Pavement Demonstration Program Project Finalization Thin Unbonded Concrete Overlay Projects – M-3 & M-1 (MDOT Job Numbers 72407 & 79673)

Final Technical Report

Prepared by:

Zhanping You, Ph.D., P.E.
Kwadwo Ampadu Boateng, Research Assistant
Jacob E. Hiller, Ph.D.
Dongzhao Jin, Ph.D.
Lei Yin, Research Assistant

MTUengineering
CIVIL, ENVIRONMENTAL, AND GEOSPATIAL ENGINEERING

Michigan Technological University
1400 Townsend Drive
Houghton, MI 49931

Submitted to:

Michigan Department of Transportation
8885 Ricks Road
Lansing, MI 48909

Report No. OR23-304, A

April 2024

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. OR23-304A	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle Pavement Demonstration Program Project Finalization Thin Unbonded Concrete Overlay Projects – M-3 & M-1 (MDOT Job Numbers 72407 & 79673)		**5. Report Date** April 2024 **6. Performing Organization Code** N/A
7. Author(s) Zhanping You, Kwadwo Ampadu Boateng, Jacob E. Hiller, Dongzhao Jin, Lei Yin		**8. Performing Organization Report No.** N/A
9. Performing Organization Name and Address Michigan Technological University 1400 Townsend Drive, Houghton, MI 49931-1295		**10. Work Unit No.** N/A **11. Contract or Grant No.** Contract 2022-0432:Z1
12. Sponsoring Agency Name and Address Michigan Department of Transportation (MDOT) Research Administration 8885 Ricks Road P.O. Box 33049 Lansing, Michigan 48909		**13. Type of Report and Period Covered** Final Report, 03/20/2023 –08/31/2024 **14. Sponsoring Agency Code** N/A
15. Supplementary Notes Conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration. MDOT research reports are available at www.michigan.gov/mdotresearch.		

16. Abstract

All demonstration projects are continually evaluated to determine whether there is enough information to create appropriate performance curves and/or determine their applicability as a Michigan Department of Transportation (MDOT) standard practice. This report summarizes projects for which a final determination can be made to finalize and end their designation as a demonstration project. This document is a final comprehensive report on the "Thin Unbonded Concrete Overlay" projects on M-3 and M-1 in Wayne County, MDOT job numbers 72407 and 79673, respectively. The M-3 and M-1 projects were constructed in 2005 and 2010, respectively. Both projects are 4-inch (thin) unbonded non-reinforced concrete overlays, each with a 15-year design life. While unbonded concrete overlays 6 inches or thicker are already a standard fix for MDOT, these demonstration projects aimed to evaluate the use of overlays less than 6 inches thick, which MDOT categorizes as "thin." Furthermore, M-3 included test sections to evaluate two different hot mix asphalt (HMA) separator layer mixes and the use of joint (transverse and longitudinal) sealing with hot-pour rubber. The usage of thin unbonded concrete overlay in these demonstration projects provided satisfactory structural and functional performance. The choice of HMA separator mixes, whether dense or open-graded, showed a negligible effect on resistance to surface distress over the life of these projects. Sealing of joints or leaving joints unsealed also did not significantly impact the distress performance of concrete panels in these demonstration projects. The overall performance of thin unbonded pavement is deemed acceptable, and this fix type is suitable for MDOT use where appropriate for future rehabilitation activities. Additionally, some best practices for concrete overlays, such as incorporating macro fibers in thin overlays, are recommended for future projects to extend the life of these pavement rehabilitation options.

17. Key Words Concrete overlay; joint; sealed; panel; unsealed; pavement; crack; distress; joint; separator; maintenance	**18. Distribution Statement** No restrictions. This document is also available to the public through the Michigan Department of Transportation.

19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 79	**22. Price** N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

Disclaimer

This report is disseminated to facilitate information exchange. The Michigan Department of Transportation (referred to as MDOT hereafter) explicitly denies any form of liability, regardless of nature or cause, that may arise from the use of this document or the information and data presented within it. MDOT also takes no responsibility for typographical errors, or the accuracy of the information included in this content. MDOT does not provide any warranties or assurances regarding the quality, substance, comprehensiveness, suitability, sufficiency, order, accuracy, or timeliness of the provided information and data. Moreover, MDOT does not assert that the contents establish standards, specifications, or regulations.

Acknowledgments

The research work was sponsored by the Michigan Department of Transportation (MDOT). The authors extend their gratitude for the direction and engagement of Justin Schenkel, Andre Clover, Michael Eacker, Fawaz Kaseer, and Kevin Kennedy, all affiliated with MDOT. Additionally, the authors acknowledge Emily Kastamo for her role as the English editor for this report.

Table of Contents

List of Tables

List of Figures

Introduction

Public Act 457 of 2016, MCL 247.651h contains what is referred to as the pavement life-cycle law. This law requires the Michigan Department of Transportation (MDOT) to conduct a life-cycle cost analysis (LCCA) on projects with pavement costs of $1.5 million or more. The LCCA process is a tool to select the lowest-cost pavement design over the expected service life of the pavement. By law, the LCCA process must include historical information for initial construction and maintenance costs and performance (service life). This information is unavailable for new pavement design types and technologies. Thus, it cannot be used in the pavement selection process until substantial information has been obtained. Accordingly, Public Act 457 of 2016, MCL 247.651i, the pavement demonstration law, provides a means for trying new and innovative ideas through demonstration projects. These demonstration projects are not subject to an LCCA process. Pavement demonstration outcomes are intended to increase service life, improve pavement condition, improve ride quality, and/or lower service life costs. Future LCCAs may utilize the cost, performance, and maintenance information from the demonstration projects. Selection of candidate projects is collaborative among MDOT Construction Field Services pavement personnel, MDOT region personnel, and paving 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 template budget. These projects are monitored until a final decision is made regarding the suitability of adopting them as MDOT standard practice. This report evaluates two projects for the "Thin Unbonded Concrete Overlay" pavement demonstration fix type on M-3 and M-1 in Wayne County, MDOT job numbers 72407 and 79673, respectively.

Project Description

The M-3 and M-1 projects were constructed in 2005 and 2010, respectively. The M-3 project is on Gratiot Avenue (north and southbound) from St. Aubin Street to McClellan Avenue, while M-1 is on Woodward Avenue (both north and southbound) from Tuxedo Street to Chandler Street. Figure 1 shows the project locations. Each project is a 4-inch unbonded concrete overlay with a 15-year design life. Transverse joints are spaced at 6 feet, while the longitudinal joints are spaced at 5.5 feet for M-3 and 5 feet for M-1 (see Table 1). Due to their relatively thin concrete panel thickness and close joint spacing, neither project includes dowel bars for load transfer at the transverse joints or tie bars at the longitudinal joints. The standard MDOT unbonded concrete overlay provides a 6-inch or thicker concrete panel with a 20-year pavement design life and joint spacings of 12 feet by 12 feet with dowels and tie bars at the joints. All joints were sealed for the M-1 project, and a dense-graded (DG) hot-mix-asphalt (HMA) bond-breaking separator layer was used between the existing pavement and concrete overlay. However, for the M-3 project, 4 different test sections were utilized, involving a combination of sealed and unsealed joints with two different HMA separator layers consisting of a standard DG HMA and more drainable, open-graded (OG) HMA. Tables 2 and 3 describe the interlayer material types and joint sealing methods used for test sections on M-3 and M-1, respectively. The maps in Figures 1 to 3 show the locations of the sections described in Tables 2 and 3.

