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DEPARTMENT OF TRANSPORTATION

Research Project # 2001-060
Evaluation of Concrete Pavement Cracking Rehabilitation

Final Report
August 2009

Prepared By:
Dave Serra and J. Alberto Medina

Evaluations and Research Section
Engineering Technology and Information Division
Bureau of Construction and Materials

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16. Abstract

A large amount of funds are spent each year by the Department on repairing and maintaining concrete pavements. To determine an appropriate repair method treatment for the severity of these cracks will result in cost saving to the Department and a higher level of service to the motorist public. In this Research different repair alternatives were used to determine their effectiveness. Dowel Bar Retrofit, Full Depth Patching and Steel Mesh Paving are the repair methods covered in this report.

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METRIC CONVERSION FACTORS		
Convert From	**To**	**Multiply By**
Length		
Foot	Meter (M)	0.3048
Inch	Millimeter (mm)	25.4
Yard	Meter (M)	0.9144
Mile (Statute)	Kilometer(KM)	1.609
Area		
Square Foot	Square Meter (M^2)	0.0929
Square Inch	Square Centimeter (CM^2)	6.451
Square Yard	Square Meter(M^2)	0.8361
Volume		
Cubic Foot	Cubic Meter (M^3)	0.02832
Gallon (U.S. Liquid)	Cubic Meter (M^3)	0.003785
Gallon (CAN. Liquid)	Cubic Meter (M^3)	0.004646
Ounce (U.S. Liquid)	Cubic Centimeter (CM^3)	29.57
Mass		
Ounce-Mass (AVDP)	Gram(G)	28.35
Pound-Mass (ADVP)	Kilogram (KG)	0.4536
Ton (Metric)	Kilogram (KG)	1,000
Ton (Short, 2,000 LBM)	Kilogram (KG)	907.2
Density		
Pound-Mass/Cubic Foot	Kilogram/Cubic Meter (KG/M^3)	16.02
Mass/Cubic Foot	Kilogram/Cubic Meter (KG/M^3)	0.5933
Pound-Mass/Gallon (U.S.)	Kilogram/Cubic Meter (KG/M^3)	119.8
Pound-Mass/Gallon (CAN)	Kilogram/Cubic Meter (KG/M^3)	99.78
Temperature		
Degree Celsius (C)	Kelvin (K)	$T_K = (T_C + 273.15)$
Degree Fahrenheit (F)	Kelvin (K)	$T_K = (T_F + 459.67)/1.8$
Degree Fahrenheit (F)	Degree Celsius (C)	$T_C = (T_F - 32)/1.8$
Illumination		
Foot-Candles	Lux (LX)	10.76
Foot-Lamberts	Candela/Meter sq. (CD/M^2)	3.426
Force and Pressure or Stress		
Pound-Force	Newton (N)	4.45
Pound-Force/sq. in.	Kilopascals (KPA)	6.89

EXECUTIVE SUMMARY

In 1995, District 3-0 noticed mid-slab cracking in the Portland Cement Concrete (PCC) sections of roadways constructed since 1992. Initially, District 3-0 attributed the cracks to problems with culverts, pipes, and bridges.

In the summer of 1998, District 3-0 began a systematic inventory of the PCC cracked slabs on Interstate 80. The purpose of this inventory was to quantify the extent of the distresses, determine the total number of cracks, monitor their growth, and note any cracking patterns that may have developed. Some roadways projects contained as many as 40 cracks per segment after only three years of service.

The Department decided to experiment with a concrete section on Interstate 80 located in Valley Township, Montour County. The project is located in the eastbound direction, east of the Danville exit (State Route 0054 interchange) from Segment 2240 Offset 0000 to Segment 2244 Offset 2675. The total length of the project was 5,305 ft and was divided into nine experimental zones (See Table X).

The rehabilitation methods to the nine designated zones consisted of both improvements and total reconstruction, including: Full Depth Reconstruction, Concrete Patching, Dowel Bar Retrofit (DBR), Steel Mesh Paving, Structural Bituminous Overlay or a combination of the above.

The only zone with a concrete wearing surface (Zone 1), showed minor spalling along the edges of the concrete patching and DBR areas after two (2) years. In addition, some high severity cracks repaired with DBR and left exposed started to develop new crack patterns. This showed that full depth patching was a better alternative for this type of distress. Zone 1 was resurfaced with a bituminous overlay in 2007 to prevent further deterioration and loss of smoothness.

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INTRODUCTION

Mid-slab cracking is considered to be one of the main causes of concrete pavement deterioration. Mid-slab cracking may cause subsequent loss of load transfer and faulting. This faulting has significant structural implications since the dynamic loading from a rough pavement reduces structural life. Mid-slab cracking can be due to a number of factors, including:

- Excessive early-age loading
- Poor joint load transfer
- Inadequate or non-uniform base support
- Excessive slab curling or warping due to temperature gradients
- Insufficient slab thickness
- Inadequate joint sawing
- Materials deficiencies
- Improper control of the shrinkage of the concrete in the early stages of curing

A large amount of funds are spent each year by the Department on repairing and maintaining cracked pavements. To determine an appropriate repair method treatment for the severity of these cracks will result in cost saving to the Department and a higher level of service to the motorist public.

