, CDOT will not specify treatments to be incorporated. It is the contractor's responsibility to build a pavement that will perform under the expectations of the warranty.

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Crack Reduction Strategies on a Pavement Warranty Project

by

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Final Report

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EXECUTIVE SUMMARY

In early 1997 Senate Bill 97-128 was passed which required the Colorado Department of Transportation to put three-year warranty projects into place under a pilot program by 1998. Three projects were selected to incorporate the warranty specification. This specification required the contractor to guarantee the pavement for three years after construction.

This was different than the current practice. Under the current program the Colorado Department of Transportation is responsible for maintenance and repair of the pavement once the contractor has completed the project. The contractor is no longer involved with the project once construction is complete.

This bill required:

1. The department establish a committee that would be responsible for selecting the HBP paving projects (Technical Advisory Committee). This team would consist of two representatives from CDOT, two individuals from the asphalt paving industry, and one independent consultant.

2. The department establish a committee that will determine the cost benefits (Cost/Benefits Analysis Committee).

A third team would also be established through the warranty specification. This team, referred to as the Pavement Evaluation Team (PET), would have final decision for acceptance authority for all warranty work. The PET would consist of three subject matter experts that were not affiliated with the project. One member would be a CDOT staff person, the second member would represent the asphalt paving industry, and the other two members would mutually agree upon the third member.

Under this warranty specification the contractor would be required to warranty the quality of work and materials for a three-year period following construction. The contractor would be

required to repair and maintain the pavement at a level outlined in the specification. The warranty specification would guarantee the pavement against:

1. Rutting and shoving greater than 0.3 inches,
2. Potholes greater than 0.2 ft^2,
3. Longitudinal joint separation from low to high,
4. Raveling and weathering greater than 1/4 inches deep and greater than 1 ft^2,
5. Moderate to high bleeding,
6. Delamination of pavement layer, and
7. Transverse cracking depending on the severity.

Three projects that incorporated the warranty specification were constructed during the 1998 construction season. This report documents one of the three warranty projects. The project is a four-mile segment of I-25 south of Fountain, Colorado that was rehabilitated during the summer of 1998. This report details the strategies that the contractor used during construction to help reduce future reflective cracking in hopes it would minimize the crack repair that would be required during the warranty period.

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1.0 BACKGROUND

Senate Bill 97-128 required the Colorado Department of Transportation to put three-year warranty projects into place under a pilot program by 1998. In 1998 three projects that incorporated the warranty specification were selected (Appendix A). The warranty specification required the contractor to guarantee the pavement for three years. This provided an opportunity for the contractor to be innovative and develop new means and methods for longer-lasting pavements.

There are four different types of warranties. Each type of warranty is defined by the amount of risk that is transferred from the owner to the contractor. The different types of warranties are discussed in a CDOT report published in 2001.[1] This report also documents the cost-benefit evaluation of the three-year warranty specification for hot bituminous pavements (HBP).

The type of warranty that was incorporated into the project that was evaluated under this study was the Materials and Workmanship Warranty. Under this warranty the contractor is responsible for correcting defects in work elements within the contractor's control during the warranty period. This includes distresses resulting from defective materials and workmanship. The pavement design is the responsibility of the owner. The contractor is not responsible for the pavement design nor are they responsible for any distresses that result from the design.

As required by the Senate Bill, three teams were established. The first team, the Technical Advisory Committee, selected the paving projects that would include the warranty specification. This committee was selected by the commission and consisted of industry paving contractors as well as department personnel that were knowledgeable in HBP paving. The second team, the Cost/Benefits Analysis Committee, was also selected by the commission and consisted of two representatives from CDOT, two individuals from the asphalt paving industry, and one independent consultant. The third team, the Pavement Evaluation Team (PET), had the final decision authority for all warranty work. The PET consisted of three subject matter experts who were not affiliated with the project. The Chief Engineer selected two of the members. One member was a CDOT employee, one was a private consultant, and the third member represented the asphalt paving industry. The PET conducted a minimum of one survey each year during the warranty period. They determined the remedial action that needed to be performed on the project where the threshold level was met or was exceeded.