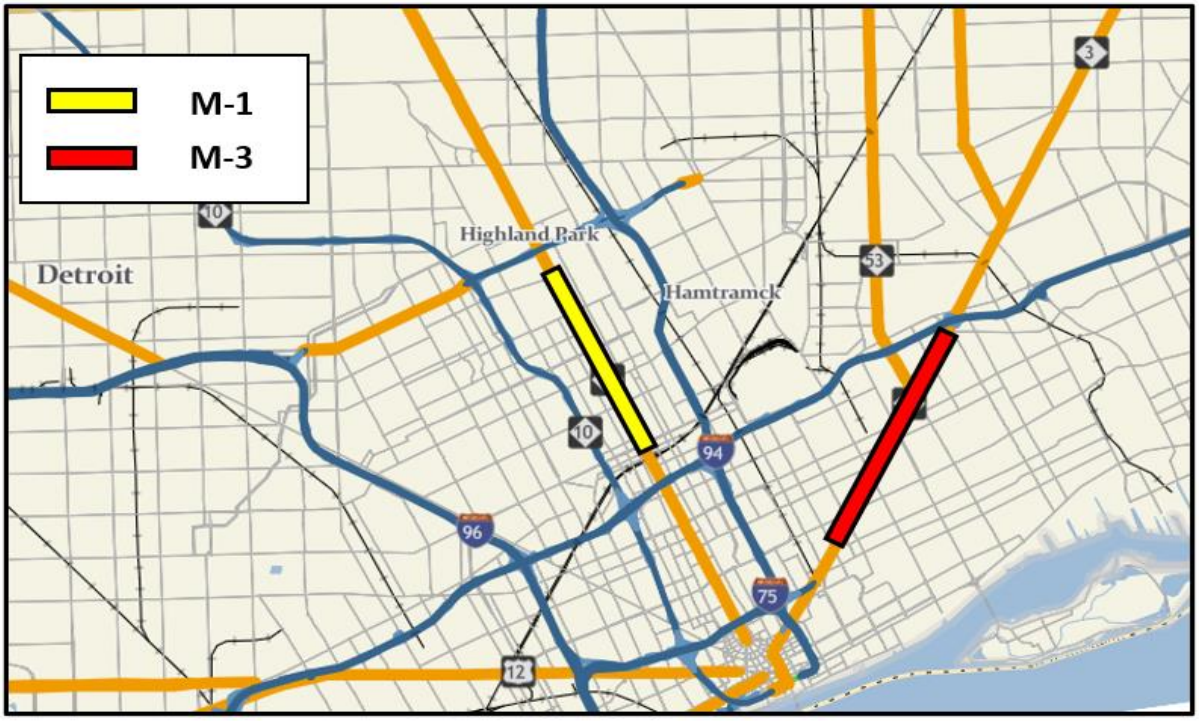

Figure 1. M-3 and M-1 Demonstration Project Location

Table 1. M-3 and M-1 Concrete Panel Summary

Project Location	Plan Panel Depth (inches)	Transverse Joint Spacing (feet)	Longitudinal Joint Spacing (feet)
M-3	4	6	5.5
M-1	4	6	5

Table 2. M-3 Demonstration Project Test Section Descriptions

Test Section Number	Test Section Description	Length of Test Section (miles)	PR Number	PR BMP	PR EMP
1	OG HMA separator, unsealed joints	0.992	4711788	1.499	2.491
2	OG HMA separator, sealed joints	0.831		2.491	3.322
3	DG HMA separator, sealed joints	0.738		3.322	4.060
4	DG HMA separator, unsealed joints	0.802		4.060	4.862

** Note: PR is Physical Road, BMP is Beginning Mile Point, EMP is Ending Mile Point. PR and MP information is per PR Version 22.*

Figure 2. M-3 Demonstration Project Test Section Locations

Table 3. M-1 Demonstration Project Description

Test Section Number	Test Section Description	Length of Test Section (miles)	PR Number	PR BMP	PR EMP
N/A	DG HMA separator-sealed joints	1.473	1591001	1.901	3.374

** Note: PR and MP information is per PR Version 22*

Figure 3. M-1 Demonstration Project Location

Existing Pavement Structure and Condition Before Demonstration Project

These roads have been serving motorized traffic for several years with the last prior major rehabilitation work for these pavements dating back to the 1950's and 1960's. The existing pavement structure on M-3 at the time of construction from top to bottom ranged from 4.5-10 inches of HMA, resting on 8.5-15 inches of concrete over 18-36 inches of unbound base (including subbase) material. In the outside lanes, 2-9 inches of HMA was laid on 3 inches of brick pavers over 8-14 inches of concrete on 18-36 inches of base material. Note that two encased trolley tracks are underneath the center of the M-3 pavement structure, as indicated in the plan review report on JN 72407 C [1]. On M-1, thirteen (13) cores were extracted from the inside, middle, outside, and center turn lanes before construction. On average, the existing pavement had 6.6 inches of HMA over 10.3 inches of concrete placed on 6.6 inches of aggregate base material over 10.6 inches of sand subbase. The northbound outside lane had 3-inch brick pavers laid on a 0.25-inch sand cushion over 9.6 inches of reinforced concrete. The underlying subbase layer was 1.5 inches of sand on average. The pavement structure was obtained from the proposed thin unbonded concrete overlay demonstration project, field investigation report CS 82131 JN 79673 [2].

Before construction in 2010, pavement distresses such as rutting, cracking (reflection and alligator cracking), and localized settlements were present on M-1. These distresses were predominant in intersections, parking lanes, stops, and around utility structures (manholes), as seen in Figures 4 to 7. Both M-3 and M-1 were rehabilitated before the placement of the unbonded concrete layer. The brick pavers were removed, and the distressed sections were cold-milled and resurfaced.

The existing pavement cross-sections on M-3 and M-1 are shown in Appendix Figures A1 to A3. Images of the 4-inch unbonded concrete layer and the asphalt separator at construction are shown in Appendix Figures A4 and A5.

Figure 4. Deteriorated Pavement in the Outside Lane from MDOT Field Investigation Report for M-1

Figure 5. Cracking in Outside Lane from MDOT Field Investigation Report for M-1

Figure 6. Distress Around Utility Mains from MDOT Field Investigation Report for M-1

Figure 7. Localized Settlement in Middle Lane from MDOT Field Investigation Report for M-1

Traffic Data and CESALs

Traffic, climate, and construction material properties are the primary factors influencing pavement performance. Climate conditions have similarly impacted Michigan pavements, and the materials used on M-3 and M-1 are considered to have met construction acceptance criteria. Therefore, traffic volume is the crucial parameter for evaluating the pavement designs and assessing the potential risk for premature distress on M-3 and M-1. Accordingly, the anticipated traffic levels from the initial designs will be compared with the actual traffic that these pavements experienced. Traffic data was obtained from MDOT’s transportation data management system (TDMS), and concrete equivalent standard axle load (CESAL) values were computed. M-3 traffic volume data were recorded at three locations within the project limits. The two-way commercial annual average daily traffic (CAADT) was collected between St. Aubin Street and Elmwood Street. The second section is situated between Elmwood Street and Van Dyke Street. The final section lies between Van Dyke Street and McClellan Street. On M-1, traffic data was reported between Chandler Street and Tuxedo Street in this database.