The Pennsylvania Department of Transportation (PennDOT), in agreement with the Federal Highways Administration (FHWA), has a set of Guidelines for Pavement Preservation for Rigid Pavements (Publication 242, Appendix G). As a general rule, concrete pavements with no more than 10% patching are economically viable to repair; projects with higher patching quantities have to justify their method comparing different alternatives.

In 2001, the Department chose to experiment with a concrete section of Interstate 80 located in Valley Township, Montour County. The project consisted of approximately one mile of roadway in the eastbound direction located east of the Danville exit (State Route 0054 interchange) from Segment 2234 Offset 1270 to Segment 2250 Offset 0455. The project was divided into nine zones and each zone contained a different rehabilitation method. The rehabilitation methods consist of both improvements and total reconstruction to State Route 80, Section 074. PennDOT's traditional repair strategy for mid-slab cracking is full-depth patching per Publication 408, *Construction Specifications*, Section 516. In addition to full-depth patching, DBR's and Steel Paving Mesh were utilized.

Both methods are designed to address the growth of existing cracks and to mitigate the migration of reflective cracks in bituminous overlays.

PROJECT SUMMARY

The research project is located in the eastbound lanes of Interstate 80 on approximately one mile of roadway East of the Danville exit (State Route 0054 interchange) from Segment 2234, Offset 1270 to Segment 2250, Offset 0455.

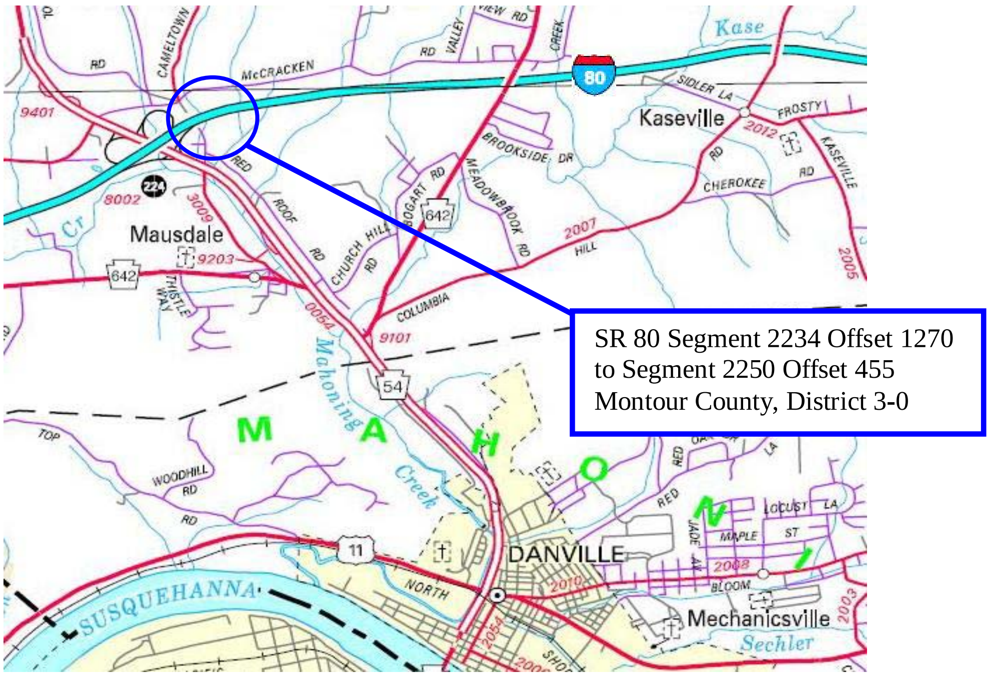

Figure 1, Construction Location

This section of Interstate 80 was originally constructed using Reinforced Concrete Pavement in 1963, with 8” of Open Grade subbase (OGS). In 1998 the surface of the pavement was Diamond Ground. Later in 1993, the section was reconstructed using the existing concrete pavement as a subbase (rubblized to 8” max) over this subbase was placed a base of 2.5” of OGS and 13” of Plain Cement Concrete with skewed saw-cut joints every 20 feet.

The Department decided to experiment with a concrete section on Interstate 80 located in Valley Township, Montour County. The project is located in the eastbound direction, East of the Danville exit (State Route 0054 interchange) from Segment 2240 Offset 0000 to Segment 2244 Offset 2675. The total length of the project was 5,305 ft and was divided into nine Experimental Zones (See Table 1).