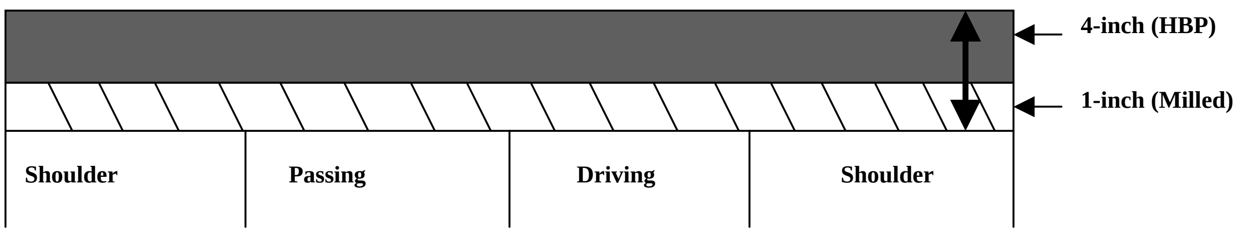
In addition to the above teams, the Research Branch staff was asked to independently evaluate the performance of the crack prevention methods that were chosen by one of the contractors. This report documents one of the three warranty projects constructed using this warranty specification. The project is a four-mile segment of I-25 south of Fountain, Colorado that was rehabilitated during the summer of 1998. On this project the contractor elected to include several reflection crack reduction methods that were deemed cost-effective, as well as other experimental features that might be resistant to reflective cracking. This report details the strategies that the contractor used during construction to help reduce future reflective cracking in hopes it would minimize the crack repair that would be required during the warranty period.

Eight experimental treatments and one control section were constructed with replication. These sections included routing and not routing the cracks and sealing with two types of crack sealer, two weights of geotextile, and two types of heavily reinforced tape systems. Two evaluation sections were established in each section, making the total number of evaluation sections 18. The performance of each type of treatment was to be evaluated over a three-year period after construction was complete. The contractor identified representative transverse cracks in each of these sections. Exact locations were mapped and reference points were established prior to the milling and overlay work. CDOT Research personnel verified the crack locations independently of the contractor’s personnel, and established crack maps for each of the test sections.

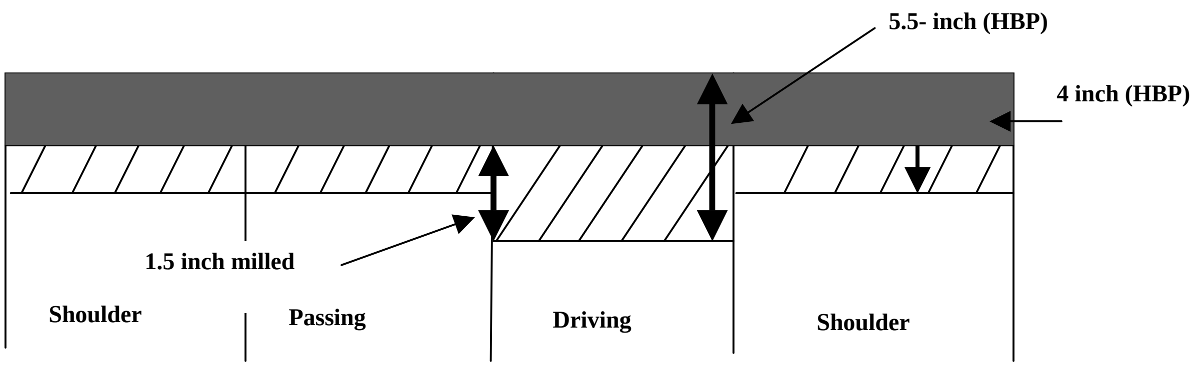
2.0 CONSTRUCTION

A four-mile segment of I-25 south of Fountain, Colorado was rehabilitated during the summer of 1998. The north and southbound lanes were overlaid with five inches of hot bituminous pavement (HBP) under a warranty contract with Western Mobile Paving. Two experimental sections were constructed as shown in Figure 1. In section 1, the entire length of the project was milled to a depth of 1 inch. In section 2 the driving lane was milled an additional 1-1/2 inches (trench section) and after the specific treatments were applied, the trench was overlaid with HBP. Figure 1 shows a diagram of section 1 and section 2.

Figure 1 - Diagram of the two experimental sections.



In section 1 the entire length was milled to a depth of 1 inch.



In section 2 the driving lane was milled an additional 1.5 inches.