The initial 15-year design CESAL values for both routes were estimated based on the AASHTO 1993 design method. The equation used for CESAL computation is as shown below:

$$CESALs_{Estimated} = CAADT \times 365 \times DD \times LD \times TF \times GF$$

Where:
GF = growth factor, $[(1+g)^n - 1]/g$
g = growth rate expressed as a decimal
n = number of years

The directional distribution factor (DD), lane distribution factor (LD), growth rate (g), and CAADT were obtained from the traffic analysis report for M-3. Similar factors were assumed for M-1, and a CAADT value commensurate with the traffic level on M-1 was used. Additionally, the actual CESAL values for M-3 and M-1 were computed by extracting traffic volume data from TDMS. A lane distribution factor (LD) of 0.9 and a truck factor (TF) of 0.93 were estimated from the M-3 traffic analysis report. The yearly actual CESAL values were computed based on the AASHTO 1993 design method. The equation used for CESAL computation is as shown below:

$$CESALs_{Actual} = CAADT \times 365 \times DD \times LD \times TF$$

Although M-3 was constructed in 2005, traffic volume data available on TDMS was from 2008 to 2022. This data was extracted and used for CESAL estimation. It should be noted that 2010 data was unavailable on TDMS for M-3. Therefore, the average CAADT values of the years 2009 and 2011 were used to estimate the 2010 CAADT value. Since M-1 was constructed in 2010, data from 2011 to 2022 was extracted for CESAL computation purposes. Since 2015 data was not available for M-1, the average CAADT values of 2014 and 2016 were used. Additionally, projections were made for the actual CESAL values in 2023, 2024, and 2025 assuming a 2% traffic growth rate. For both projects, to estimate actual CESAL, the same LD was assumed, but the TF value was reduced to 0.74 matching new information as found from more recent adjacent projects. A summary of the initial design and actual computed CESAL values is shown in Table 4. A detailed breakdown of the initial design and actual estimated CESAL values can be found in the Appendix, Tables C1 to C5. The projects were subjected to similar CESALs as was estimated during the initial design, so these appear to be reasonably designed.

Table 4. Traffic and Estimated CESALs for M-3 and M-1 Test Sections

Route	Location	Period	Estimated Design CESALs	Actual Computed CESALs
M-3	St. Aubin Street to Elmwood Street	2008-2022	≈ 2,900,000	≈ 2,500,000
M-3	Elmwood Street to Van Dyke Street	2008-2022	≈ 2,900,000	≈ 2,700,000
M-3	Van Dyke Street to McClellan Street	2008-2022	≈ 2,900,000	≈ 2,600,000
M-1	Chandler Street to Tuxedo Street	2011-2025	≈ 1,500,000	≈ 1,400,000

Pavement Condition Surveys and Performance Data

For pavement demonstration projects, site condition field surveys are conducted and reported annually in the annual MDOT Demonstration Program Legislative Report, *Pavement Demonstration Program Status Report Public Act 457 of 2016* [3]. Crack and repair data is typically collected and reported in this survey. Crack and repair data were collected in both directions (southbound and northbound) on M-3 and M-1. Data was collected on the inside and middle lanes of M-1. On M-3, data was collected on the inside, middle, and outside lanes (2 inner panels). Typical lane configurations of M-3 and M-1 are shown in Figures 8 and 9. It should be noted that the outside lane of M-3 has 3 panels (as shown in Figure 8) to accommodate intermittent on-street parking along this route, as opposed to 2 panels on M-1. Due to this variation in the number of lanes and panels, the performance of M-3 and M-1 is challenging to compare directly.