Table 1, Experimental Zones

Zone	Beginning (Segment/Offset)	Ending (Segment/Offset)	Length (ft)
1	2240/0000	2240/0707	707
2	2240/0707	2240/1400	693
3	2240/1400	2240/1647	247
4	2240/1647	2244/0574	1,557
5	2244/0574	2244/1045	471
6	2244/1045	2244/1545	500
7	2244/1545	2244/1801	256
8	2244/1801	2244/2081	280
9	2244/2081	2244/2675	594
Total	2240/0000	2244/2675	5,305

The Project Contract number : 003062 (CMS project)
Project General Contractor : Eastern Industries
Construction Date : May 7, 2001 to August 22, 2001
Average Daily Traffic (2001) : 15,400
Average Daily Traffic (2011) : 18,772 (Estimated)
Estimated Repair Life : 10 Years

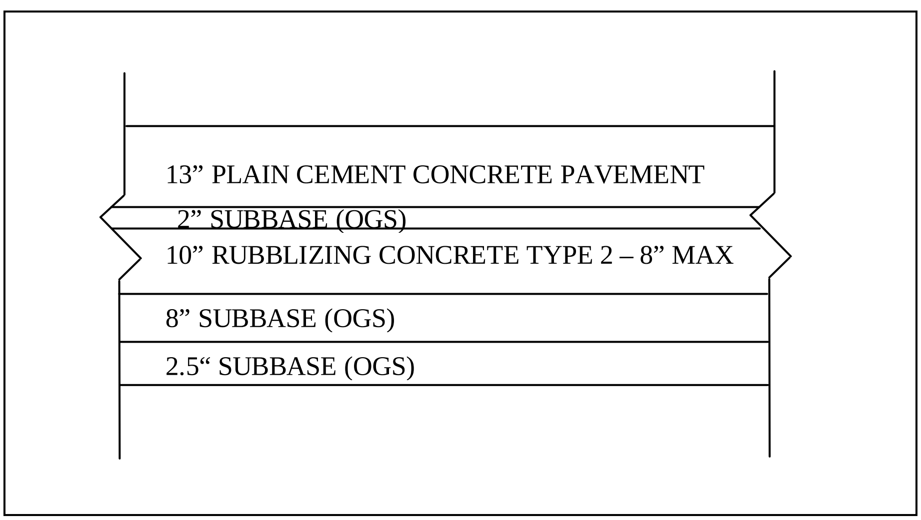

Figure 2, Typical Roadway Section

The follow is the Roadway historic information found in the PennDOT Roadway Management System.

Table 2, Pavement History from RMS

YEAR	CONSTRUCTION / TREATMENTS	ADT	% TRUCK	IRI (In/Mi)
2007		10,804	26	54
2005				52
2004		14,872	26	52
2003	REHABILITATION PROJECT PATCHING, DBR, OVERLAY			50
2002		16,196	26	75
1996		12,634	26	
1995				64
1993	RECONSTRUCTION 13” PLAIN CEMENT CONCRETE 2.5” OGS SUBBASE 8” RUBBLIZING TYPE 2 – 8” MAX			147
1992				126
1991				113
1988	CPR (WITH DIAMOND GRINDING)			
1971		13,700	26	
1963	CONSTRUCTION 10” REINFORCED CEMENT CONCRETE 8” OGS SUBBASE			

Table 3, Record of Pavement layers

LIMIT OF WORK	PLAIN CEMENT CONCRETE PAVEMENT	1993	13
ADJACENT TO	OGS SUBBASE	1993	2.5
SEGMENT 2234 OFFSET 1370	RUBBLIZING TYPE 2 – 8” MAX	1993	10
	DRAINABLE BASE W/ EDGE DRAINS	1993	
	OUT OF SERVICE RECONSTRUCTED	1993	
	OGS SUBBASE	1963	8
SEGMENT 2234 OFFSET 1370 TO	PLAIN CEMENT CONCRETE PAVEMENT	1993	13
SEGMENT 2250 OFFSET 0355	OGS SUBBASE	1993	2.5
	RUBBLIZING TYPE 2 – 8” MAX	1993	10
	DRAINABLE BASE W/ EDGE DRAINS	1993	
	OUT OF SERVICE RECONSTRUCTED	1993	
	OGS SUBBASE	1963	8
LIMIT OF WORK	PLAIN CEMENT CONCRETE PAVEMENT	1993	13
ADJACENT TO	OGS SUBBASE	1993	2.5
SEGMENT 2250 OFFSET 0355	RUBBLIZING TYPE 2 – 8” MAX	1993	10
	DRAINABLE BASE W/ EDGE DRAINS	1993	
	OUT OF SERVICE RECONSTRUCTED	1993	
	OGS SUBBASE	1963	8

Table 4, Description of Severity of Cracks Levels, from Publication No.336 "Automated Pavement Condition Surveying Field Manual"