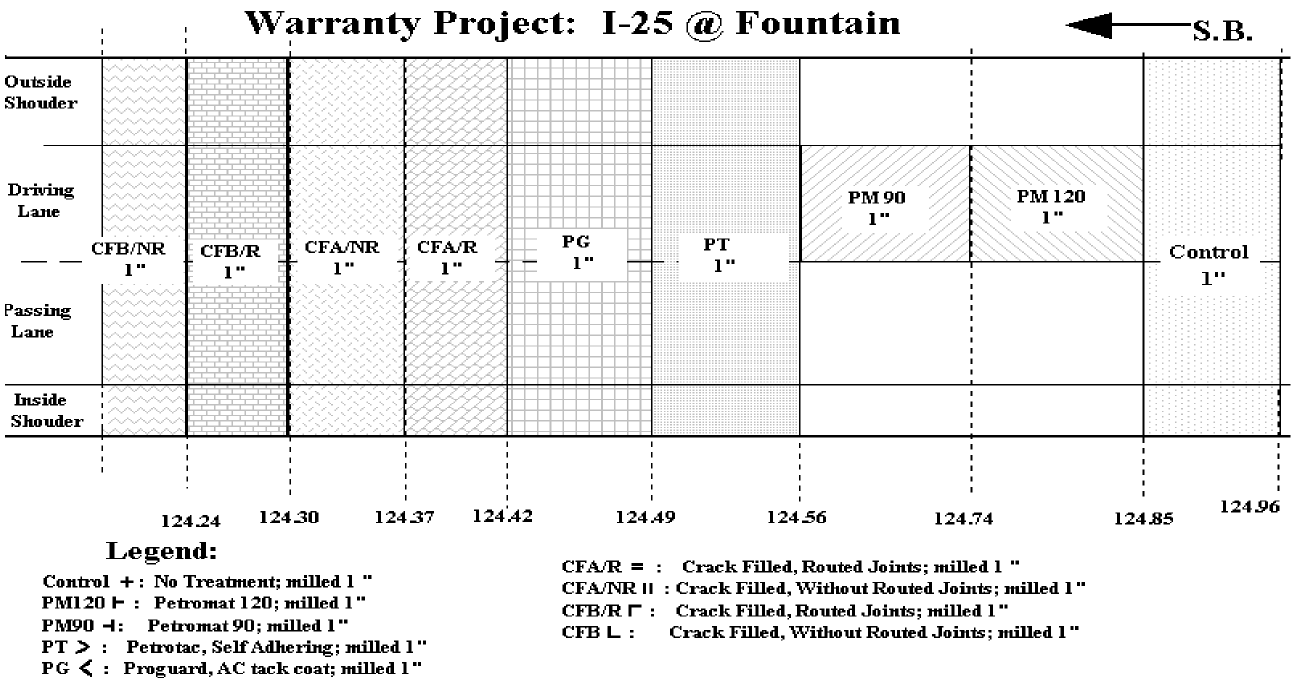
Treatments consisted of eight crack prevention methods over the 2-1/2 inch (1-1/2 inch trench in a 1-1/2 inch milled section of the driving lane) as well as the standard 1-inch milled surface. Each section included a control section where no crack prevention treatment was used.

The rotomilling operation is shown in the following photo (Figure 2). This was in the southbound driving lane where the additional 1-1/2 inch trench was milled.

Figure 2 - Rotomilling operation.

Only the southbound lanes were targeted for reflection cracking research, and 18 test sections were established for evaluation of a variety of reflection cracking prevention treatments. While the 18 test sections were exclusively targeted for an evaluation of reflection cracking (typically of transverse cracking variety) propagation, two additional test sections (T-Bond) were identified in the northbound lanes to observe the longitudinal cracks that might reflect through the overlay. T-Bond is a modified polymeric bituminous joint tape designed and manufactured to seal longitudinal and transverse cold joints. In this northbound evaluation sections, T-Bond was placed in both bottom and top lifts for one test section between the driving and passing lanes, and only in the top lift in the second test section to evaluate the performance of the individual method. A layout of the test sections in the 1" milled section can be seen in Figure 3. A layout of the test sections in the 2-1/2" milled section can be seen in Figure 4. A layout of the T-Bond test sections can be found in Figure 5.

Figure 3 – Layout of evaluation section in 1” milled section.



In Figures 3 and 4 the symbols to the right of the type of treatments are the symbols that were used to identify each section on the pavement. These symbols were marked in the shoulders on the project.

Figure 4 - Layout of specific evaluation sections in 2-1/2” milled section.