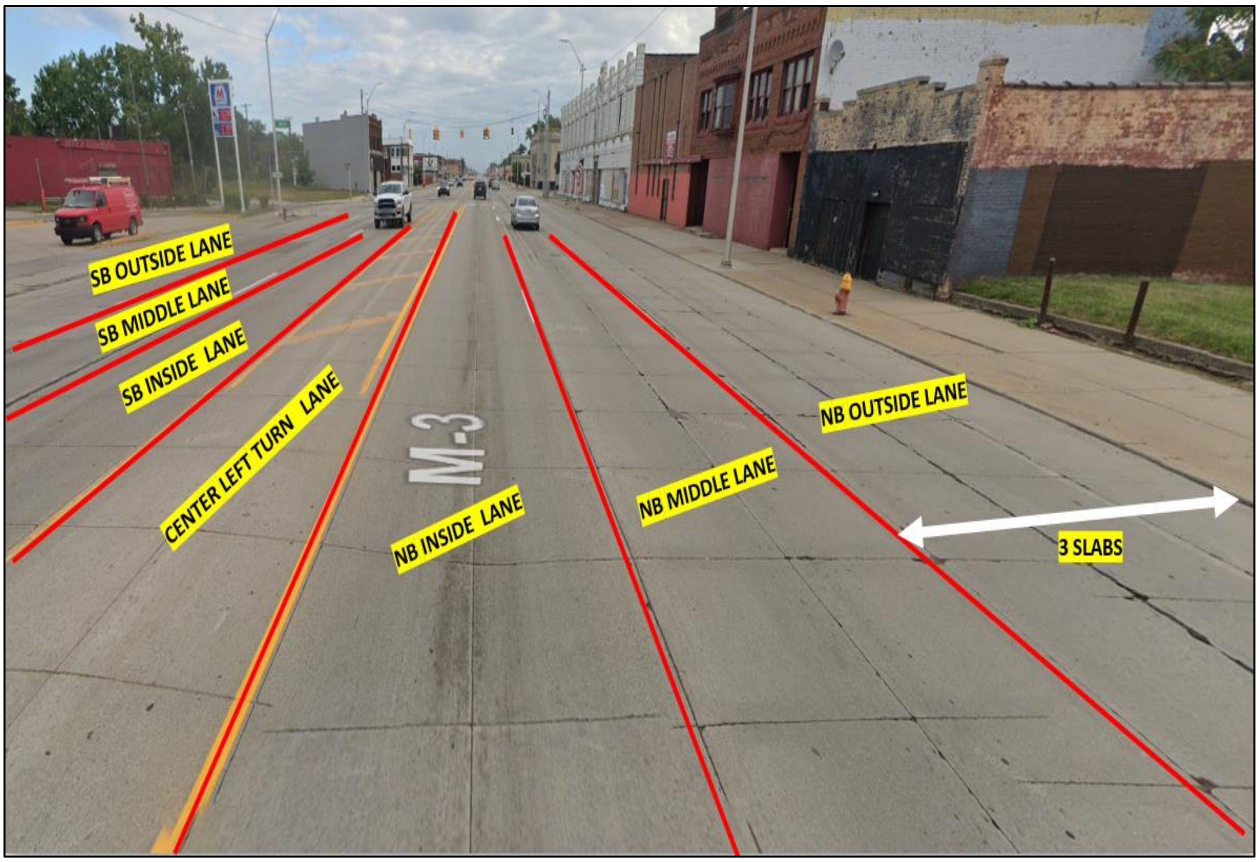

Figure 8. Lane Configuration for M-3, Google Maps Image 2022

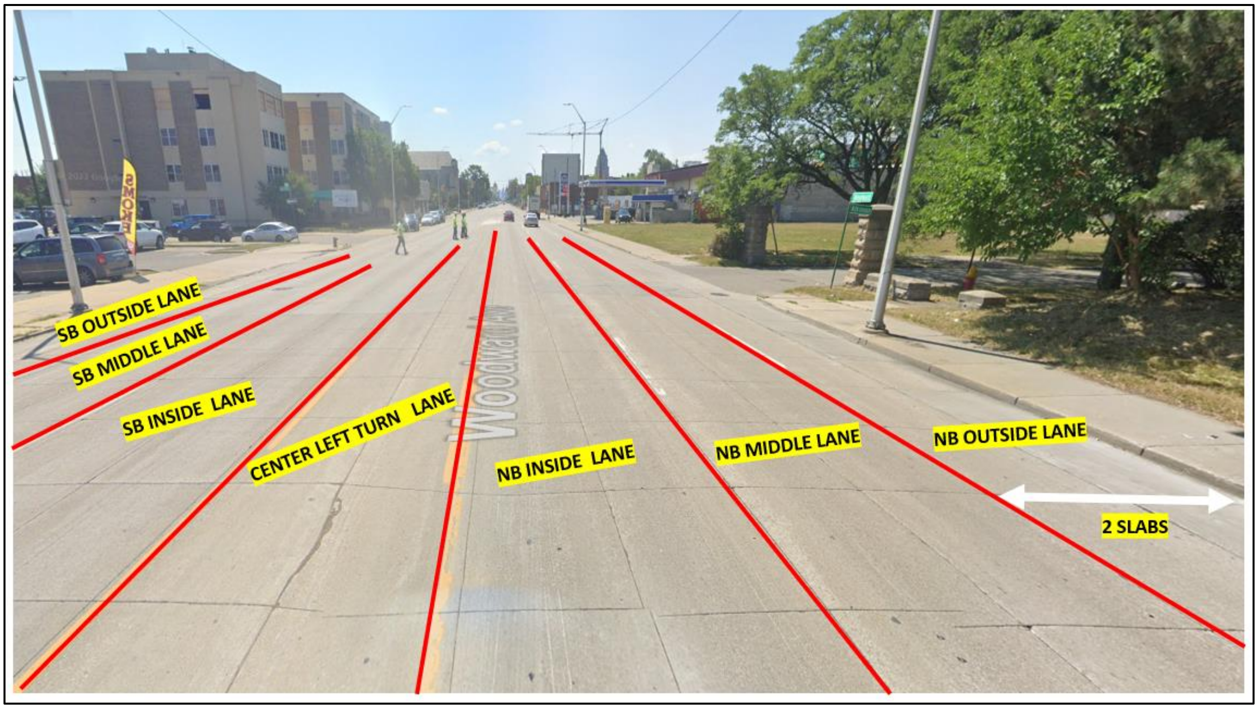

Figure 9. Lane Configuration for M-1, Google Maps Image 2022

The field visit of M-3 conducted in April 2022 noted that after 17 years of service (2022), approximately 13% of all concrete panels on M-3 are either cracked or repaired. The percentages of repaired or cracked panels are shown in Table 5. The DG HMA separator with sealed joints section currently has the highest percentage of cracked or repaired panels at 15.0%. The OG HMA separator with sealed joints and the DG HMA separator with unsealed joints have comparable percentages of cracked or repaired panels of 11.8% and 12.0%, respectively. The percentage of cracked or repaired panels of 13.1% for the OG HMA separator with unsealed joints is marginally higher than that of the OG HMA separator with sealed joints and the DG HMA separator with unsealed joints. However, it is lower than that of the DG HMA separator with sealed joints. Figure 10 shows the overall trend of cracked and repaired panel percentages through the pavement's design life.

Each year, as the pavement has continued to age, an increase in distresses like raveling, cracking, and spalling has been observed throughout the project. Specifically, sections 2 and 3 of the northbound outside lanes have experienced significant spalling in their middle longitudinal joint. The highest distress concentration is observed at intersections, bus lanes, transitions, and manholes. To address this, maintenance and repair work has been conducted, and about 87% of the remaining panels do not exhibit cracking as of 2022. Pictures of the current pavement condition on M-3 are shown in Appendix Figure A10. The field visit summary notes described the pavement's overall performance as fair*.

** Note: "Condition ratings of good/fair/poor have been assigned to each project based on a subjective evaluation of the condition at the time of the latest field visit. Ratings are intended to provide a general sense of the performance (in terms of anticipated distress and ride quality per the design type) of each project and may not reflect future decisions about performance after all relevant information is obtained to make a final determination."*

Table 5. Condition Survey Summary for M-3 April 2022

Section Description	Cracked /Repaired Panel Percentage (%)
OG HMA separator, unsealed joints	13.1
OG HMA separator, sealed joints	11.8
DG HMA separator, sealed joints	15.0
DG HMA separator, unsealed joints	12.0
All test sections (Overall)	**13**

The annual visit for M-1 in April 2022 noted that after 12 years in service (2022), 9.1% of panels have been cracked and repaired. Additionally, intermittent black staining was observed on either side of the transverse and longitudinal joints. This may be attributed to pumping of water at the HMA interlayer, but as is noted in the following section, no moisture was found to be present during slab replacement repairs. Accordingly, the panels where the staining occurs do not exhibit much distress, and the corresponding joints are in fair to good condition. Of the panels cracked/repaired, about 73% occurred in the middle travel lanes (next to the outside lanes). The high presence of distress in the middle lane may also be due to the propagation of distress from the outside lane. While not included in the counts, most panels in the outside lanes have been repaired due to many being faulted or shattered. Throughout the project length, annual maintenance has been performed over the past 4 years to repair localized areas of distressed panels. The field visit summary notes described the performance of this section as fair*.

** Note: "Condition ratings of good/fair/poor have been assigned to each project based on a subjective evaluation of the condition at the time of the latest field visit. Ratings are intended to provide a general sense of the performance (in terms of anticipated distress and ride quality per the design type) of each project and may not reflect future decisions about performance after all relevant information is obtained to make a final determination."*

Table 6. Condition Survey Summary for M-1 April 2022

Section Description	Cracked /Repaired Panel Percentage (%)
DG HMA separator-sealed joints	9.1

Figure 10 shows the percentage of panels cracked or repaired for each combination of HMA separator and joint sealing method used on M-3 and M-1. For the sections on M-3, the DG HMA separator with sealed joints experienced the highest crack and repair activity. The OG sealed HMA separator has the lowest crack or repair; hence, it is the best-performing section. However, the difference in crack and repair percentage of the lowest and highest performing sections is only 3%. Therefore, all sections can be deemed to have comparable performance. Moreover, as the pavement approaches the design life of 15 years, there is a sharp rise in cracks and repairs. This trend may suggest that the thin unbonded concrete overlay can provide adequate performance for 15 years but may require more maintenance or major rehabilitation and/or reconstruction thereafter.

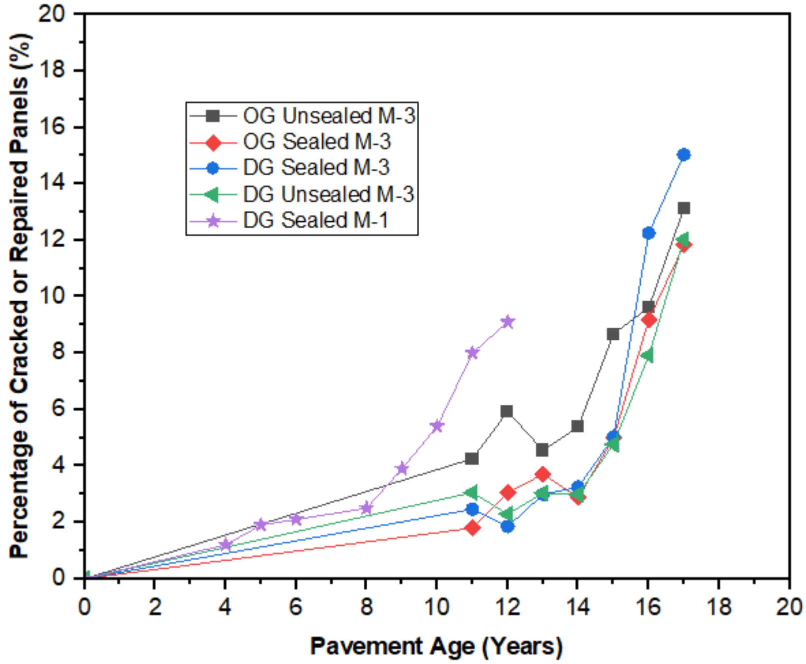

Figure 10. Percentage of Cracked or Repaired Panels Per Pavement Age of M-3 and M-1 for each Test Section

Figure 11 compares the overall crack and repair percentage for the entire routes, M-3 and M-1. At a similar pavement age, M-1 appears to have more cracks/repairs when compared with M-3.