LOW SEVERITY CRACK: Average Crack Width≤ hairline Fatigue cracking consisting of only longitudinal cracks in the outside wheel path. The size of the crack opening is often referred to as hairline since it is the width of a hair; just barely discernable. This severity rating indicates a pavement is beginning to suffer from structural loading but the cracks do not yet allow water to enter the pavement structure.
MEDIUM SEVERITY CRACK: Average Crack Width > hairline and≤ 0.25 in Fatigue cracking consisting of longitudinal and interconnecting cracks typically forming a diamond shaped, chicken wire or alligator's hide pattern. The crack width ranges from fine, just over hairline cracking to widths that allow water to penetrate the surface as well as loss of some material from the surface or spalling.
HIGH SEVERITY CRACK: Average Crack Width > 0.25 in Fatigue cracking consisting of longitudinal and interconnecting cracks typically forming a diamond shaped chicken wire or alligator's hide pattern. The cracks are sufficiently wide to allow water to enter the pavement surface. The width measurement includes loss of surface material or crack spalling.

CONSTRUCTION SUMMARY

ZONE 1 (707 ft)

SEGMENT 2240 OFFSET 0000 TO SEGMENT 2240 OFFSET 0707

LOW SEVERITY CRACK:	DBR
MEDIUM SEVERITY CRACK:	DBR
HIGH SEVERITYCRACK :	CONCRETE PATCH

ZONE 2 (693 ft)

SEGMENT 2240 OFFSET 0707 TO SEGMENT 2240 OFFSET 1400

LOW SEVERITY CRACK:	DBR
MEDIUM SEVERITY CRACK:	DBR
HIGH SEVERITYCRACK :	CONCRETE PATCH

OVERLAY;

1 ½" Superpave, HMA Wearing Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL E

2 ½" Superpave, HMA Binder Course, RPS, PG 64-22, 10 to < 30M ESALS, 19mm

Variable Depth HMA Scratch Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL L

ZONE 3 (247 ft)

SEGMENT 2240 OFFSET 1400 TO SEGMENT 2240 OFFSET 1647

LOW SEVERITY CRACK:	DBR
MEDIUM SEVERITY CRACK:	DBR
HIGH SEVERITYCRACK :	CONCRETE PATCH

DBR @ MIDPOINT ON UNBROKEN SLABS

OVERLAY;

1 ½" Superpave, HMA Wearing Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL E

2 ½" Superpave, HMA Binder Course, RPS, PG 64-22, 10 to < 30M ESALS, 19mm

Variable Depth HMA Scratch Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL L

ZONE 4 (1,557 ft)

SEGMENT 2240 OFFSET 1647 TO SEGMENT 2244 OFFSET 0574

LOW SEVERITY CRACK:	REMOVE ALL MAIN LANE PAVEMENT SLABS
MEDIUM SEVERITY CRACK:	AND REPLACE WITH 14" CONCRETE
HIGH SEVERITYCRACK :	PAVEMENT PATCHING TYPE C

OVERLAY;

1 ½" Superpave, HMA Wearing Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL E

2 ½" Superpave, HMA Binder Course, RPS, PG 64-22, 10 to < 30M ESALS, 19mm

Variable Depth HMA Scratch Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL L

ZONE 5 (471 ft)
SEGMENT 2244 OFFSET 0574 TO SEGMENT 2244 OFFSET 1045
LOW SEVERITY CRACK: DBR
MEDIUM SEVERITY CRACK: DBR
HIGH SEVERITYCRACK : CONCRETE PATCH
STEEL PAVING MESH W/SLURRY SEAL
OVERLAY;
1 ½" Superpave, HMA Wearing Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL E
2 ½" Superpave, HMA Binder Course, RPS, PG 64-22, 10 to < 30M ESALS, 19mm
Variable Depth HMA Scratch Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL L

ZONE 6 (500 ft)
SEGMENT 2244 OFFSET 1045 TO SEGMENT 2244 OFFSET 1545
LOW SEVERITY CRACK: NO REPAIR
MEDIUM SEVERITY CRACK: DBR
HIGH SEVERITYCRACK : CONCRETE PATCH
STEEL PAVING MESH W/SLURRY SEAL
OVERLAY;
1 ½" Superpave, HMA Wearing Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL E
2 ½" Superpave, HMA Binder Course, RPS, PG 64-22, 10 to < 30M ESALS, 19mm
Variable Depth HMA Scratch Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL L

ZONE 7 (256 ft)
SEGMENT 2244 OFFSET 1545 TO SEGMENT 2244 OFFSET 1801
LOW SEVERITY CRACK: DBR
MEDIUM SEVERITY CRACK: DBR
HIGH SEVERITYCRACK : CONCRETE PATCH
DBR @ MIDPOINT ON UNBROKEN SLABS
OVERLAY;
1 ½" Superpave, HMA Wearing Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL E
2 ½" Superpave, HMA Binder Course, RPS, PG 64-22, 10 to < 30M ESALS, 19mm
Variable Depth HMA Scratch Course, RPS, PG 64-22, 10 to < 30M ESALS, 9.5mm, SRL L