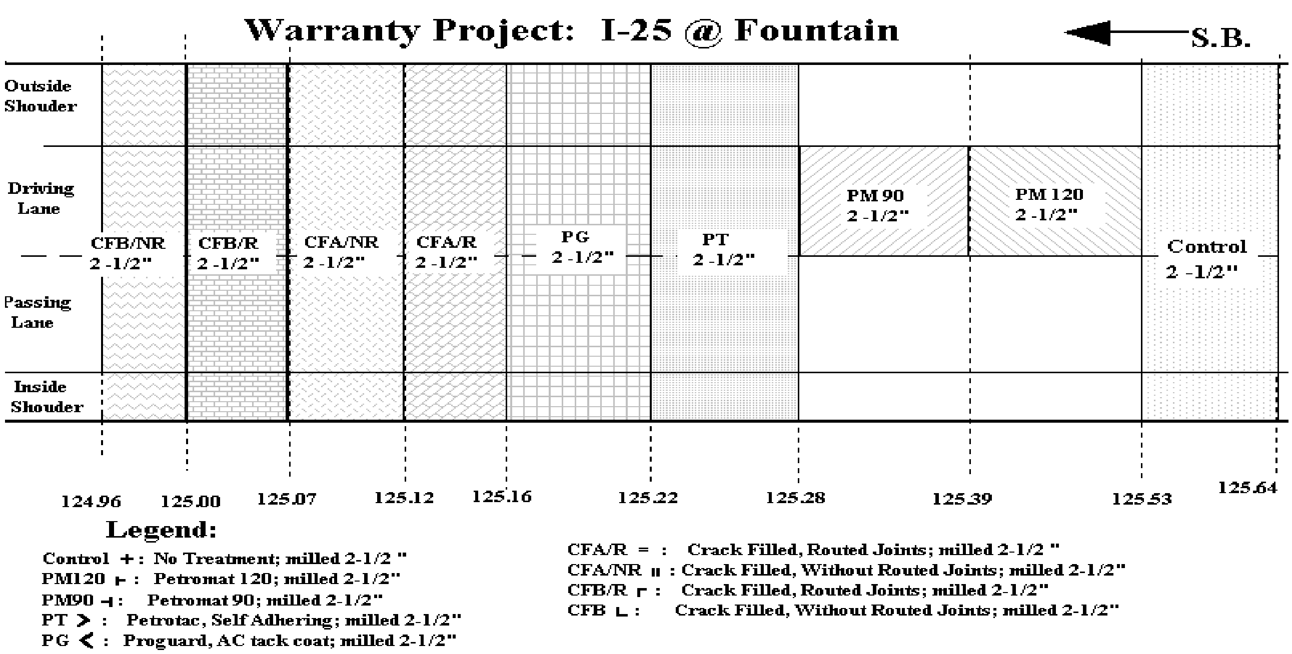
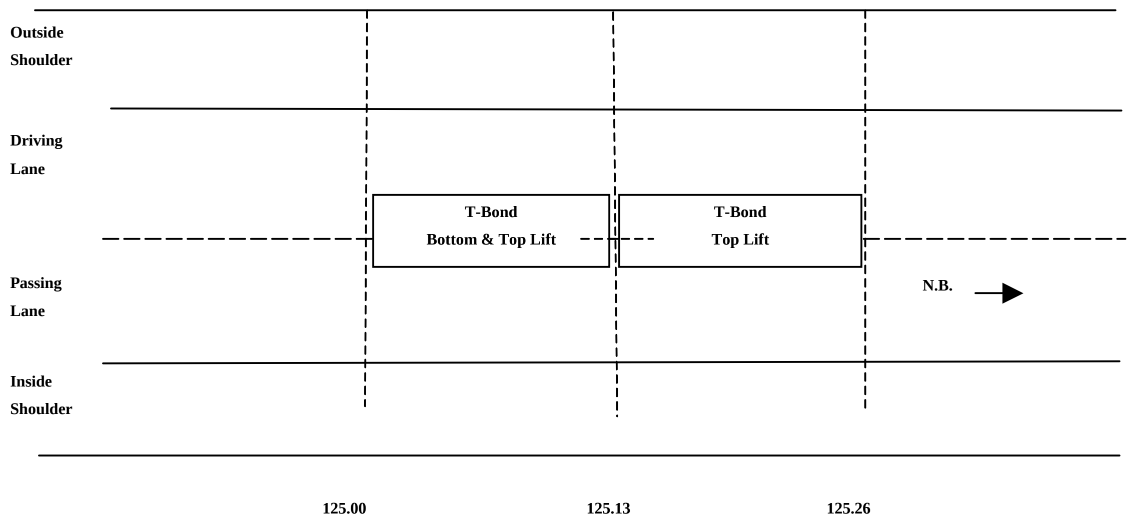


Figure 5 – Evaluation sections for T-Bond.