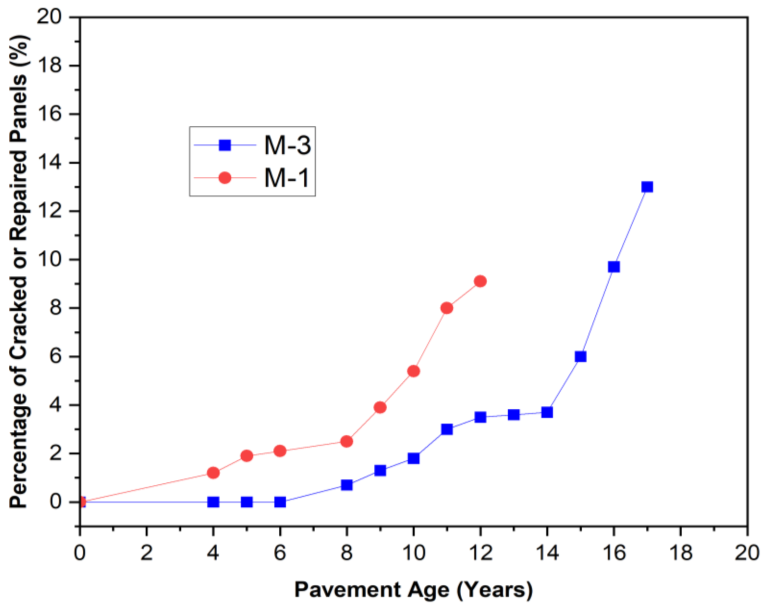

Figure 11. Percentage of Cracked or Repaired Panels Per Pavement Age of M-3 vs M-1

For MDOT roadways, pavement performance for each project is measured by a variety of methods, including faulting, MDOT's Distress Index (DI), International Roughness Index (IRI), and the Pavement Surface Evaluation and Rating (PASER). Faulting is the difference in elevation across joints (or cracks), measured in inches. The total number of faults is identified by the number of times a difference in elevation is observed. The DI measurement is the total accumulated distress point value for a given pavement section normalized to a 0.1-mile length. It is a unitless value that indicates 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 that physical distresses such as faulting and rutting can impact its measurement). PASER is a visual method of assessing road conditions on a scale of 1 (failed) to 10 (excellent). Measurements for this data are to be taken in the rightmost lane (outside lane) unless this lane was not available due to construction or other lane obstruction. Accordingly, on M-3, the data was collected on the outside lane of the Northbound route (away from downtown Detroit). On M-1, the data was obtained on the outside lane of the southbound route (towards downtown Detroit). Therefore, the performance measurements may not be directly comparable to the annual site condition surveys since measurements occurred in only one direction and lane.

Note that historically through 2019, MDOT network-level data collection for DI, IRI, and rut-or-fault was 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, the annual IRI collection began in at least one direction of all National Highway System (NHS) routes.
- Starting in 2018, the annual IRI collection on at least one direction of all NHS routes was reduced to only Interstate routes.
- Also, starting in 2018, the 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.

A summary of IRI and DI on M-3 and M-1 is presented in Tables 7 and 8 and Figures 12 and 13. The faulting measurements (per the right wheel path) for each route are shown in Tables 9 and 10 and Figures 15 and 16. The PASER value for each test section is shown in Figure 14. Figure 12 presents IRI data for M-3 and M-1. The DG separator with sealed joints on M-1 had an early high roughness index near its construction and worsened throughout the pavement life, exceeding the MDOT threshold of 170 inches/mile for pavements with poor roughness. This may be attributed to late saw cutting during construction, which is a primary contributor to panel cracking and joint faulting. On M-3, for sections with OG HMA separator, sealing of joints leads to low roughness. However, for the DG HMA separator sections, the impact of sealing joints is negligible. Figure 13 shows that at the early stage of the service life (less than 5 years) of M-3 and M-1, all sections had a DI of less than 10. Ten years into the pavement service life, all sections had DI values of less than 25. At about 15 years, the DI for all sections is below 40. All values are below 50 DI, which is the value used in the MDOT Pavement Selection Manual [4] to approximate the end of service life. Overall, the pavement is showing a fair performance as quantified by DI. Using the PASER rating as an evaluation tool, most sections have a fair or good rating level, as shown in Figure 14. The one exception is the OG HMA separator section with unsealed joints, which has a poor PASER rating after 14 years of service. Although M-3 has higher faulting than M-1, as depicted in Figure 15, both routes showed a drop in faulting, as seen in Figure 16. This indicates that the regular maintenance activities on both routes have helped re-establish adequate ride quality.

Overall, the thin unbonded concrete overlays have demonstrated satisfactory pavement performance throughout their 15-year design life, as evidenced by the condition survey and performance data. The data trends have remained low, with nearly all measurements being considered good to fair throughout this period. Therefore, it is advisable to plan maintenance work within this timeframe to mitigate potential increases in distress and extend the pavement serviceability.

Table 7. Yearly Progression of IRI and DI for M-1

Data Year (Pavement Age)	DG HMA separator, Sealed Joints	
	IRI	DI
2011 (1)	112	-
2012 (2)	140	4.256
2013 (3)	114	-
2014 (4)	126	3.988
2015 (5)	140	-
2016 (6)	139	6.406
2017 (7)	203	-
2018 (8)	140	20.585
2021 (11)	238	-

Table 8. Yearly Progression of IRI and DI for M-3

Data Year (Pavement Age)	OG HMA separator, Unsealed Joints		OG HMA separator, Sealed Joints		DG HMA separator, Sealed Joints		DG HMA separator, Unsealed Joints	
	IRI	DI	IRI	DI	IRI	DI	IRI	DI
2006 (1)	99	0.092	69	0	80	0.274	70	0.177
2007 (2)	116	1.838	70	0	77	1.035	74	0.328
2009 (4)	119	-	84	-	89	-	71	-
2010 (5)	112	1.204	70	0.78	83	0.545	81	0.893
2011 (6)	117	-	72	-	93	-	85	-
2012 (7)	119	12.245	72	4.846	88	4.369	87	2.848
2013 (8)	159	-	94	-	107	-	109	-
2014 (9)	126	17.495	77	17.777	96	22.723	93	7.191
2015 (10)	134	-	85	-	105	-	105	-
2016 (11)	146	27.874	85	32.177	104	45.694	109	15.914
2017 (12)	135	-	83	-	106	-	102	-
2018 (13)	159	31.672	93	17.469	128	34.132	110	4.144
2021 (16)	163	-	98	-	152	-	131	-

