Michigan Department of Transportation

Pavement Demonstration Program Project Finalization I-75 Northbound Unbonded Concrete Overlay (MDOT Job Number 73873)

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EXECUTIVE SUMMARY

This is a Michigan Department of Transportation (MDOT) supplementary technical report to the Pavement Demonstration Program Status Report, the latter of which summarizes annual performance of active demonstration projects as required per Public Act 457 of 2016, MCL 247.651i. All demonstration projects are continually being evaluated to determine if there is enough information to create appropriate performance curves and/or make a final determination as to their applicability in MDOT standard practice. This report summarizes one of those projects for which final determination can be made to finalize and close it out as a demonstration project. This is a final comprehensive report on the I-75 Northbound Unbonded Concrete Overlay in Ogemaw County from Ski Park Road to the Roscommon County line, MDOT job number 73873. This demonstration project was constructed in 2003 as a 6-inch unbonded non-reinforced concrete overlay with a 20-year design life. While this is already a standard fix for MDOT, the intent of this demonstration project was to evaluate the following features:

- 10- and 12-foot transverse joint spacing.
- Sections without dowel bars at transverse joints.
- Transverse joints cut to 1/8” width and left unsealed or 1/4” and sealed with hot-pour rubber.
- Longitudinal joints cut to 1/8” width and left unsealed or the 1/4” and sealed with hot-pour rubber.
- Open-graded hot mix asphalt (HMA) separator layer.

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INTRODUCTION

Public Act 457 of 2016, MCL 247.651i allows the Michigan Department of Transportation (MDOT) to construct demonstration projects that are not subject to a Life-Cycle Cost Analysis (LCCA). The LCCA process is a tool to select the lowest cost pavement design over the expected service life of the pavement. The LCCA process must include, by law, historical information for initial construction and maintenance costs, and performance (service life). This information is not available for new pavement design types and new pavement technologies and thus they cannot be used in the pavement selection process until the information has been obtained. The pavement demonstration legislation provides a means for trying new and innovative ideas. Potential outcomes of pavement demonstration projects include increased service life, improved customer benefits and lower maintenance costs. Future LCCAs may utilize cost, performance, and maintenance information from the demonstration projects.

Selection of candidate projects is a collaborative effort among MDOT Construction Field Services pavement personnel, MDOT region personnel and pavement industry groups. Once the demonstration project is identified, it goes to MDOT's Engineering Operations Committee for formal approval. Once approved, the project becomes part of the Pavement Demonstration Program. All costs for the demonstration project are funded by the respective MDOT region's rehabilitation and reconstruction budget.

All demonstration projects are continually being evaluated to determine if there is enough information to create appropriate performance curves and/or make a final determination as to their applicability in MDOT standard practice. This report summarizes one of those projects for which final determination can be made to finalize and close it out as a demonstration project. This project is the I-75 Northbound (NB) Unbonded Concrete Overlay in Ogemaw County from Ski Park Road to the Roscommon County line, MDOT job number 73873.

This demonstration project was constructed as a 6-inch unbonded non-reinforced concrete overlay with a 20-year design life. While this is already a standard fix for MDOT, the intent of this demonstration project was to evaluate whether unsealed joints (lacking hot pour rubber) and the removal of load transfer (dowel) bars could be utilized to lower the cost while maintaining equivalent pavement performance as the standard section of sealed and doweled joints. In addition, a reduction of the standard 12-foot joint spacing to 10-feet was also included to evaluate if reducing the spacing would improve performance. Therefore, this project was split into 5 distinct test sections to evaluate the demonstration performance with test Section 5 serving as the standard MDOT design. The sections descriptions and locations are defined in Table 1 and shown in Figures 1 and 2. Note that test section 1 is at the beginning of the project, near Ski Park Road. As a secondary feature, within the entire limits of the project the HMA separator layer was designed to be more open than used on previous unbonded overlays to improve the cross-section water capacity and drainage. Otherwise, typical unbonded overlay design was followed on this project, including tie bars used at the longitudinal joints and allowing the concrete overlay to vary as necessary for grade correction, while maintaining a 6-inch minimum thickness.

Table 1. I-75 NB Demonstration Project Test Section Descriptions

Test Section Number	Test Section Description	Length of Test Section	PR Number	PR BMP	PR EMP
1	10' transverse joint spacing, unsealed joints, no load transfer bars	0.260 miles	1005802	11.440	11.700
2	10' transverse joint spacing, sealed joints, no load transfer bars	0.252 miles	1005802	11.700	11.952
3	12' transverse joint spacing, unsealed joints, no load transfer bars	1.439 miles	1005802	11.952	13.391
4	12' transverse joint spacing, sealed joints, no load transfer bars	1.421 miles	1005802	13.391	14.812
5	12' transverse joint spacing, sealed joints, load transfer bars	0.478 miles	1005802	14.812	15.290

* *Note: PR is Physical Reference, BMP is Beginning Mile Point, EMP is Ending Mile Point*

Figure 1. I-75 NB Demonstration Project Location

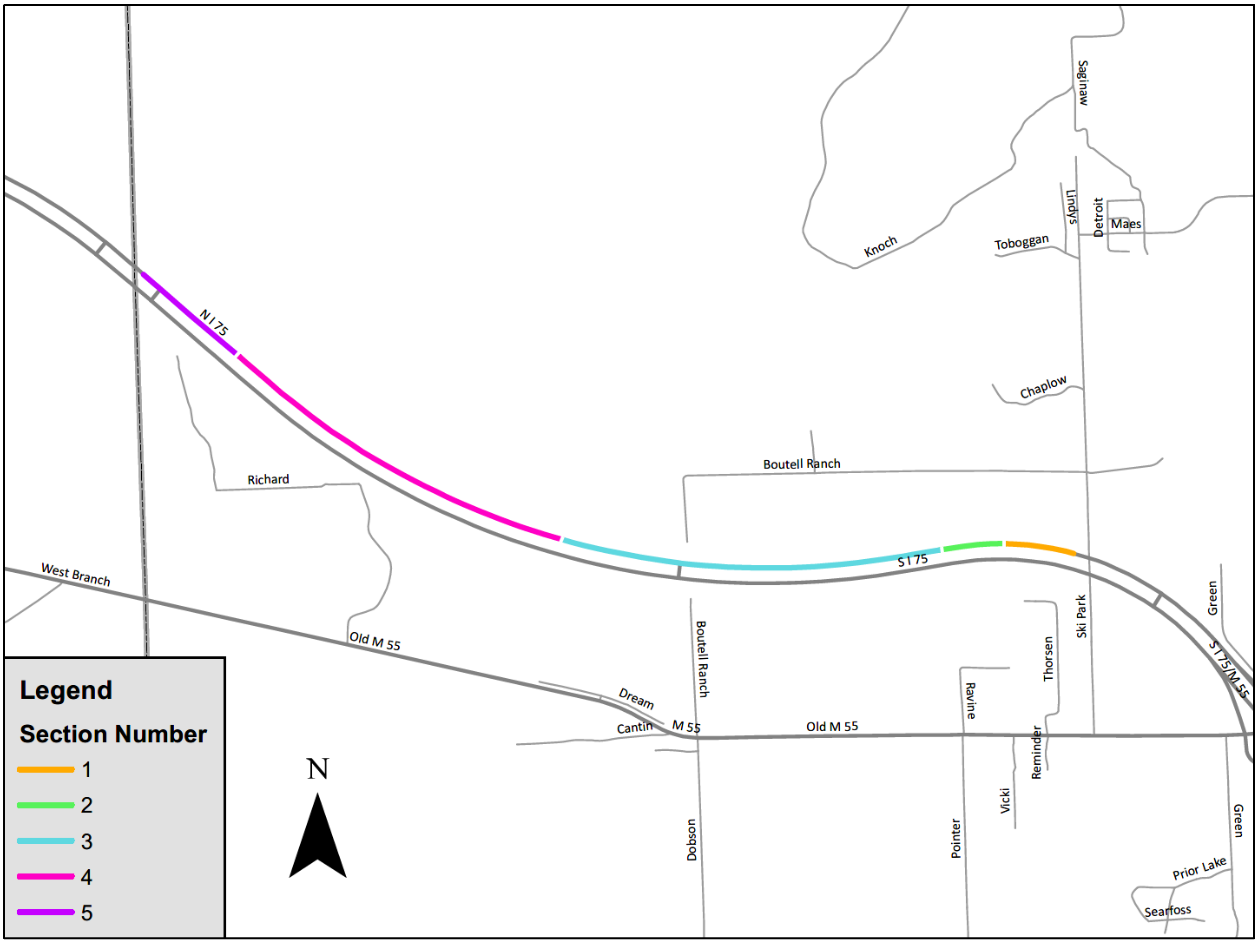

Figure 2. I-75 NB Demonstration Project Test Section Locations

This project was constructed in 2003, in the northbound direction only. The southbound direction, constructed at the same time under a separate contract (MDOT job number 45824), was rubblized (existing concrete pavement broken into smaller pieces resembling gravel) and overlaid with 6.5-inches of HMA. This section serves as an approximate comparison to the northbound demonstration project in consideration of the time of construction and similar existing cross-sections prior to their overlays (in consideration that either fix type could have been used per the existing cross-section). The unbonded overlay took 69 days from start to completion of paving for its 12 lane-miles plus shoulders, while the rubblize and HMA surfacing took 51 days from start to completion of paving for its 8 lane-miles plus shoulders. Noted concerns during the construction of the unbonded overlay project were that some of the lane tie bars were misplaced, the concrete paver track was running on the edge of the HMA separator layer, and voids of the HMA separator layer were filled with concrete. See the Appendix, Figures A9, A10, and A11 for examples. For a complete report on the construction of this project, see MDOT Report # R-1465, *Unbonded Concrete Overlay Demonstration Project on I-75 in Ogemaw County – Construction Report (2005)*.