ZONE 8 (280 ft)
SEGMENT 2244 OFFSET 1801 TO SEGMENT 2244 OFFSET 2081
LOW SEVERITY CRACK: DBR
MEDIUM SEVERITY CRACK: DBR
HIGH SEVERITYCRACK : CONCRETE PATCH
DBR @ MIDPOINT ON UNBROKEN SLABS

ZONE 9 (594 ft)

SEGMENT 2244 OFFSET 2081 TO SEGMENT 2244 OFFSET 2675

LOW SEVERITY CRACK:	DBR
MEDIUM SEVERITY CRACK:	DBR
HIGH SEVERITYCRACK :	CONCRETE PATCH

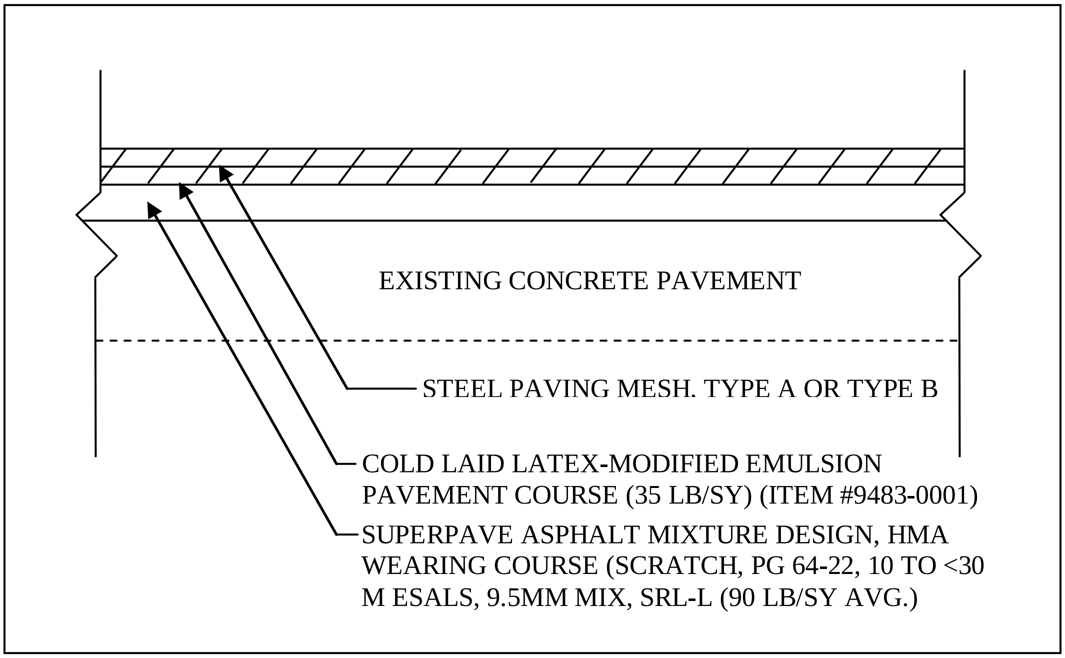

Figure 3, Steel Paving Mesh Cross Section

Table 5, Items Costs

Item	Unit Measure	Unit Cost	Plan Quantity	Final Quantity	Item Cost
Concrete Pavement Patching Type A 13” Depth, Reinforcement Method 2	S.Y.	$220.00	48.0	48.4	$10,648.00
Concrete Pavement Patching Type C, 14” Depth, Reinforcement Method 1	S.Y.		4,120.0	4,186.09	$355,817.65
Concrete Pavement Patching Type A, 13” Depth, Reinforcement Method 1	S.Y.	$200.00	72.0	118.39	$23,678.00
DBR	Each	$50.00	1,704.0	1739.0	$86,950.00
Accelerated Concrete Pavement Patching Type A, 13” Depth, Reinforcement Method 1	S.Y.	$240.00	38.0	65.33	$15,679.20
Concrete Shoulder, Type 2, Special	S.Y.	$200.00	24.00	13.34	$2,668.00
Steel Paving Mesh, Type L and Type H	S.Y.	$8.50	2,878.0	2,838.17	$24,124.45
Cold Laid Latex-Modified Emulsion Pavement Course	S.Y.	$5.80	2,878.0	2,838.17	$16,461.39
Joint Rehabilitation Special	L.F.	$1.90	5,876	5,471.30	$10,395.47

Table 6, Comparison of Section Cost by Repair Type

Repair Type		Area	Unit Cost	Quantity	Total Cost
Steel Paving Mesh	One full slab coverage(coverage of the entire area between transverse joints)	12' wide by 20' long	$8.5 SY	27 SY	$229.50
DBR	4 dowel bars per wheel path, per 2 wheel paths	One joint in one lane	$8 each	8 DBR's	$400
Concrete Pavement Patching	Type A, 14" depth	12' wide by 6' long	$85 SY	8 SY	$680

CONCLUSIONS

The evaluation of this project showed that DBR is a viable solution for repairing low severity cracks, where slab stabilization is required. DBR also showed to be a faster repair when compared to concrete patching. The DBR repair method would only be cost effective on a large scale basis due to the specialized equipment involved. This is shown by comparing the condition of the DBR's and type A patches in Zone 1.