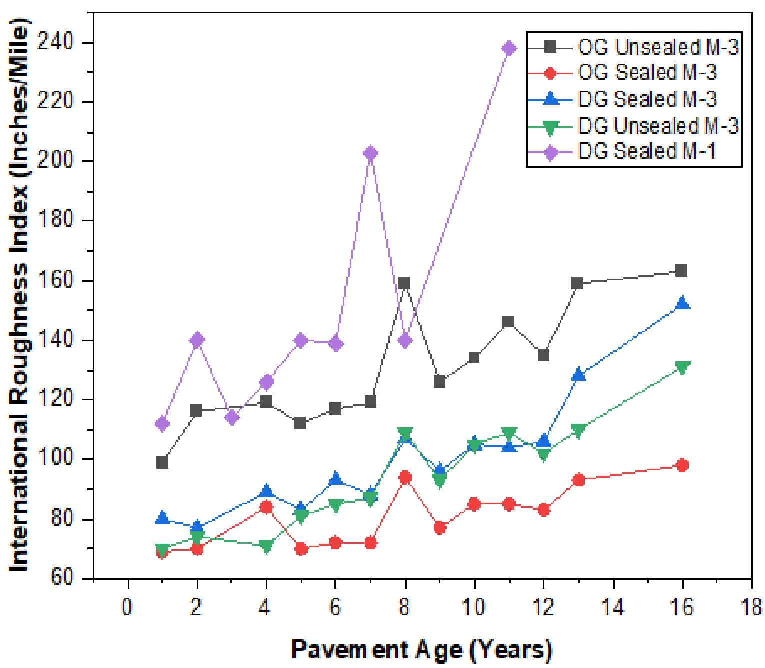

Figure 12. Yearly IRI Performance for Test Sections on M-3 and M-1

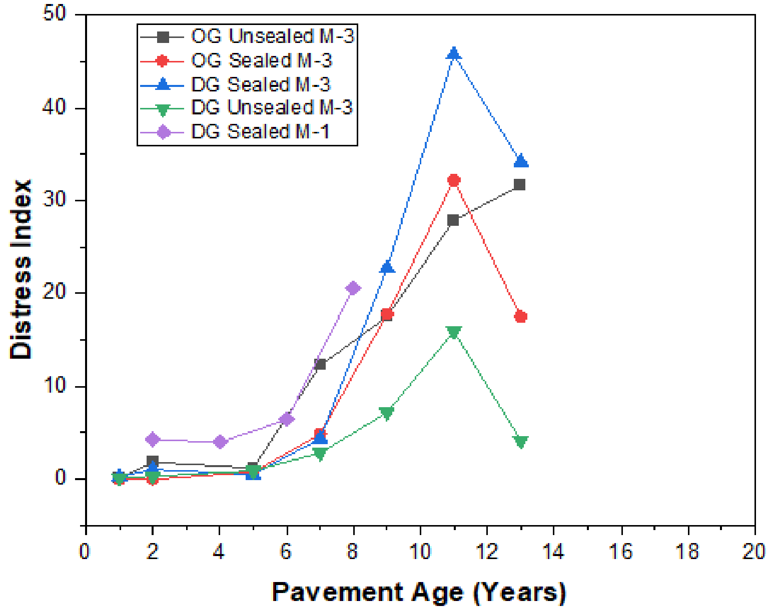

Figure 13. Yearly DI Performance for Test Sections on M-3 and M-1

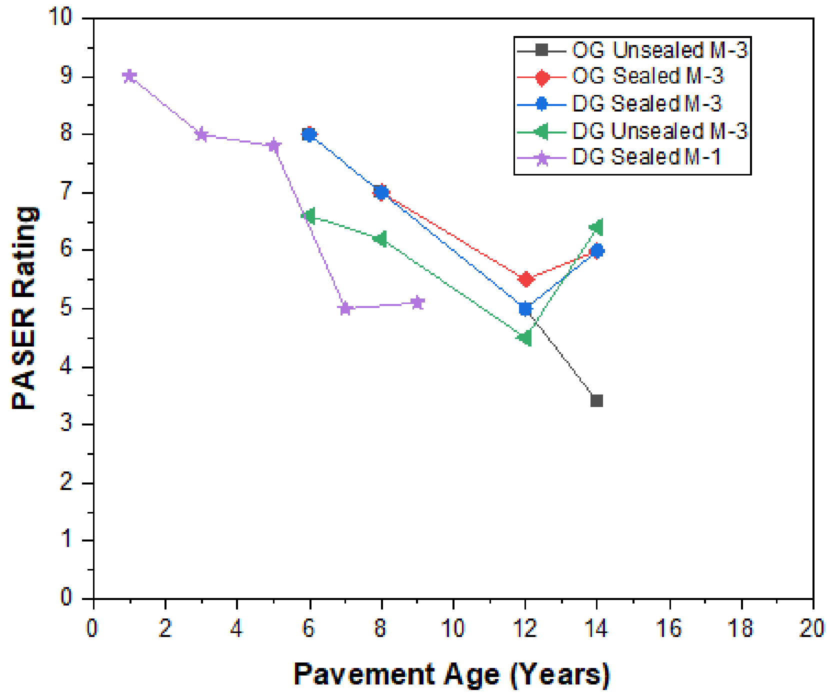

Figure 14. Yearly PASER Performance for Test Sections on M-3 and M-1

Table 9. Yearly Progression of Right Wheel Path Faulting for M-3

Data Year (Pavement Age)	Total No. Faults/Mile	Avg Fault (in)
2006 (1)	6	-
2007 (2)	6	-
2009 (4)	23	-
2010 (5)	19	-
2011 (6)	17	-
2012 (7)	652	0.09
2014 (9)	953	0.05
2016 (11)	2280	0.22
2018 (13)	881	0.1

Table 10. Yearly Progression of Right Wheel Path Faulting for M-1

Data Year (Pavement Age)	Total No. Faults/Mile	Avg Fault (in)
2011 (1)	6	-
2012 (2)	398	0.08
2014 (4)	600	0.04
2016 (6)	1092	0.17
2018 (8)	632	0.1