At the time of construction (2003), the two-way average annual daily traffic (AADT) was 13,250, with about 11 percent being commercial. The estimated growth rate was 1.7 percent. The actual AADT in 2018 was 16,043, with about 8 percent being commercial, so the actual growth rate from 2003 to 2018 was approximately 1.3 percent. The estimated 20-year concrete equivalent single axle load (CESAL) for pavement design was 6,197,610. However, per the actual AADT and commercial traffic, the estimated 20-year CESAL is 5,260,000. The existing cross-section thicknesses (from bottom to top) were approximately 10-inches of sand subbase, 4-inches of dense-graded aggregate base and 9-inches of jointed reinforced concrete pavement. This pavement was originally constructed in 1973 with a 71-foot joint spacing and HMA shoulders. Before overlaying the existing pavement, full-depth concrete patches were constructed at slabs having deteriorated joints and/or cracks. Additionally, while not always conducted prior to unbonded concrete overlays, existing joints and cracks were filled with overband crack fill. The overlay was 1-inch of permeable (open-graded) HMA separator layer under 6-inches of new concrete pavement. Per as-constructed randomly obtained cores in the outside lane, the average concrete thickness was slightly more than 7.5" and the average separator layer thickness was slightly more than 1". Prefabricated Drainage Systems (PDS) drains or leaching trenches for drainage were to be constructed under both shoulders, but during the construction phase, leaching trenches were only placed under the inside shoulder and neither was placed under the outside shoulder due to the favorable drainage of the subgrade soil (drainable sand).

CONDITION SURVEYS AND PERFORMANCE DATA

Annual site condition field surveys were conducted and reported on in the annual MDOT Demonstration Program Legislative Report, *Pavement Demonstration Program Status Report Public Act 457 of 2016*. Per the latest field visit in April 2019, (field evaluation shown in the Appendix, Figure A12) it was noted that all sections were repaired with intermittent full-depth slab replacement in 2018. No new cracks were observed. However, the number of slabs repaired was tracked as an indication of those slabs that had some type of distress in need of repair, which may include faulting, cracking, or spalling. Accordingly, for Section 1, the number of repaired slabs (22) may indicate a slight increase in distress (84 repairs/mile). Section 2, which was distress-free until 2016, had a fair number of slabs replaced (37), which may indicate a moderate increase in distress (147 repairs/mile). Section 3 had the most slabs repaired (39), which is consistent with past reviews (27 repairs/mile). For Section 4, the number of repaired slabs (20) indicates that this section remained stable (14 repairs/mile). For Section 5, the number of repaired slabs (12) may indicate a slight increase in distress (25 repairs/mile). The number of replaced/distressed concrete slabs for the entire project is approximately 7 percent. The number of slabs repaired per mile (repaired slab number divided by section length) are shown in Table 2. Pictures of the unbonded overlay project taken during the latest field review are shown in the Appendix, Figures A13 and A14.

Table 2. 2019 Observed Number of Slabs Repaired Per Mile Per I-75 Test Section

Test Section Number	Number of Slabs Repaired Per Mile
1	84
2	147
3	27
4	14
5	25

Per that same site visit (April 2019), it was observed that the rubblized project in the southbound direction continued to exhibit longitudinal and transverse cracking, with more new transverse cracks being observed. There was also evidence of heaving at some of the transverse cracks. The joint at centerline appeared to be widening, possibly indicating poor joint construction. The heaving of the cracks has been the most problematic condition of this pavement section. Initial investigations indicated that the concrete base in the area of joints/cracks may not have been fully rubblized, which may be inhibiting drainage, resulting in the surface heaving due to freezing. Therefore, to mitigate the transverse crack heaving and longitudinal joint quality issues, a major rehabilitation project was constructed after the field review in 2019 for southbound I-75. Pictures of southbound I-75 taken during the latest field review (2019) are shown in the Appendix, Figure A15.

Pavement performance for the concrete overlay is measured by faulting, MDOT's Distress Index (DI) and International Roughness Index (IRI). Faulting is the difference in elevation across joints (or cracks), measured in inches. The total number of faults are identified by the number of times a difference in elevation is observed. The faulting measurements (per the right wheel path) for each section are shown in Table 3 and Figures 3 and 4. The DI measurement is the total accumulated distress point value for a given pavement section normalized to a 0.1-mile length, collected per a sampling of the 0.1-mile length. It is a unitless value that provides an indication of a pavement's 2-dimensional surface distress condition, (so faulting and rutting are not included). The IRI measurement is the roughness of the road profile in inches/mile, (so faulting and rutting can impact its measurement). The IRI and DI measurements for each section are shown in Table 4 and Figures 5 and 6. Note that a maintenance project occurred within the full limits of the demonstration project in 2018, which improved the pavement condition. Therefore, all three performance measurement values in 2018 were impacted by this project.

Note that historically through 2019, MDOT network-level data collection for DI, IRI, and rut-or-fault is intended to be obtained every other year for any given route segment (including both directions of divided routes). However, the following is a list of exceptions to that biennial schedule:

- Starting in 2009, annual IRI collection began on at least one direction of all National Highway System (NHS) routes.
- Starting in 2018, annual IRI collection on at least one direction of all NHS routes was reduced to only Interstate routes.
- Also starting in 2018, annual collection of DI and rut-or-fault began (in addition to IRI) on one direction of the Interstate routes.

- Schedules for data collection are subject to roadway availability, so construction or similar operations may prevent data collection for that anticipated year.

Table 3. Right Wheel Path Faulting Yearly Progression Per I-75 Test Section

Data Year (Pavement Age)	Section 1		Section 2		Section 3		Section 4		Section 5	
	Avg Fault (in)	Total No. Faults/ Mile	Avg Fault (in)	Total No. Faults/ Mile	Avg Fault (in)	Total No. Faults/ Mile	Avg Fault (in)	Total No. Faults/ Mile	Avg Fault (in)	Total No. Faults/ Mile
2007 (4)	0.34	4	0.15	4	0.11	19	0.11	6	0	0
2009 (6)	0.12	4	0.11	4	0.12	61	0.12	34	0	0
2010 (7)	0.12	8	0.13	24	0.13	74	0.12	67	0.14	10
2011 (8)*	0.16	8	0.12	8	0.12	11	0.11	4	0.15	13
2013 (10)	0.06	354	0.05	448	0.08	468	0.10	486	0.06	207
2015 (12)	0.05	388	0.07	464	0.09	443	0.10	468	0.05	192
2017 (14)	0.04	358	0.08	500	0.11	455	0.11	474	0.08	157
2018 (15)	0.06	42	0.04	44	0.05	64	0.05	58	0.08	8

**: The 2011 data was collected in the middle lane instead of the right-most lane (truck lane) and has not been used in Figures 3 and 4 below.*