Steel Paving Mesh showed to retard reflective cracking but by no means should be used on concrete pavements that are not sound prior Concrete Pavement Restoration (CPR)

In the section with exposed DBR's, some spalling occurred and the IRI started to deteriorate rapidly, specifically when DBR was used to repair high severity cracks, showing in this case a full depth patch as better alternative. The section with DBR protected by an overlay showed better performance over time than the exposed sections.

RECOMMENDATIONS

Due to the high cost of the CPR operations, it is recommended to monitor concrete pavements and at the first sign of deterioration start documenting the pavement condition through detailed condition surveys quantifying and categorizing the severity of cracks. Every year PennDOT performs an automated condition survey on the Interstate System, but the level of detail is not adequate to monitor deterioration at a project level, making a detailed condition survey of the project necessary.

It is important to acknowledge that concrete pavements that need more than 8% of full depth patching exhibit a deterioration that may change the scope of work from concrete restoration to reconstruction. An economic evaluation of the different alternatives has to be made at this point to calculate and justify the alternative selected.

It is recommended to use deterioration models with historical condition data to give an expected lifespan of the road and anticipate the need of CPR. Suitable cracks for DBR’s can deteriorate to the point that concrete patching is needed instead. The number of DBR’s and patching quantities increases every year raising the repair cost rapidly.

In order to determine realistic quantities for a project to have the right project scope, an expected increase in deterioration has to be computed based on the previous speed of deterioration (deterioration model) and anticipated construction time.

A combination of CPR and asphalt overlay showed to be the best alternative to preserve the structural integrity of the concrete slabs.

CPR is recommended where much of the pavement slab remains in good condition with only limited areas of deterioration/loss of riding quality due to problems at joints and cracks.

APPENDIX A

August 26, 2004

ZONE CONDITION EVALUATION

Zone 1

This zone consists of the DBR for the low and medium severity cracks and accelerated concrete patching, type A, with 6” x 12” Wire Welded Fabric (WWF) reinforcing for high severity cracks. There is no bituminous overlay in this zone.

Crack Survey 08/26/04

Travel Lane: 36 slabs

12 New Cracks
4 Concrete Patches with No Distress
3 Concrete Patches with Distress
10 DBR’s with Spalling
7 DBR’s Cracked

Passing Lane: 36 slabs

8 New Cracks
2 Concrete Patches with No Distress
1 DBR with Minor Spalling

Zone 2

This zone consists of the DBR for the low and medium severity cracks and Class AA concrete patching, with 6” x 12” WWF reinforcing for high severity cracks. The bituminous overlay including saw and seal begins in this zone. There was one small crack observed along the edge of the travel lane at Offset 722 at the time of this inspection.

Zone 3

This zone consists of the DBR for the low and medium severity cracks and Class AA concrete patching, with 6” x 12” WWF reinforcing for high severity cracks. There are pre-emptive sawcuts and DBR’s added at the midpoint of unbroken slabs. There is bituminous overlay including saw and seal in this zone. There were no problems observed at the surface of the overlay at the time of this inspection.

Zone 4

This zone consists of full depth concrete patching. Existing concrete was excavated down to the existing rubblized concrete roadway. Approximately 4” of 19 mm binder was placed under 14” of Class AA concrete with 6” x 12” WWF for reinforcing. Joints were placed on a 90-degree angle with 16’ spacing, center to center, between joints.

There is bituminous overlay including saw and seal in this zone. There were no problems observed at the surface of the overlay at the time of this inspection.

Zone 5

This zone consists of the DBR for the low and medium severity cracks and Class AA concrete patching, with 6” x 12” WWF reinforcing for high severity cracks. Steel paving mesh with a slurry seal (35 LB/SY) overlay was used in this zone. The superpave overlay in this zone was not sawed and sealed due to the steel paving mesh. There were no problems observed at the surface of the overlay at the time of this inspection.

Zone 6

This zone consists of the DBR for the medium severity cracks. No DBR’s were made on the low severity class. For the high severity cracks, Class AA concrete patching, with 6” x 12” WWF reinforcing was used. Steel paving mesh with a slurry seal overlay was used in this zone. The superpave overlay in this zone was not sawed and sealed. There were no problems observed at the surface of the overlay at the time of this inspection.

Zone 7

This zone consists of the DBR for the low and medium severity cracks and Class AA concrete patching, with 6” x 12 “ WWF reinforcing for high severity cracks. There are pre-emptive sawcuts and DBR’s added at the midpoint of unbroken slabs. This zone ends the bituminous overlay and the saw and seal. There was one transverse crack at offset 1780.