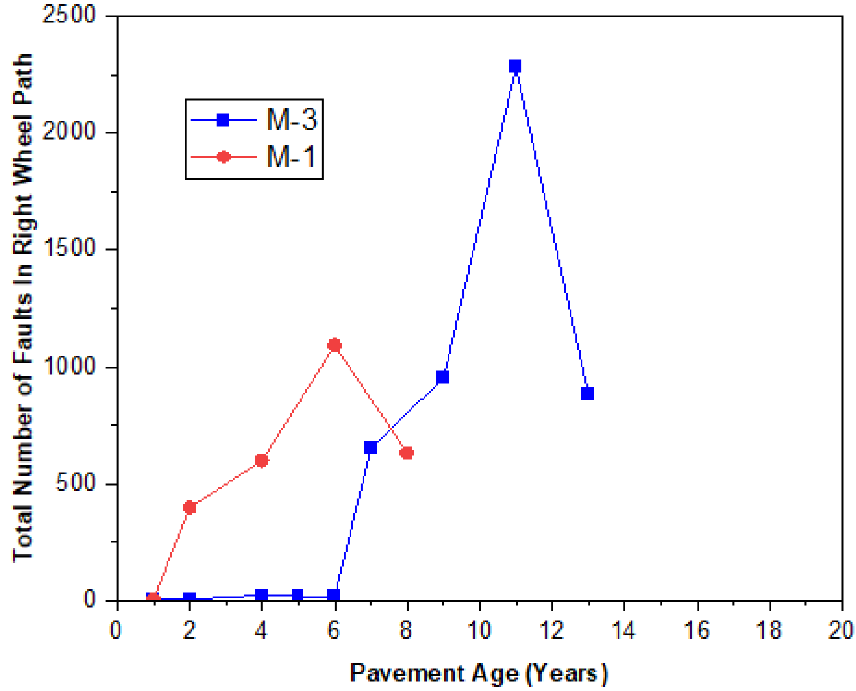

Figure 15. Yearly Count of Observed Faults in Right Wheel Path for M-3 and M-1

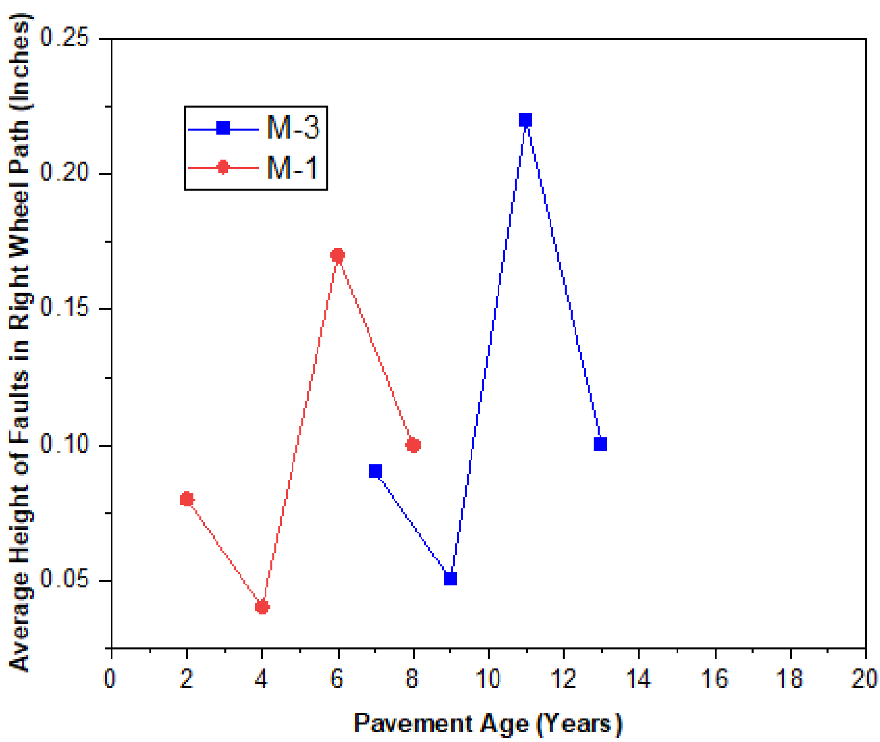

Figure 16. Yearly Performance of Fault Height in Right Wheel Path for M-3 and M-1

Data Analysis and Observations

The falling weight deflectometer (FWD) measurement on M-1 before construction in 2010 was obtained by using MDOT's KUAB FWD [2]. MODULUS, a back-calculation program developed by the Texas Transportation Institute was used to obtain the pavement layer moduli values. Accordingly, FWD results show a variation in the modulus of elasticity for HMA, concrete, and subgrade materials in different lanes, as depicted in the back-calculated layer moduli values in Table 11. Note that these FWD results are relative to the condition at the time it was taken and may not represent the yearly average or seasonal corrected value for the location. While higher moduli generally suggest reduced deflections under truck loads, the variation in moduli may lead to varied pavement performance over time. Therefore, though thin unbonded concrete overlay can provide adequate performance, underlying pavement conditions could significantly affect performance.

For M-3, some panels at an intersection were repaired in 2008 due to premature failure. These panels exhibited distresses like blowups, cracking, and spalling, as shown in Appendix Figures A12 and A14. Cores were extracted to better understand the cause of the failure, as shown in Figures A15 and A17 of the Appendix. It was observed that sections with severe failure had a concrete overlay thickness less than the design thickness of 4 inches. In general, the causes of failure of the thin unbonded concrete overlay were due to variability in construction rather than poor performance of the designed thin overlay.

Table 11. FWD Layer Moduli Properties for M-1

Lane Description	Average Pavement Layer Moduli Values (psi)		
	Concrete	**HMA**	**Subgrade**
NB Outside Lane	2,479,162	495,497	25,939
NB Middle Lane	4,746,768	714,277	25,948
NB Inside Lane	1,706,528	467,757	26,099
Center Left Turn Lane	3,799,506	312,905	18,984
SB Middle Lane	2,711,537	458,943	24,978
SB Inside Lane	1,691,669	579,638	25,623
SB Outside Lane	439,974	378,982	21,688

Ground penetrating radar (GPR) data were obtained for M-1 and M-3 in 2015 to assess the thickness of the thin concrete overlay data. It should be noted that limited concrete cores were available, so the GPR measurements cannot be confirmed. The GPR measurements can be used for estimation based on these limited available cores. The mean thickness of thin unbonded concrete overlay on M-3 and M-1 is summarized in Table 12. Variable concrete overlay depths were observed for different lanes, and in general, the mean depth is approximately 4 inches or above, with some lanes having concrete depths of less than 4 inches. A frequency histogram of pavement thickness is presented in Figures 17 and 18. A detailed frequency histogram for all lanes is presented in Figures C1 to C9 in Appendix C.

Table 12. Mean Concrete Overlay Depth for M-3 and M-1

Route	Northbound Mean Concrete Overlay Depth (inches)			Southbound Mean Concrete Overlay Depth (inches)		
	Inside Lane	Middle Lane	Outside Lane	Inside Lane	Middle Lane	Outside Lane
M-3	4.38	3.55	3.47	2.53	3.97	4.83
M-1	-	4.66	3.68	-	4.51	4.69