T-Bond/B&T C.L.: T-Bond Bottom and Top Lift @ Centerline
T-Bond/T C.L. : T-Bond Top Lift @ Centerline

In the first two sections adjacent to the control section, Petromat paving fabric was placed in the driving lane as shown in Figure 6. Petromat is a geotextile paving fabric manufactured by Amoco using needle-punched polypropylene. Two weights of Petromat were placed. Petromat 4597 is a higher strength version (120 psi tensile) than Petromat 4599 (90 psi tensile). The 4599 is the most commonly used Petromat product, and the one used routinely by Lafarge for much rehabilitation work. Both products come in rolls approximately 12-feet-wide and were applied to the milled pavement surface using an AC10 tack coat. As shown in Table 1 (page 11), Petromat 4597 was placed over cracks located at 594 through 1,187 feet and 4,211 through 4,740 feet in the evaluation section. Petromat 4599 was placed over cracks located at 1,343 through 1,752 feet and 4,799 through 5,653 feet in the evaluation section.

Figure 6 – Placement of Petromat material.

The next section is self-adhering Petrotac. Figure 7 shows the placement of Petrotac over existing severely cracked sections of roadway. Amoco also produces this product for use in reflection cracking reduction. Petrotac is a self- adhesive asphalt tape approximately 12 inches wide. It was applied over transverse cracks located at 1,930 through 2,171 and 5,747 through 6,048 feet in the evaluation section (Table 1).

Figure 7 – Petrotac placement.

In the next section a product called Proguard was used. AC10 tack coat was applied with a distributor prior to placing Proguard crack prevention material over the existing transverse crack. Proguard is another Amoco product manufactured as a reflection cracking reducer. It is another tape approximately 18 inches wide, significantly heavier than Petrotac, and not self-adhesive. Applying the product was a significant challenge. The first section placed was in the driving lane over cracks location between 2,220 to 2,467 feet in the evaluation section (Table 1). AC10 tack coat was applied using the spray bar on the asphalt distributor. This method applied too much tack coat and resulted in the overlay asphalt shoving during compaction. The second attempt at placing Proguard occurred in the passing lanes. This time an SS-1h emulsion was used as a tack coat. However, the SS-1h did not provide enough adhesion for the heavy Proguard. The result was pickup of the Proguard on the tires of the asphalt haul trucks. Concrete nails were used to attach the Proguard to the pavement in addition to the SS-1h. Although this method helped, pickup on the tires was not prevented. The third method of attachment reverted back to the AC10 tack coat for cracks located between 6,083 to 6,416 feet in the evaluation section. However, instead of applying the tack with the distributor, the material was painted on the Proguard with a broom. This was the most successful method of attachment.   Figure 8 shows the placement of Proguard.

Figure 8 – Proguard placement.

In the next section, Crack Filler Type A and Crack Filler Type B in routed and non-routed joints were placed for evaluation in four different test locations. All routed as well as non-routed cracks were thoroughly cleaned prior to filling with sealer.

Crack Filler Type A is crack filler distributed by Vance Brothers. This product is manufactured to meet the requirements described in ASTM D3405-Standard Specification for Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements. This crack filler was applied to all sections except the controls and sections containing Crack Filler Type B. All sections had cracks blown clean using compressed air prior to filling; in addition, sections with cracks located at 2,535 through 2,654 feet in the evaluation section and cracks located at 6,486 to 6,703 in the evaluation section (Table 1), were routed before being cleaned with compressed air (Table 1). Figure 9 shows the equipment used to clean the cracks before the sealant was placed.

Figure 9 – Equipment used to clean cracks prior to filling with sealant.

The next evaluation contained Crack Filler Type B. Crack Filler Type B is manufactured by Deery American Corporation and is called “Super Stretch”. Specifications for this product are contained in Appendix B. This crack filler was placed in cracks located between 3,036 to 3,579 feet in the evaluation section and cracks located between 7,086 to 7,699 feet in the evaluation section (Table 1). Cracks located between 3,036 to 3,347 feet in the evaluation section and cracks located between 7,086 to 7,340 feet in the evaluation section (Table 1) were routed and blown out using compressed air; others were only blown out.

Routing of irregular crack patterns provides better surfaces for crack filler material to seal the transverse cracks. Figure 10 shows the equipment used to rout the crack prior to filling it.