Zone 8

This zone consists of the DBR for the low and medium severity cracks. Class AA concrete patching, with #5 transverse bar and #6 longitudinal bar reinforcing, was used on the high severity cracks. There are pre-emtive sawcuts and DBR’s added at the midpoint of unbroken slabs. There is no bituminous overlay in this zone. The final survey of this zone was on June 6, 2003 as this zone was reconstructed with the SR 80 81M project.

Crack Survey 06/06/03

Travel Lane: 14 slabs

2 Concrete Patches with No Distress
2 DBR's with Spalling
9 DBR's Cracked
1 DBR with no distress

Passing Lane: 14 slabs

8 DBR's with Spalling
2 DBR's Cracked
4 DBR's with no distress

Zone 9

This zone consists of the DBR for the low and medium severity cracks. Class AA concrete patching, with #5 transverse bar and #6 longitudinal bar reinforcing, was used on the high severity cracks. There are no pre-emptive sawcuts or DBR's at the midpoints of the unbroken slabs. There is no bituminous overlay in this zone. The final survey of this zone was on June 6, 2003 as this zone was reconstructed with the SR 80 81M project.

Crack Survey 06/06/03

Travel Lane: 30 slabs

2 Concrete Patches with No Distress
1 DBR's with Spalling
23 DBR's Cracked
1 New Crack
3 Slabs with no distress
7 Slabs with ½" settlement

Passing Lane: 30 slabs

3 DBR's with Spalling
16 DBR's Cracked
2 Concrete Patches with No Distress
3 New Cracks
6 Slabs with No Distress

<u>No Bituminous Overlay</u>

The reinforced (WWF and rebar) patches show no signs of major distress, however, since last year's survey, several of the patches have begun to spall along the seal. The slabs that had preemptive sawcuts at the mid-slabs and DBR's installed do not show signs of distress. A majority of the mid-slab cracks that were repaired with DBR's show signs of distress in the form of cracking; spalling and popouts (Refer to the attached photos). The majority of these are in the travel lane which is to be expected due to higher loadings. The DBR repairs appear to be a better repair strategy for the passing lane where most of the low severity cracks are present and have no movement. High severity cracks like the one shown in Figure 2 seem to be a better candidate for full depth patch.

<u>Bituminous Overlay</u>

There are only two distresses in the bituminous overlay for this survey, which seems to be the result of a misaligned saw cut in the overlay. Since it has only been three years since construction was completed, it is too soon to make any conclusions on the results of these repairs.

Test Section Photographs

Pictures depict typical conditions for this entire test section.

Figure 1: New Crack

Figure 2: DBR Installation

Figure 3: Concrete Patch with no Distress (Note DBR in passing lane)

Figure 4: Pre-emptive mid-slab DBR with no Distress

Figure 5: Minor Spalling of DBR

Figure 6: DBR with Minor Spalling and Pop-out

Figure 7: DBR with New Crack

APPENDIX B

June 7, 2005

ZONE CONDITION EVALUATION

Zone 1: 2240/0000 to 2240/0707

Zone 1 consists of DBR's and accelerated concrete patching, Type A with 6"x 12" WWF reinforcing. No bituminous overlay was placed in this Zone to better monitor the repairs.

Zone 1: DBR Review

A condition survey conducted on June 7th, 2005 revealed no signs of degradation on exposed DBR's throughout Zone 1 due to traffic or further slab movement (See figure 1.0).

Figure 1.0 Typical DBR Condition

Figure 1.0 shows a DBR location in the eastbound driving lane. Note that the passing lane now has cracked near the middle of the slab (top of photo). This condition did not exist during the time of original DBR construction.

There was one DBR location in the passing lane at 2240/0438 where the grout material placed in the DBR slots was scaling and spalling. This could be due to construction-related factors such as poor field curing, grout beginning to set-up during placement, etc. Otherwise, the DBR at this location seems to be stable and performing as designed. (See figures 2.0 and 2.1)

Figure 2.0 Compromised DBR at 2240/0438

Figure 2.0 shows scaling and spalling of grout in DBR slots. No evidence of slab movement exists.

Figure 2.1 Close-up View of Figure 2.0

Zone 1: Type A Concrete Patching Review

Type A patching in Zone 1 is showing some settlement and movement-related problems as evidenced by spalling along the transverse joints a contributing factor to this may be an inadequate seal at the joint. (See figures 3.0 and 4.0)

Figure 3.0 Type A Concrete Patch at 2240/0302

Figure 3.0 shows a Type A patch placed in the traveling lane. Note the spalling of the Type A patch along the leave side of the transverse joint.

Figure 4.0 Type A Concrete Patch at 2240/0384

Figure 4.0 shows a Type A patch placed in driving lane with spalling in original concrete roadway.