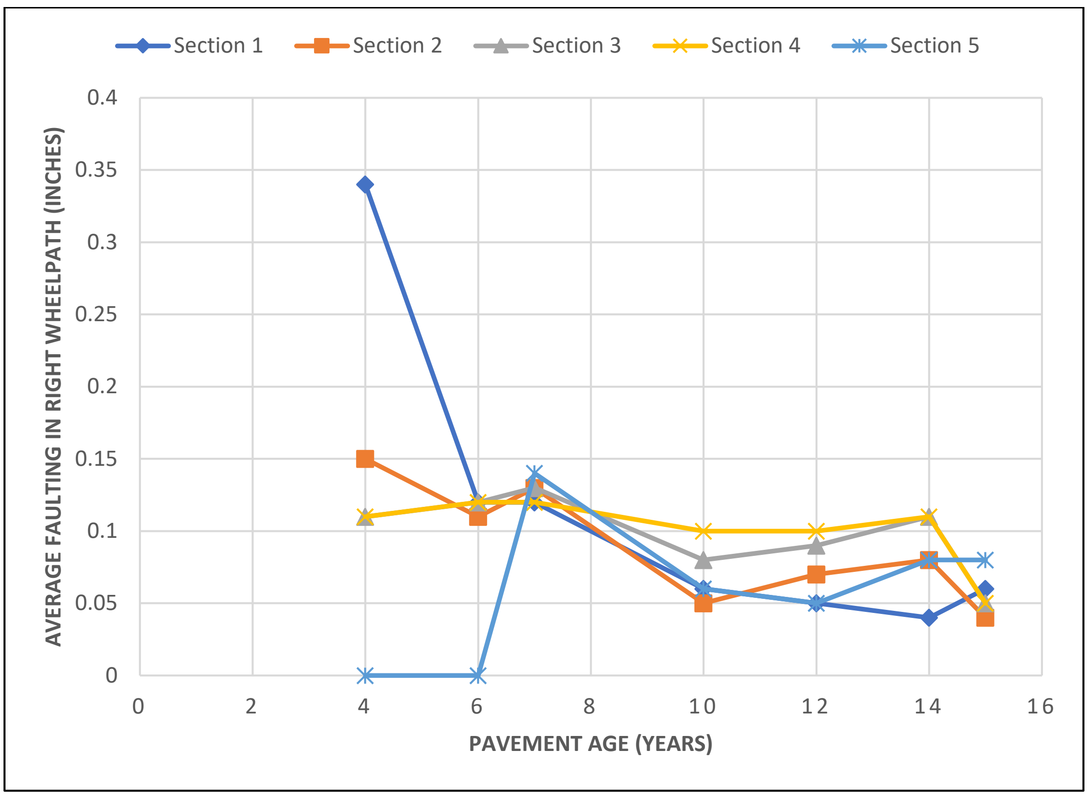

Figure 3. Right Wheel Path Average Fault Yearly Progression Per I-75 Test Section

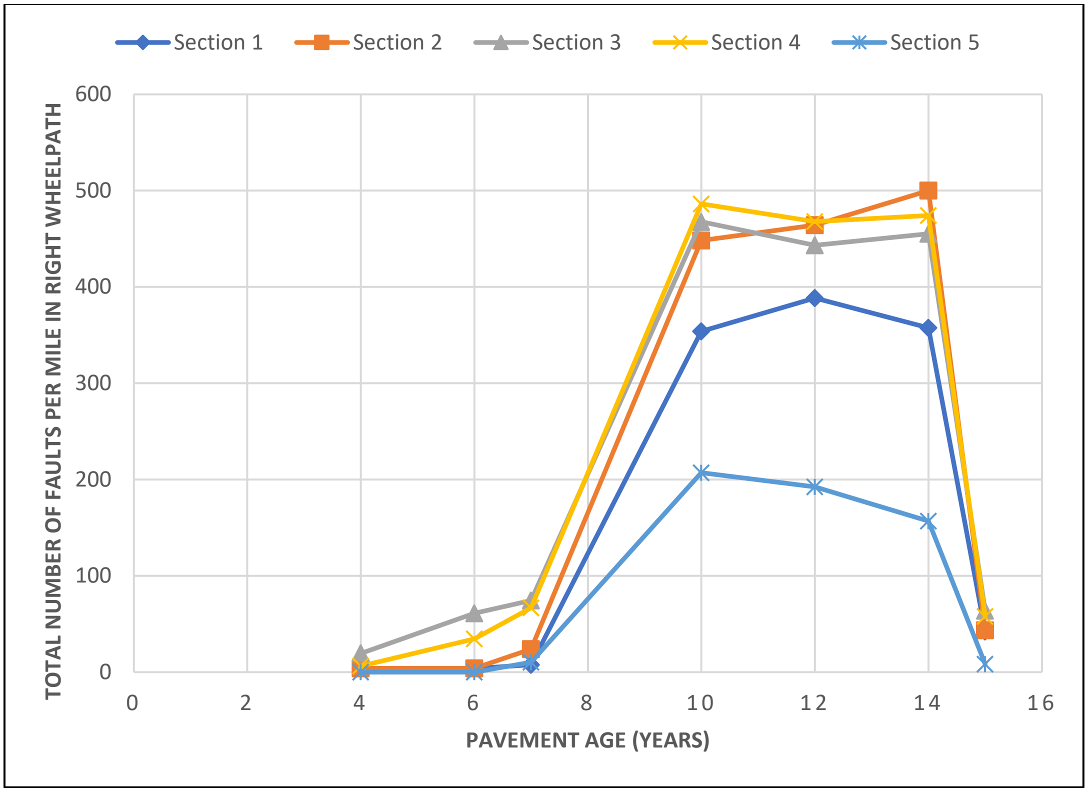

Figure 4. Right Wheel Path Total Number of Faults Per Mile Yearly Progression Per I-75 Test Section

Table 4. IRI and DI Yearly Progression Per I-75 Test Section

Data Year (Pavement Age)	Section 1		Section 2		Section 3		Section 4		Section 5	
	IRI	DI	IRI	DI	IRI	DI	IRI	DI	IRI	DI
2005 (2)	76	0.0	64	0.0	51	0.0	56	0.0	74	0.0
2007 (4)	94	0.0	73	0.0	64	0.3	79	0.0	77	0.0
2009 (6)	94	0.2	80	0.0	77	0.4	89	0.1	79	0.0
2010 (7)	86	-	86	-	90	-	112	-	89	-
2011 (8)*	98	0.0	89	0.4	73	0.2	82	0.2	81	0.3
2012 (9)	96	-	87	-	92	-	105	-	85	-
2013 (10)	94	0.0	98	1.0	101	2.6	118	1.0	88	2.3
2014 (11)	107	-	103	-	115	-	131	-	96	-
2015 (12)	99	1.0	105	1.9	112	4.6	128	0.9	94	5.1
2016 (13)	99	-	107	-	114	-	129	-	92	-
2017 (14)	99	13.9	108	1.9	118	14.0	134	4.5	93	23.9
2018 (15)	51	-	48	-	46	-	51	-	46	-

**: The 2011 data (IRI and DI) was collected in the middle lane instead of the right-most lane (truck lane) and has not been used in Figures 5 and 6 below.*