Figure 10 – Equipment used to rout the crack prior to filling it with sealant.

Conventional crack filling tools were used to place the sealant after making sure all moisture was removed. Figure 11 shows the filling of a crack after it was prepared.

Figure 11 – Filling the crack with crack sealant.

Table 1 – Location of evaluation sections and number of cracks evaluated.

Extra 1-1/2 inch millings		
	Distance from start of section	
Section Begins at MP.125.64	Beginning and ending of section (ft)	Number of cracks evaluated
Control	**0 to 580.8**	**5**
Petromat 4597	**580.8 to 1320.0**	**6**
Petromat 4599	**1320.0 to 1900.8**	**6**
Petrotac	**1900.8 to 2217.6**	**6**
Proguard	**2217.6 to 2534.4**	**6**
Crack Filler Type A Routed	**2534.4 to 2745.6**	**6**
Crack Filler Type A Not Routed	**2745.6 to 3009.6**	**6**
Crack Filler Type B Routed	**3009.6 to 3379.9**	**6**
Crack Filler Type B Not Routed	**3379.2 to 3590.4**	**6**

Plan Milling		
	Distance from start of section	
Section Begins at MP.125.64	Beginning and ending of section (ft)	Number of cracks evaluated
Control	**3590.0 to 4171.20**	**5**
Petromat 4597	**4171.2 to 4752.0**	**6**
Petromat 4599	**4752.0 to 5702.4**	**6**
Petrotac	**5702.4 to 6072.0**	**8**
Proguard	**6072.0 to 6441.6**	**8**
Crack Filler Type A Routed	**6441.6 to 6705.6**	**6**
Crack Filler Type A Not Routed	**6705.6 to 7075.2**	**6**
Crack Filler Type B Routed	**7075.2 to 7392.0**	**6**
Crack Filler Type B Not Routed	**7392.0 to 7699.0**	**6**

3.0 POST-CONSTRUCTION EVALUATION

Although the warranty specifications on this project addressed items other than the recurrence of reflective cracking, the research portion of this study focused on the performance of crack reduction methods. The dominant transverse cracking that was evident on this section of the Interstate pavement was thought to be mitigated by various crack prevention treatments as shown in the previous pictures. Prior experience with pavement fabrics showed that such treatment typically was equal to one-inch of HBP when the fabric was used to reduce or retard reflective cracking. However, little research has been done by research on single crack treatments with materials such as Petrotac and Proguard in reducing or retarding transverse cracking.

Depending on the extent and severity of existing cracking, CDOT typically specifies crack filling to be done before resurfacing pavements. The ASTM D3405 specifications for such crack filling operations are used. To establish existing conditions, existing cracking patterns were documented prior to commencement of construction, and their exact locations marked on maps so that re-emerging cracks can be identified and correlated to previous cracking patterns. Five to seven transverse cracks were identified in each treatment test section. All test sections were marked with paint after the paving project was completed. After the paving project was completed, signs were placed in the highway right-of-way to ensure the exact test section location for the duration of the evaluation period (Figure 12).

Figure 12 – Signs were placed in the right of way to identify each evaluation section.

Although the evaluation was to be conducted by representatives from the paving contractor, CDOT Research personnel also performed annual pavement evaluations for the next three years. The first of these evaluations took place in the spring of 1999 (almost one year after construction).

Minimal transverse cracking was observed in the course of this evaluation. Any of the observed cracks were located almost exclusively in the shoulder areas and acceleration and deceleration lanes. Only a small percentage of the transverse cracking extended into the driving lanes. Evaluation continued for the subsequent two years.

The evaluations consisted primarily of mapping the recurrence of cracks in the test sections as illustrated in Figures 3 and 4. The contractor had identified specific cracks in each of the treatment sections. Reference distances with respect to the beginning of the test section were recorded. Members of the Research Branch verified the location of these crack locations prior to the start of the rehabilitation project as shown in Table 1. An average of six cracks were identified in each of the treatment methods. The contractor placed color-coded survey stakes along the road, and after paving was complete, the legends as shown in Figure 3 and 4, were used to place markings on the road shoulder. Permanent signs, as mentioned earlier in the report, were installed to ensure the section identification for the three-year evaluation period. Test section lengths varied from approximately 200 feet to 950 feet for the transverse cracking evaluation and 1,300 feet for the longitudinal cracking evaluation sections. The number of pre-existing cracks that were to be evaluated for the three-year period ranged from typically 6 cracks to 8 cracks per treatment section.