Figures 5.0, 5.1, and 5.2 show mid-slab cracking in the driving lane which has occurred since construction:

Figure 5.0 Mid-slab Crack at 2240/0070

Figure 5.1 Mid-slab Crack at 2240/0107

Figure 5.2 Mid-slab Crack at 2240/0168

Zone 2: 2240/0707 TO 2240/1400

Construction was typical of Zone 1 utilizing Class AA (Class AA was used throughout the project for patching). The bituminous overlay begins in this Zone.

Figure 6.0 Typical Condition of Zone 2

Figure 6.0 shows the condition of surface at 2244/1127 over an existing concrete pavement joint. This location was typical of conditions throughout the Zone. The 2005 condition survey revealed absolutely no visible signs of deterioration. Most importantly, no reflective type cracking was noted at mid-slab locations where pre-emptive sawing was not performed.

Zone 3: 2240/1400 to 2240/1654

Construction was typical of Zone 2 with the addition of pre-emptive sawcutting and DBR's added at the mid-points of unbroken slabs.

Figure 7.0 Typical Condition of Zone 3

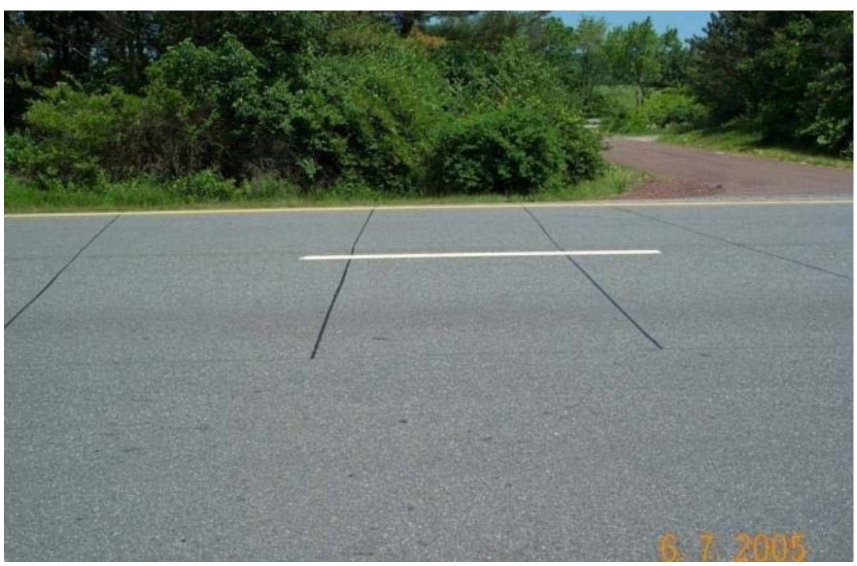

Figure 7.1 Typical Condition of Zone 3

Figures 7.0 and 7.1 show sawed joints over new Type A patches. The "sawed and sealed" joints over existing and pre-emptive pavement joints were in good condition, with no visible evidence of distress.

Zone 4: 2240/1647 to 2244/0574

Full depth pavement reconstruction utilizing 14" of class AA concrete with 6" x 12" WWF and dowel baskets place 90 degrees to centerline at 16' spacing. Concrete was placed on 4" 19mm binder.

Figure 8.0 Zone 4 at 2240/1815

Figure 8.0 shows the typical condition of Zone 4 which received total reconstruction. No deterioration was noted in the field during the 2005 condition survey.

Zone 5: 2244/0574 to 2244/1045

Construction was typical of Zone 2 with the addition of steel paving mesh and slurry seal overlays.

Figure 9.0 Zone 5 at 2244/0698

Figure 9.0 shows typical condition of Zone 5. This Zone received the steel paving mesh with a slurry seal prior to placement of the bituminous overlay. No evidence of cracking exists anywhere.

<u>Zone 6: 2244/1045 to 2244/1545</u>

Construction was typical of Zone 5, except DBR's were not used on low severity cracks.

Figure 10.0 Zone 6 at 2244/1310

Figure 10.0 shows condition of the overlay above an existing pavement joint. This zone received the steel paving mesh typical to Zone 5 and no cracking was found. Zone 6 also did not receive DBR's at pre-existing low-severity crack locations. The mesh appears to be performing as expected over these locations. The condition of Zone 6 is similar to Zone 5.

Zone 7: 2244/1545 to 2244/1801

Construction was typical of Zone 3. The bituminous overlay ends in this zone.

Figure 11.0 Zone 7 - Transverse Cracking at 2244/1791

Figure 11.0 shows transverse crack across both travel lanes. This location was near the end of the bituminous overlay which was terminated at 2244/1801 shown at top right in photo. The condition of Zone 7 is similar to Zone 3. However, transverse cracking was found through the bituminous overlay at 2244/1770 and 2244/1791 over DBR locations. Pre-existing low-severity cracks existed at both of those locations and they were retrofitted with DBR's. The area where the cracks are located was within the paving transition very near the end of the bituminous overlay (2244/1801).