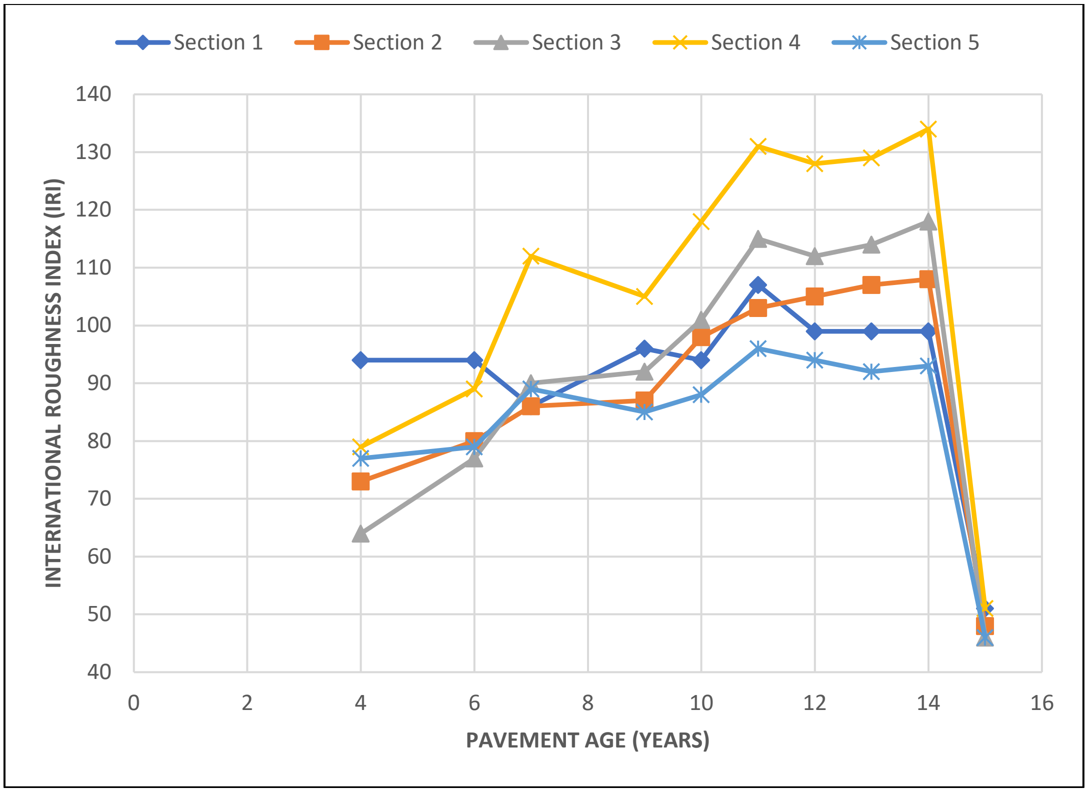

Figure 5. IRI Yearly Progression Per I-75 Test Section

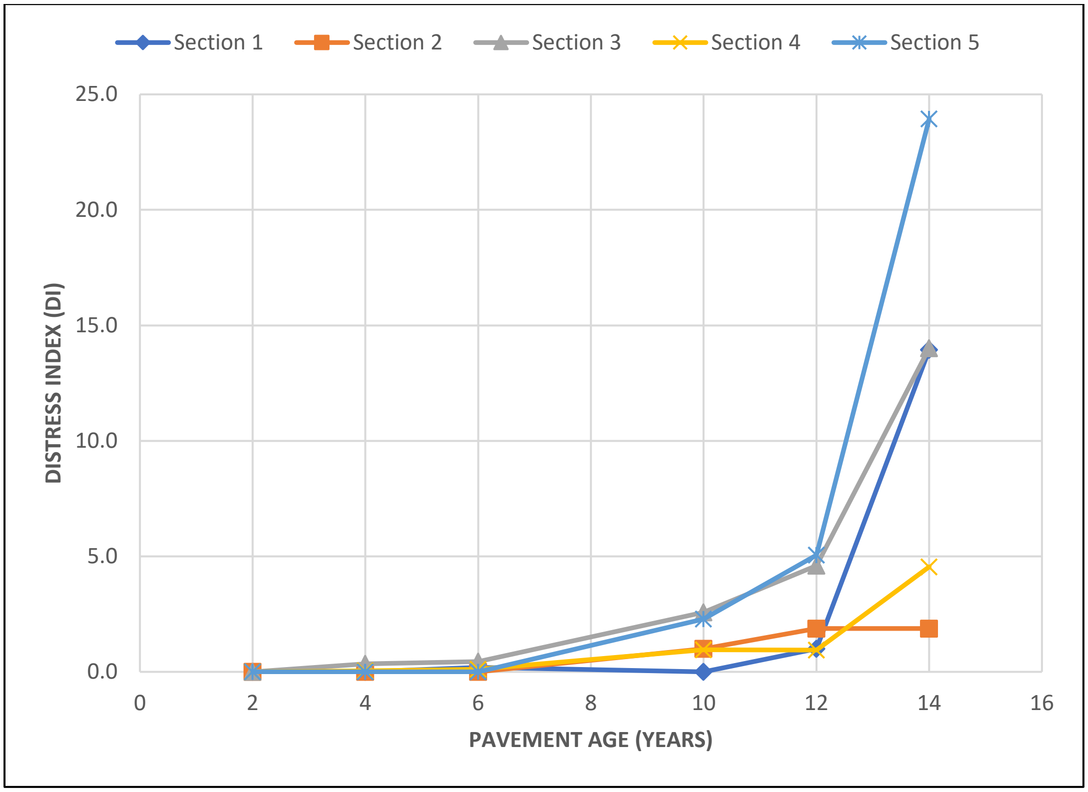

Figure 6. DI Yearly Progression Per I-75 Test Section

As shown, Sections 2, 3, and 4 exhibited the highest number of recorded faulted locations per mile with final totals before maintenance of 500, 455, and 474, respectively. Section 5 consistently had the lowest number of recorded faulted locations per mile with the final total before maintenance of 157. The average faulting measure was somewhat inconclusive for all sections over the timeseries of data. For IRI, Sections 3 and 4 exhibited the highest (worst) and the most rapid increase with final IRI before maintenance of 118 and 134, respectively. Section 5 had the lowest rate of IRI increase with final IRI before maintenance of 93. For DI, Section 5 exhibited the highest (worst) and the most rapid increase followed by Sections 3 and 1 with final DI before maintenance of 23.9, 14.0, and 13.9, respectively. Section 2 had the lowest rate of DI increase with final DI before maintenance of 1.9. It should be noted that these DI measurements are not consistent with the number of repairs per mile, faulting measurements, or IRI, so per further investigation, it was found that Section 5 had minor corner cracking that added to the DI value (as shown in the Appendix, Figure A16). This type of distress may not require repair, contribute to faulting, or add roughness. Other DI inconsistencies may be due to the location of sampling. Moreover, Section 5 has a lane reduction from 3 lanes to 2 lanes near its midpoint, so some of the DI measurements may have been taken in the outer lane that was tapering, unlike the other sections that were all taken in a single continuous lane. While this does not invalidate the DI, it is a variable that may impact the DI measurement.

DATA ANALYSIS AND OBSERVATIONS

This demonstration project was examined as part of an MDOT research project conducted by the University of Michigan to study the performance of jointed plain concrete pavement (JPCP) overlays, MDOT Report # RC-1574, *Improved Performance of JPCP Overlays (2013)*. This research found that there was poor drainage at the outside edge of pavement throughout the entire demonstration project. The existing dense-graded HMA shoulder was not removed (as verified by cores with example in the Appendix, Figure A17), so the open-graded HMA separator layer does not extend to the outer edge of the shoulder as designed. This prevents the water that collects in the open-graded layer from draining down to the subgrade and out of the cross-section. This resulted in pumping and loss of materials as shown in the Appendix, Figure A18, contributing to most of the observed distresses. These effects are exacerbated in all the sections with un-doweled joints, but particularly in Sections 3 and 4. These sections exhibited pumping-related distresses such as faulting, cracking (transverse and longitudinal), and severe corner breaks (prior to the recent maintenance repair), which increased their IRI and reduced their ride quality. Furthermore, the research finds that the use of dowel bars appears to result in reduced pumping distresses. This is evident from the lower number of faults and IRI values of Section 5 which has sealed and doweled transverse joints.

Per MDOT Report # R-1465, falling weight deflectometer (FWD) testing was conducted before and after the unbonded concrete overlay was constructed. This is a non-destructive test used to evaluate in-situ stiffness of the pavement cross-section layers and characterize the structural condition. As a result of this testing, it was observed that Section 5 has a noticeable increase in deflection measurements, indicating a reduction in layer stiffnesses. Therefore, the base and subgrade conditions are most poor in Section 5 as compared to all other sections. The FWD measurements are shown in Figures 7, 8, and 9. Note that per these figures, Section 5 approximately begins and ends at distance 18,250-feet and 20,800-feet, respectively.

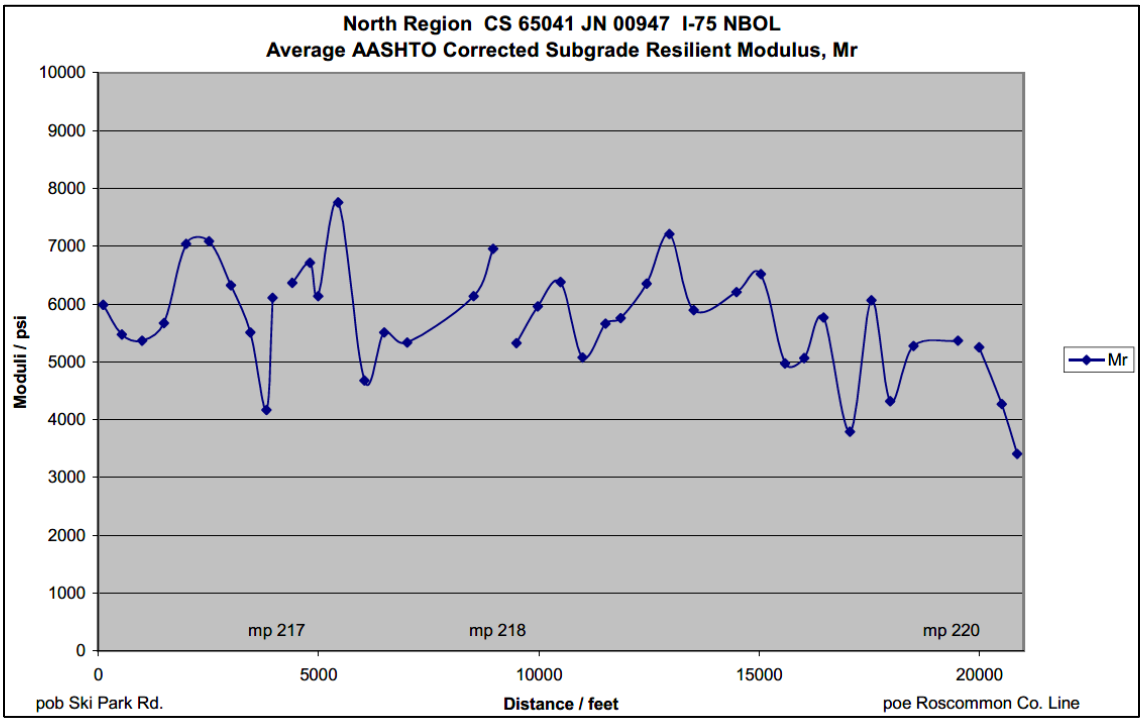

Figure 7. MDOT Report # R-1465, Appendix, FWD Results Before Construction, I-75 Demonstration Project AASHTO Corrected Subgrade Resilient Modulus, Mr