Shown in Figure 13 is a typical Petrotac treatment after the trenched section had been overlaid. The picture shows some of the excess tack material bleeding through the 1-1/2 inch overlay. The excessive tack was not apparent once the final lift was placed. Subsequent tack coat applications were reduced to ensure that the tack did not bleed through the mat and also to eliminate the shoving of the Petrotac fabric.

Figure 13 –Typical Petrotac treatment after the trenched section has been overlaid.

Figures 3 and 4 show the test section layout. All treatments were repeated in the two evaluation segments. The difference is the extra depth of milling, as indicated in Figure 2. The driving lane (lane No. 2) was milled an additional 1-1/2 inches (trench), while the remainder (passing lane, inside and outside shoulders) of the pavement was milled to 1-inch depth for surface correction. This, in effect, gave this portion of the pavement an extra thickness to avoid reflection cracking. The northbound lanes were milled to a one-inch depth prior to the new overly. Two test sections were established to evaluate recurrence of longitudinal construction joint cracking. “T-Bond” was used in bottom and top lift, and in the top lift only at two test locations (Figure 5).

The evaluation described in this report deals mainly with proposed implementation of several products and methods to mitigate the most likely failures on this project at minimal additional cost to CDOT. It is this area the Research Branch was asked to evaluate.

Although the research team mapped all cracks, the emphasis was on transverse cracking, because the various prevention treatments were typically applied to those types of cracking. The exception was the Petromat fabric, which, was placed in areas that had extensive alligator cracking.

Although a pictorial representation of the cracking is available from the crack maps, the more important issue was to identify which of the transverse cracks were recurring at different time intervals. Table 2 is a listing of all transverse cracks that were identified prior to rehabilitation. Over the three-year evaluation period, any cracking that could be attributed to reflective cracking was reported, regardless of its severity or extent.

Table 2 – Transverse cracks identified prior to construction and the treatment performance.

Section Begin from M.P. 125.64 (Feet)	Extra 1-1/2 inch milling (Begin M.P. 125.64)					Section Begin from M.P. 125.64 (Feet)	Plan Milling (Begin M.P. 124.98)				
	Distance from Section Start	Distance between Cracks	Crack Recurrence Year				Distance from Section Start	Distance between Cracks	Crack Recurrence Year		
			1	2	3				1	2	3
Control	0					3590.4	3612				
	104	104					3695	83			
	183	79			X		3794	99			
	283	100					3909	115			X
	417	134					4020	111			X
	510	93					4101	81			
580.8	594	84				4171.2	4211	110			
Petromat	645	51					4304	93			
120	702	57					4413	109			
	781	79					4514	101			X
	833	52					4640	126	X		
	945	112					4740	100			
1056	1063	118				4752	4799	58	X		
Petromat	1187	124					4924	126			
90	1343	156					5089	165			
	1483	140					5263	174			
	1656	173					5379	116			
	1752	96					5653	274			
1900.8	1930	178				5702.4	5747	94			
Pertrotac	1991	61					5816	69			
	2033	42					5866	50			
	2082	49					5899	33			
	2137	55					5930	31			
	2171	34					5963	33			
2217.6	2220	49					6011	48			
Proguard	2284	64					6048	37			
	2340	56				6072	6083	35			
	2410	70					6125	42			
	2439	29					6162	37			
	2467	28					6211	49			
2534.4	2515	48					6266	55			
Crack Filler	2535	20					6304	38			
Type A/R*	2562	27					6327	23	X		
	2580	18					6416	89			
	2597	17				6441.6	6486	70	X		
	2654	57					6527	41	X		
2745.6	2723	69					6577	50	X		
Crack Filler	2792	69					6624	47			
Type A/NR*	2825	33					6639	15			
	2892	67					6703	64	X		
	2941	49				6705.6	6746	43			
	3003	62					6812	66	X		
3009.6	3036	33					6855	43			X
Crack Filler	3065	29					6897	42			X
Type B/R*	3140	75					6947	50			
	3276	136					6993	46			
	3332	56				7075.2	7086	93			
	3347	15					7186	100	X		
3379.2	3383	36					7259	73			
Crack Filler	3434	51					7293	34			
Type B/NR*	3487	53					7305	12			
	3519	32					7340	35			X
	3547	28				7392	7405	65			
	3579	32					7488	83	X		
							7530	42	X		
							7566	36	X		
							7530	64			

***R – Routed, *NR – Not Routed**

4.0 CONCLUSION

As can be seen in Table 2, less than a quarter of the cracking recurred within one year after construction. Furthermore, the cracking that did appear was primarily found in the pavement that had the one-inch milling “Plan Milling” prior to a 4-inch overlay. Only the control section in the “Extra Millling” segment (additional 1-1/2 inch hot-mix thickness), which had no existing crack treatment, had one recurring crack (2%) after three years.