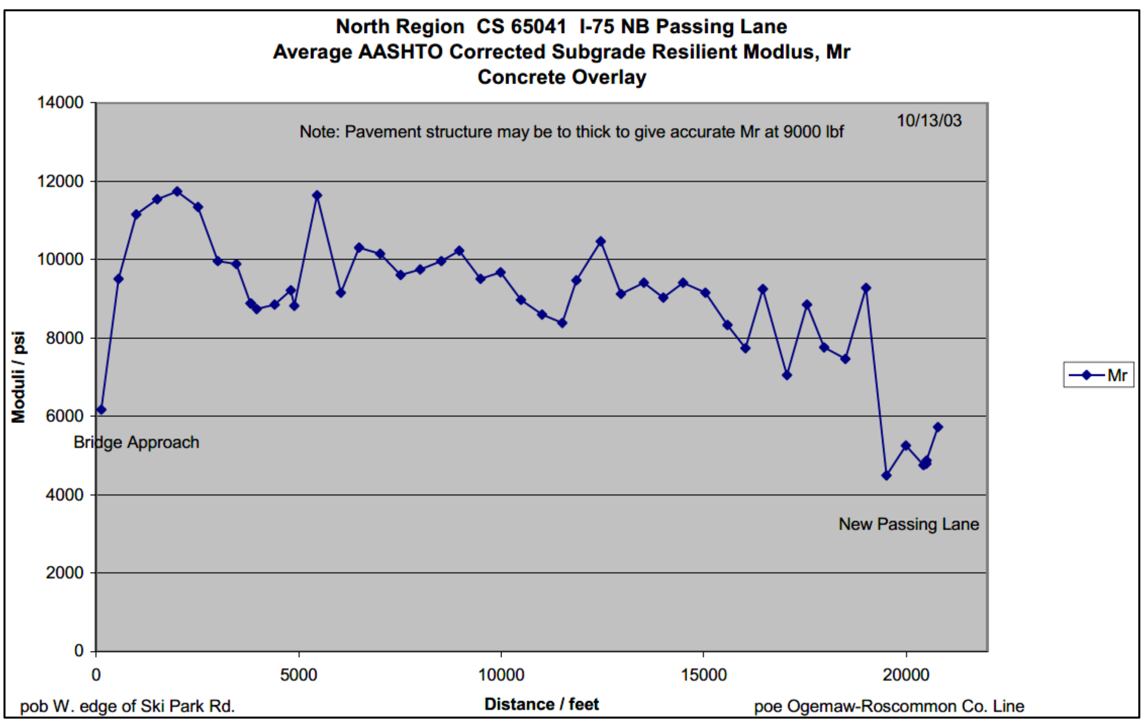

Figure 8. MDOT Report # R-1465, Appendix, FWD Results After Construction, I-75 Demonstration Project AASHTO Corrected Subgrade Resilient Modulus, Mr

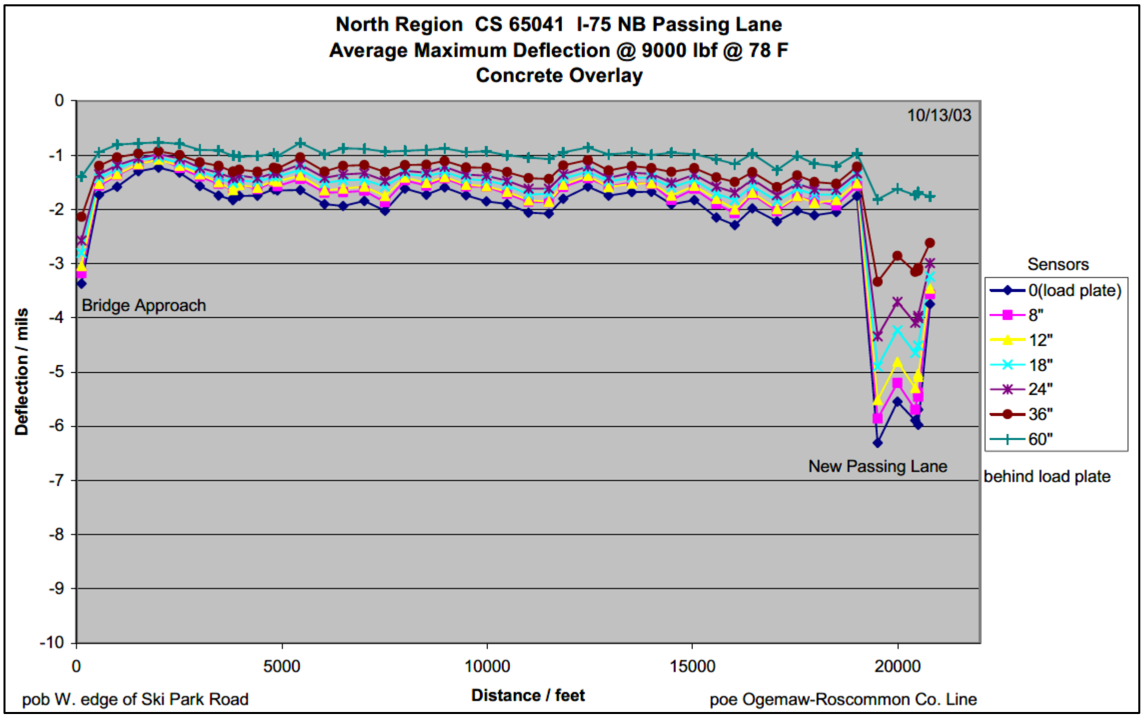

Figure 9. MDOT Report # R-1465, Appendix, FWD Results After Construction, I-75 Demonstration Project Maximum Deflections Per Load Plate at 9000 lbs Drop

Per a review of the MDOT condition surveys, overall, Sections 1 and 2 had the most repairs per mile, which would seem to indicate that they had the most cracked, spalled, and/or faulted slabs. Most of the distressed slabs were in the innermost lane. Both sections are superelevated or banked for the curvature of the road, so water is draining and moving to the low, inner side of the pavement, mostly likely causing this observed distress. However, the pavement performance measurements for faulting, IRI, and DI do not correlate with this observation. This is because these measurements are taken (typically) in the outermost lane (where most loading and damage typically occurs), so these measurements are not reflective of the inside lane. Therefore, Sections 1 and 2 seem to be performing the worst, even though not all pavement performance measurements are reflective of this.

Otherwise, per the pavement performance measurements for IRI and faulting, Sections 3 and 4 had the worst ride quality, so the most pumping and slab movement in the outside lane. This is likely due to the open-graded HMA separator layer not extending through the shoulder due to the existing dense-graded HMA shoulder left in place. This caused water to collect underneath the outermost lane, leading to a loss of support. While this is true for all sections, this was not as much of an issue in the outermost lane for Sections 1 and 2 because most water was moving to the inside lane, instead of the outside lane.

In review of all MDOT condition surveys and pavement performance data (the number of repairs per mile, total faulting per mile, and IRI), Section 5 had the best or near best performance, other than per DI, which does not seem representative of the true performance of the section. Section 5 has the same 12-foot joint spacing as Sections 3 and 4 and sealing like Sections 2 and 4, but unlike all other sections, it is doweled. Therefore, the loss of support that is similarly occurring in Section 5 is not leading to significant slab movement due to the load transfer available between slabs.

PERFORMANCE COMPARISON

As of the date of this report, within the limits of this I-75 demonstration project there have been 3 noted maintenance projects. There was a project consisting of longitudinal joint sealing and a few full-depth slab replacements in 2009 (age 6), transverse and longitudinal joint sealing project in 2011 (age 8), and a project consisting of diamond grinding with intermittent full-depth slab replacement in 2018 (age 15). Accounting for inflation, the 2017 cost per lane-mile of these fixes would be $8,225, $3,700, and $88,000, respectively. The comprehensive MDOT list of unbonded concrete overlay projects indicates that on average, preventative maintenance occurred at ages 11, 13, 15, and 17 with anticipated major rehabilitation or reconstruction (R&R) at age 23. Accounting for inflation, the 2017 cost per lane-mile of the maintenance fixes would be $18,209, $10,481, $19,611 and $18,707, respectively. See Table 5 for a summary of the pavement ages for when maintenance occurs and the associated maintenance costs. The average age for which maintenance occurs compares adequately with the demonstration project schedule so far, with three cycles at ages 6, 8, and 15, (it hasn't reached the end of its life, so a fourth cycle may occur). Currently, no maintenance or R&R project is planned within the next five years, so this project is expected to exceed 23 years before an R&R may be anticipated. As for cost, the first 2 maintenance cycles of the demonstration project had much lower costs per lane-mile as compared to the averages of the comprehensive list. However, the third maintenance cycle cost of the demonstration project is much higher, greatly exceeding the costs of the comprehensive list through the first 3 cycles. Still, as compared to standard unbonded overlay projects, eliminating dowel bars and sealing would save approximately $56,500 and $10,000 per lane-mile, respectively. If incorporating these savings, then the extra maintenance costs are offset, but the cost of future maintenance is likely to be at a higher cost than average due to the continued slab movement of the non-doweled joints.

Table 5. Maintenance Project Timing and Cost for I-75 Demonstration Project and Average of MDOT Unbonded Concrete Overlay Projects

Maintenance Cycle	I-75 Demonstration Project		Average of MDOT Unbonded Concrete Overlay Projects	
	Pavement Age	Maintenance Cost (per 2017)	Pavement Age	Maintenance Cost (per 2017)
1	6	$8,225	11	$18,209
2	8	$3,700	13	$10,481
3	15	$88,000	15	$19,611
4	N/A	N/A	17	$18,707

CONCLUSIONS

Despite having the lowest subgrade modulus, Section 5 had the best or near best performance in all measurable categories, other than its previously noted inconsistent DI. It may be difficult to isolate which of its factors including joint sealant, dowel bars, or 12-foot joint spacing is contributing most to its success, but since no other section has dowel bars, that may be the most critical performance factor. Therefore, while drainage continues to be an important factor for unbonded concrete pavement performance success, dowel bars can ensure that load transfer takes place and ride quality does not suffer as a result of increased slab movement due to lack of drainage.

To isolate joint spacing performance, it is best to exclude Section 5 due to its dowel bar inclusion and compare Sections 1 and 2 (10-foot joint spacing) to 3 and 4 (12-foot joint spacing). As such, no significant benefit was noted in crack-mitigation when joint spacing was reduced to 10-feet, (which increases the cost of jointing). Rather, Sections 1 and 2 seemed to have the worst performance (per the latest MDOT condition survey observed repairs per mile) despite having a reduced spacing.

For joint sealing performance, again, it is best to exclude Section 5 and compare Sections 1 and 3 (unsealed) to 2 and 4 (sealed). In doing so, the long-term results are inconclusive. However, according to MDOT Report # RC-1574, "Section 3 has been exposed to the worst case scenario of pumping as a result of no joint seals. This section developed longitudinal cracking at the transverse joints in year one…rapidly propagating into full length cracks." This is shown in Figures A19 and A20 of the Appendix. Unsealed joints can get filled with incompressible fine materials that prevent the slabs from expansion and cause spalling. Therefore, early joint spalling is likely the result of not having sealed the joints. Additionally, not sealing inherently allows more water into the pavement cross-section, and potentially leads to water entrapment if the water cannot drain out. For this project, it appears that other factors, such as not providing load transfer and insufficient drainage may have more greatly influenced the long-term pavement performance, but sealing appears to have delayed early life pavement damage.

The open-graded HMA separator layer could not be adequately evaluated due to previously noted issues with the existing dense-graded HMA shoulder not being removed and blocking gravitational drainage out of the cross-section.

Overall, the demonstration project is performing as well as most MDOT unbonded overlay projects. However, as compared to the MDOT standard design in Section 5 (control section with dowel bars and sealed joints), all other demonstration sections have underperformed and required higher cost to maintain, despite having better existing base and subgrade conditions.

RECOMMENDATIONS

Since an adequate amount of time has passed and enough data is available to fully evaluate this project and its experimental aspects (unsealed joints, no dowel bars, reduced joint spacing), MDOT recommends that monitoring of this demonstration project end and be considered complete. Per the findings and conclusions of this report, unbonded concrete overlays should have sealed transverse and longitudinal joints. Additionally, transverse joints should be doweled along with longitudinal joints being tied. Finally, 12-foot joint spacing should be maintained for 6-inch (or more) concrete pavement with adequate provisions to ensure proper drainage of the HMA open graded interlayer.

REFERENCES

Michael Eacker and Andrew Bennett, "Unbonded Concrete Overlay Demonstration Project on I-75 in Ogemaw County – Construction Report", MDOT Research Report R-1465, June 2005.

Will Hansen and Zhichao Liu, "Improved Performance of JPCP Overlays", MDOT Research Report RC- RC-1574, July 2013.

Justin Schenkel, "Pavement Demonstration Program Status Report Public Act 457 of 2016", June 2019. All past reports can be retrieved from the MDOT public webpage for Legislative Reports, https://www.michigan.gov/mdot/0,4616,7-151-9622_11045_12737---,00.html.