The 21% recurrence of transverse cracking in the Plan Milling section is too excessive for a successful rehabilitation project. An additional 10% transverse cracking was observed after the three-year evaluation period, resulting in a total of 32% recurrence at the end of the Warranty period. Although the severity of the observed cracks was in the low category, it is most likely that with any presence of moisture these cracks will become a problem to maintenance in the near future.

The performance evaluation of the T-Bond treatment, which is not shown in Table 2, was somewhat surprising. It was assumed that crack reduction material placed in the bottom and top lift would perform better than the alternate treatment, which only had the treatment in the top lift. But the only cracks to resurface after three years were observed in the top and bottom lift section treatment. The reflective crack is offset from the original construction joint by the width of the T-Bond tape (approximately 3 inches). It is not possible to draw any firm conclusion that would explain such behavior without further experiments and material tests.

There was, however, an inordinate amount of longitudinal construction joint failure throughout the project, as validated by the Pavement Evaluation Panel (PET) after the end of the warranty period (3 years). The Principal Investigator of this report was present at the evaluation, and the series of photographs (Figures 14, 15, 16, 17, 18, 19, 12, 21, 22, and 23) will demonstrate this failure mode.

Although it is apparent from the cracking that the additional milling reduced the amount of reflective cracking after three years, the majority of this research was based on visual observations, and consequently making sound engineering judgment on the outcome would not be appropriate.   It is encouraged to conduct a follow-up evaluation at 5 years and 10 years to determine if any differences can be identified at that time.

Figure 14 – Longitudinal construction joint failure at end of warranty period. Longitudinal crack is evident throughout most of the project.

Figure 15 - Close-up view of a fairly open construction joint crack.

Figure 16 - Coring operation on the affected joint.

Figure 17 - Full-depth (11inch) pavement with exploratory core sample removed. Stripped aggregate material can be seen adjacient to the core hole.

Figure 18 - Lack of AC as result of stripping at the construction joint.

Figure 19 - Fragmented and badly stripped cores.

Figure 20 - In order to determine the lateral extent
of stripping, additional cores were obtained at six-inch
intervals transversely to the construction joint.

Figure 21 - It is apparent from this picture that the stripping
occurs only immediately at the joint. Only the core sample
right over the construction joint (right core) has evidence of stripping.

Figure 22 - This photo shows an offset crack from the construction joint, possibly the reflective crack from the original construction joint.

Figure 23 -The resulting core verifies the crack propagation is emanating from the underlying existing pavement layer.

Regardless of the propagation mechanism/cause, the existence of such cracking will eventually weaken the pavement due to moisture, temperature, and traffic loading leading to stripping, as seen in some of the previous photos.

The recommendation of the PET led to a corrective project, consisting of milling approximately a one-foot-wide section along the construction joint and patching the milled area. Although such remedial action will prolong the life of this project for some time, the remedial action resulted in the replacement of one open joint with two well-sealed joints, which could ultimately exacerbate the problem (Figure 24).

Figure 24 – This photo shows the initial longitudinal joint crack on the left.   Then the contractor milled and filled one foot to the right of the crack. Eventually this pavement cracked on the edge of the 1-foot mill and fill, creating 2 cracks.

5.0 IMPLEMENTATION

The Colorado Department of Transportation will continue to track and monitor performance of warranted projects through the PET. Innovations, such as the crack reduction treatments that were incorporated into this project will continue to be encouraged. However, on warranty projects the department does not specify treatments to be incorporated. Because this decision is solely the contractor's, it will be their responsibility to build a pavement that will perform under the expectation of the warranty. CDOT continues to allow regions to use warranted projects however the cost benefit and performance issues have not been quantified.

6.0 REFERENCES

1. Aschenbrener, T. B. and DeDios, R.E., "Cost-Benefit Evaluation Committee- Materials and Workmanship Warranties for Hot Bituminous Pavement," Colorado Department of Transportation, CDOT-DTD-R-2001-18, December 2001.