APPENDIX

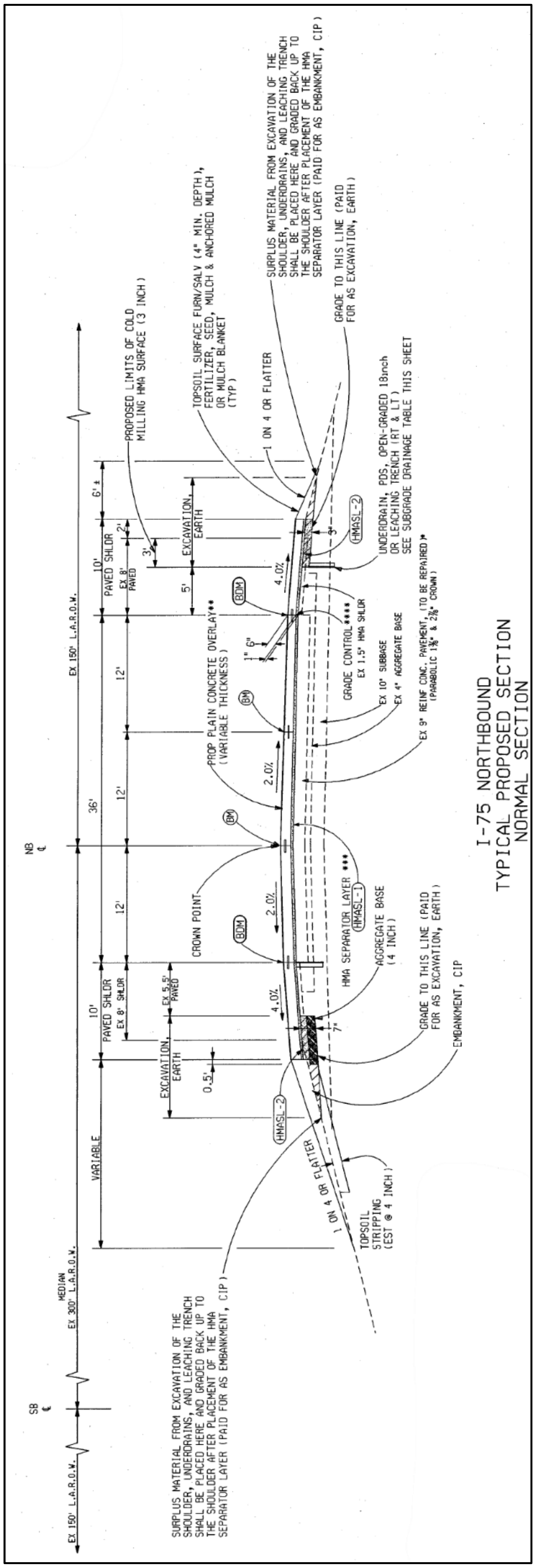

Figure A1. JN 73873 Typical Normal Cross-Section

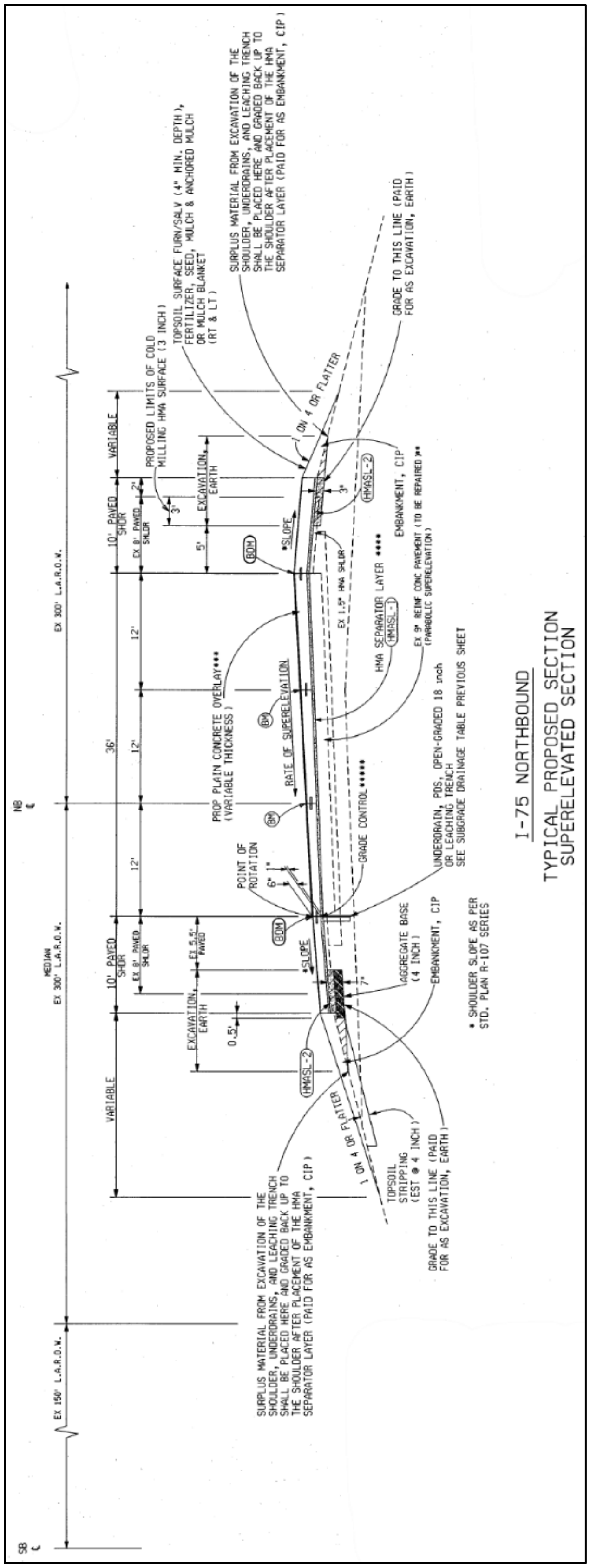

Figure A2. JN 73873 Typical Superelevated Cross-Section

UNBONDED CONCRETE OVERLAY JOINT TABLE FOR DETAILS OF ALL MODIFIED CONCRETE JOINTS SEE NEXT TYPICAL SHEET			
SECTION	**TRANSVERSE JOINT TYPE**	**LONGITUDINAL BULKHEAD JOINT TYPE**	**LONGITUDINAL LANE TIE JOINT TYPE**
STA 650+28.66 TO STA 664+00	MODIFIED Ⓤ TRANSVERSE PLANE OF WEAKNESS JOINT AT 10' SPACING	MODIFIED Ⓑ LONGITUDINAL BULKHEAD JOINT (UNSEALED JOINT WITHOUT SAWCUT)	MODIFIED Ⓓ LONGITUDINAL LANE TIE JOINT (UNSEALED JOINT WITH 1/8" SAWCUT)
STA 664+00 TO STA 694+00 (SEE STA EQN)	MODIFIED Ⓦ TRANSVERSE PLANE OF WEAKNESS JOINT AT 10' SPACING	MODIFIED Ⓑ LONGITUDINAL BULKHEAD JOINT (SEALED JOINT WITH 1/4" SAWCUT)	MODIFIED Ⓓ LONGITUDINAL LANE TIE JOINT (SEALED JOINT WITH 1/4" SAWCUT)
STA 694+00 TO STA 770+00	MODIFIED Ⓤ TRANSVERSE PLANE OF WEAKNESS JOINT AT 12' SPACING	MODIFIED Ⓑ LONGITUDINAL BULKHEAD JOINT (UNSEALED JOINT WITHOUT SAWCUT)	MODIFIED Ⓓ LONGITUDINAL LANE TIE JOINT (UNSEALED JOINT WITH 1/8" SAWCUT)
STA 770+00 TO STA 845+00	MODIFIED Ⓦ TRANSVERSE PLANE OF WEAKNESS JOINT AT 12' SPACING	MODIFIED Ⓑ LONGITUDINAL BULKHEAD JOINT (SEALED JOINT WITH 1/4" SAWCUT)	MODIFIED Ⓓ LONGITUDINAL LANE TIE JOINT (SEALED JOINT WITH 1/4" SAWCUT)
STA 845+00 TO STA 870+06.48	MODIFIED (Cp) OR (C3p) TRANSVERSE CONTRACTION JOINT AT 12' SPACING	MODIFIED Ⓑ LONGITUDINAL BULKHEAD JOINT (SEALED JOINT WITH 1/4" SAWCUT)	MODIFIED Ⓓ LONGITUDINAL LANE TIE JOINT (SEALED JOINT WITH 1/4" SAWCUT)

Figure A3. JN 73873 Unbonded Concrete Overlay Joint Table and Test Section Stationing

* CONSTRUCT FULL-DEPTH CONCRETE PAVEMENT REPAIRS ON EXISTING NORTHBOUND ROADWAY. CONCRETE JOINT REPAIR LOCATIONS WILL BE LAID OUT BY THE ENGINEER PRIOR TO CONSTRUCTION. CONTRACTION JOINT, CRG SHALL BE CONSTRUCTED WITHOUT SAWING AND SEALING. EXPANSION JOINT, ERG SHALL BE CONSTRUCTED WITHOUT SEALING. THE EXPANSION FIBER JOINT FILLER SHALL BE PLACED FLUSH WITH THE TOP OF THE EXISTING PAVEMENT SURFACE.

** FOR THE LOCATION AND TYPE OF CONCRETE JOINTS TO USE SEE THE "UNBONDED CONCRETE OVERLAY JOINT TABLE"

*** ONE WEEK PRIOR TO PLACING THE HMA SEPARATOR LAYER THE EXISTING CONCRETE PAVEMENT SURFACE SHALL BE SEALED ACCORDING TO THE SPECIAL PROVISION FOR "OVERBAND CRACK FILL." ALTERNATE #3 FROM THE MATERIALS SUBSECTION OF THE SPECIAL PROVISION SHALL BE USED FOR THE OVERBAND CRACK FILLING. IT SHALL BE MEASURED AND PAID FOR AS "OVERBAND CRACK FILL, ROADBED." WAX BASED, WHITE CURING COMPOUND SHALL NOT BE APPLIED TO THE HMA SEPARATOR LAYER.

**** CONTRACTOR SHALL ESTABLISH GRADE CONTROL FROM THE POINT DESIGNATED ON THE TYPICALS OR AS DIRECTED BY THE ENGINEER PRIOR TO PAVING THE CONCRETE PAVEMENT.

Figure A4. JN 73873 Cross-Section Notes

HMA APPLICATION ESTIMATE

IDENT NO.	ITEM	RATE PER SYD	PERFORMANCE GRADE	REMARKS
HMASL-1	HOT MIX ASPHALT SEPARATOR LAYER	110 #/Syd	64-28	HMA SEPARATOR LAYER
HMASL-2	HOT MIX ASPHALT SEPARATOR LAYER	330 #/Syd	64-28	HMA FOR TRENCHED SHOULDER
BA	HMA APPROACH	385 #/Syd	58-28	CROSS-OVERS, 4C & 3C
	BOND COAT*	0-0.1 GAL		FOR INFORMATION ONLY

*FOR INFORMATION ONLY

Figure A5. JN 73873 HMA Application Table

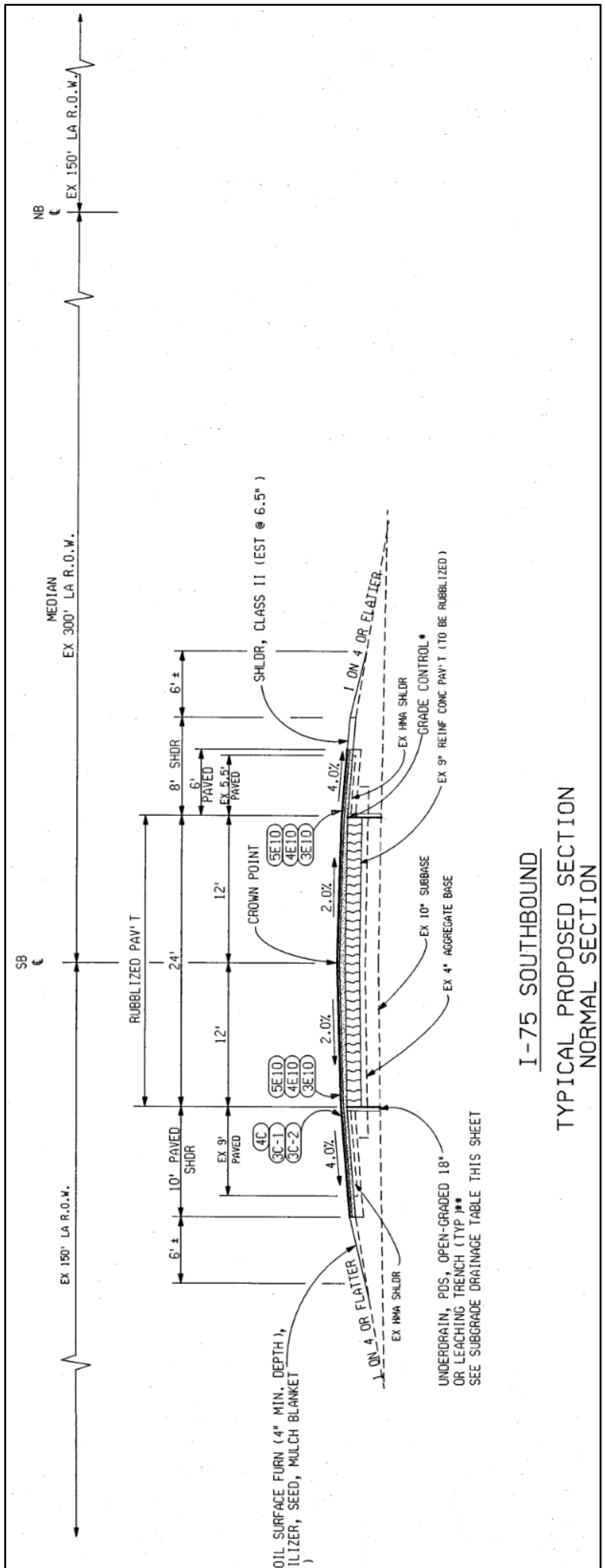

Figure A6. JN 45824 Typical Normal Cross-Section

* CONTRACTOR SHALL ESTABLISH GRADE CONTROL AT THE POINT DESIGNATED ON THE TYPICALS OR AS DIRECTED BY THE ENGINEER PRIOR TO PAVING THE HMA WEDGING FOR CROWN AND SUPERELEVATED MODIFICATIONS

** SURPLUS MATERIAL OBTAINED FROM EXCAVATING THE UNDERDRAINS AND/OR LEACHING TRENCH SHALL BE PLACED ON THE EXISTING DITCH FORESLOPE AS DIRECTED BY THE ENGINEER. IT SHALL BE USED AS PROP SHLDR, CLASS II OR TO ESTABLISH SIDESLOPES AFTER PAVING . THE COST OF GRADING THIS MATERIAL SHALL BE INCLUDED IN THE PAYMENT FOR OTHER PAY ITEMS.

Figure A7. JN 45824 Cross-Section Notes

HMA APPLICATION ESTIMATE

IDENT NO.	ITEM	RATE PER SYD	PERFORMANCE GRADE	REMARKS
5E-10	HMA, 5E10	165 #/SYD	64-28	TOP COURSE - MAINLINE AWI-260
4E-10	HMA, 4E10	220 #/SYD	64-28	LEVELING COURSE - MAINLINE
3E-10	HMA, 3E10	330-413 #/SYD	58-22	BASE COURSE (VARIABLE RATES REPRESENT WEDGING FOR CROWN MODIFICATIONS)
4C	HMA, 4C**	165 #/SYD	58-28	TOP COURSE - SHOULDERS AWI-260
3C-1	HMA, 3C**	220 #/SYD	58-28	LEVELING COURSE - SHOULDERS
3C-2	HMA, 3C**	330 #/SYD	58-28	BASE COURSE - SHOULDERS
BA	HMA APPROACH	385 #/SYD	58-28	CROSS-OVERS, 4C & 3C-1
4E-W	HMA, 4E10	VARIES	64-28	WEDGING, SUPERELEVATION SECTIONS
3C-W	HMA, 3C**	VARIES	58-28	WEDGING SHOULDERS
	BOND COAT*	0-0.1 GAL		FOR INFORMATION ONLY

* FOR INFORMATION ONLY

** TARGET AIR VOIDS SHALL BE LOWERED BY 1% WHEN USED IN SEPARATE SHOULDER PAVING OPERATION

Figure A8. JN 45824 HMA Application Table

Figure A9. MDOT Report # R-1465, Figure 5, Paver Track Running on Asphalt Separator Layer

Figure A10. MDOT Report # R-1465, Figure 7, Loose Asphalt Separator Layer. Note Embedded Lane Tie That Can Not Be Straightened for The Adjacent Lane

Figure A11. MDOT Report # R-1465, Figure 9, Voids in The Separator Layer Are Plugged with Construction Debris

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Research Proj.:	**Date:** 4/3/19	**Weather:** 40°F, clear, sunny
Proj. Manager:	**Control Sec./Job No.:**	
Item(s) Surveyed: Unbonded overlay demonstration project		
Location: I-75 NB, north of West Branch		
Contractor(s):		
Objective: Yearly visual evaluation		

Attendance:

J. Schenkel
A. Bennett

Observations:

NB Unbonded Overlay:

SECTION 1: 22 slabs with full depth repair
- 18 slabs in leftmost lane
- 3 slabs in center lane
- 1 slab in rightmost lane

SECTION 2: 37 slabs with full depth repair
- 4 slabs in leftmost lane
- 1 slabs in center lane
- 32 slab in rightmost lane

SECTION 3: 39 slabs with full depth repair
- 0 slabs in leftmost lane
- 4 slabs in center lane
- 35 slab in rightmost lane

SECTION 4: 20 slabs with full depth repair
- 0 slabs in leftmost lane
- 2 slabs in center lane
- 18 slab in rightmost lane

SECTION 5: 12 slabs with full depth repair, with one of those slabs cracked
- 4 slabs in leftmost lane
- 5 slabs in center lane (1 of these slabs are cracked)
- 3 slab in rightmost lane

Spalls in leftmost lane are filled with a mastic repair. The repairs look good.
The full-depth repairs look good.
Grinding and grooving of center and rightmost lanes. Shoulder has tapered grind.
All joints have been resealed. Most joints look tight.
The ride quality has greatly improved due to the repairs.

SB Rubblized:

Full-width transverse cracking appearing in both lanes. Transverse crack spacing varies from 12' - 40'. Intermittent longitudinal cracking in the wheel path. Longitudinal cracking appearing off of the longitudinal joint, (~2' off joint in one lane or the other). The centerline joint itself has continued to open. There is faulting at the

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longitudinal joint and at transverse cracks. An R&R project is scheduled to begin in 2019.

Conclusions: The NB demonstration project has greatly improved due to the recent maintenance project. The repair project appears to be well done and should greatly benefit the location. NB Section 3 had the most repairs, which is consistent with past reviews showing the most distressed slabs. Notwithstanding the maintenance project to NB, the SB section appears to have performed worse over a similar time period, considering that it requires an R&R type fix in 2019. The faulting of the longitudinal joint and transverse cracks has been the most problematic condition of this pavement section. Initial investigations indicate that the concrete base may not have been fully rubblized, which may be why faulting is occurring in the HMA surface.

Future Work: Continue with annual evaluations.

Notes taken by: Justin Schenkel & Andrew Bennett

Figure A12. April 2019 Field Evaluation Report (Latest)

Figure A13. April 2019 Field Evaluation Pictures of Northbound I-75 (Latest, 1-6)

Figure A14. April 2019 Field Evaluation Pictures of Northbound I-75 (Latest, 7-12)

Figure A15. April 2019 Field Evaluation Pictures of Southbound I-75 (Latest, 1-5)

Figure A16. Minor Corner Cracking in Section 5 on Northbound I-75 (Google Maps, Image Capture: September 2019)

Figure A17. MDOT Report # RC-1574, Figure A3, Dense-graded HMA Not Milled Off During Construction

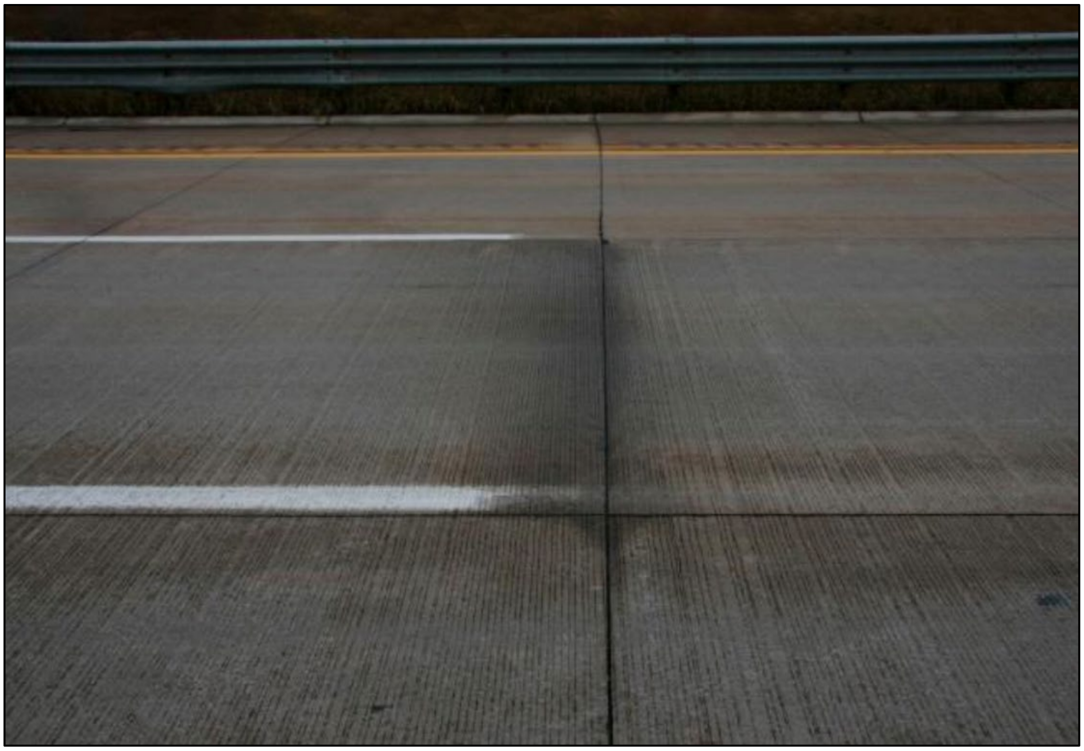

Figure A18. MDOT Report # RC-1574, Figure A4, Pumping in Super Elevation Part of Section 1 Sloping to The West *(away from the photographer)*

Figure A19. MDOT Report # RC-1574, Figure A11, Start of Longitudinal Cracking at Joints in Section 3 Within Year 1 (October 2004)

Figure A20. MDOT Report # RC-1574, Figure A12, Top-Down Longitudinal Cracking Starting at Transverse Joint Station 709+08 (Section 3)