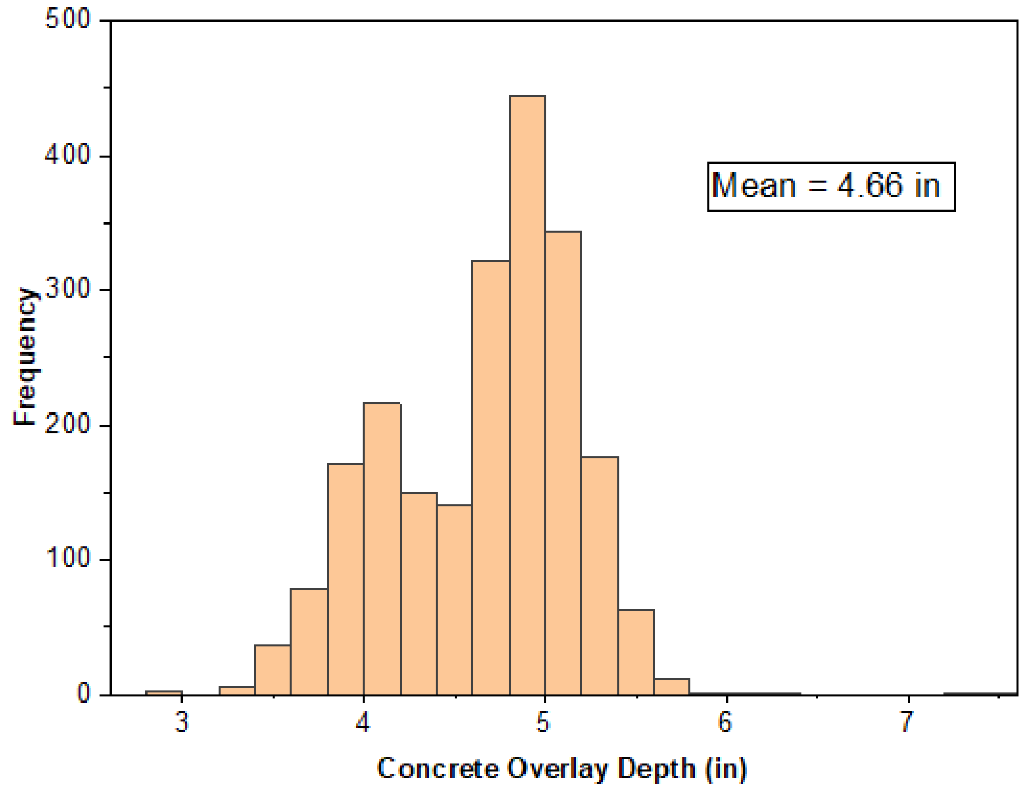

Figure 17. Overlay Depth for Northbound Middle Lane M-1

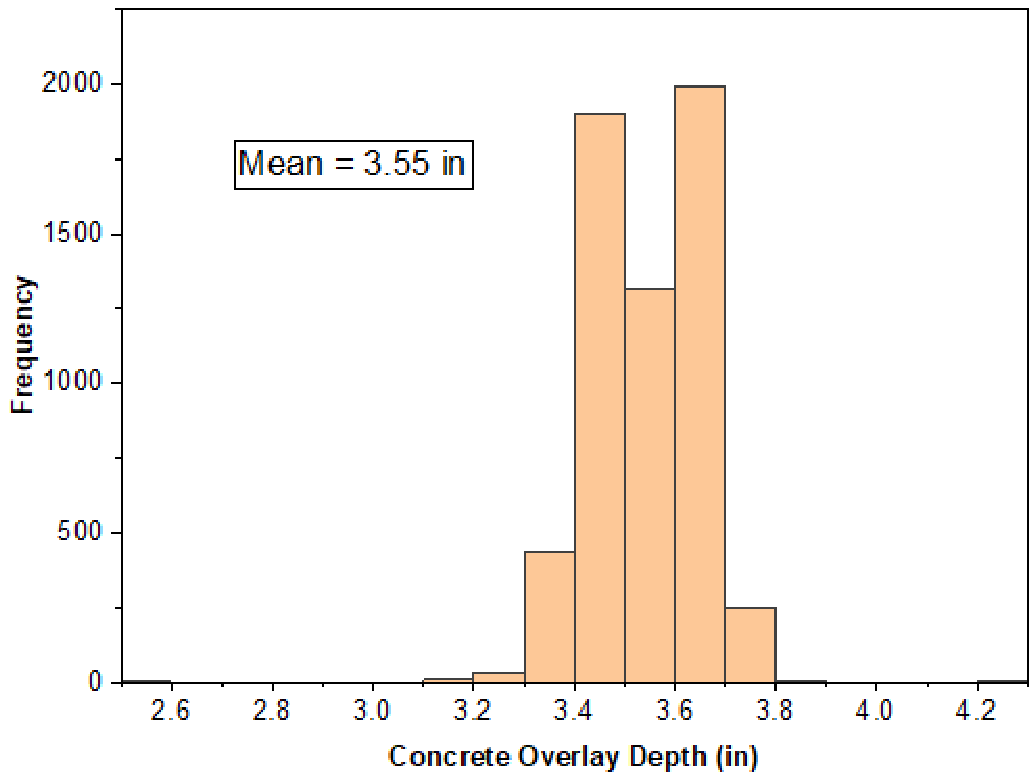

Figure 18. Overlay Depth for Northbound Middle Lane M-3

Most distressed, cracked, or repaired panels appear at or near areas with a business presence. For example, the outermost lane of M-3 has excessive spalling close to a Faygo Beverages business site, as shown in Figure 19. This location was completely replaced sometime after 2019, as shown in Figure 20. Clogged drains shown in Figure 21 could have also accelerated the deterioration of these sections. Furthermore, distribution trucks traveling or parking along this section likely exacerbated the distress.

In comparison, areas with less business presence appear to have better-performing pavement, as shown by the example in Figure 22. This spalling distress is less prevalent on the M-1 project compared with M-3 at the same age. M-1 joints are holding much more tightly, so their distress is more due to panel cracking and faulting. Therefore, as poor panels are replaced and distress is mitigated, the DI progression for M-1 may slow to perform like the M-3 demonstration project.

Figure 19. Distressed Panels on M-3 near Faygo Property Site, Google Maps Image 2019

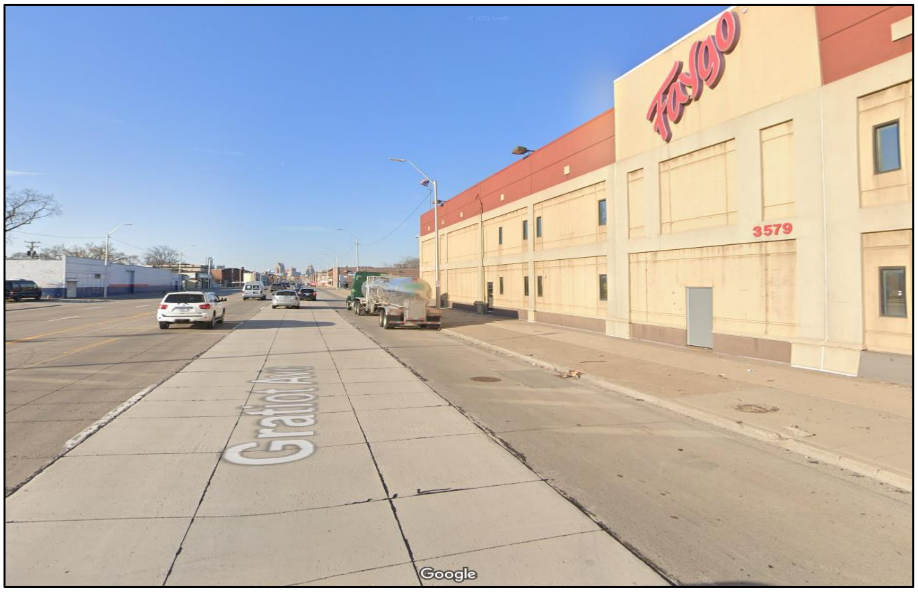

Figure 20. Repaired Panel on M-3 near Faygo Property Site, Google Maps Image 2022

Figure 21. Clogged Drains on M-3, Google Maps Image 2021

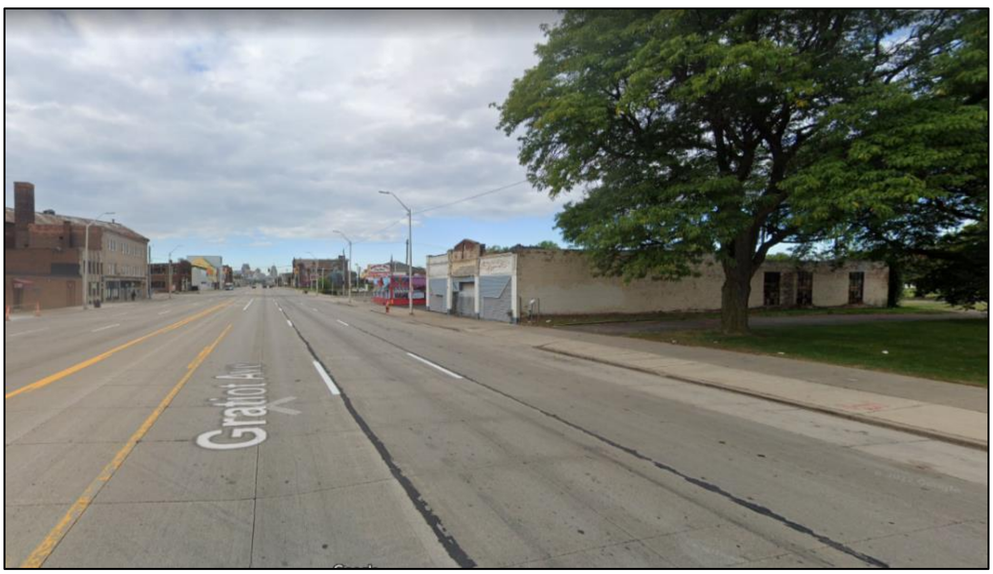

Figure 22. Good Pavement on M-3 near Mack Avenue, Google Maps Image 2022

To further evaluate the potential of trapped moisture beneath the surface concrete as indicated by observed surface black staining at the joints, MDOT personnel, who have conducted past maintenance work, were consulted regarding any indications of water observed during repairs for both projects. They have not observed any evidence of water throughout any past repair work, and this is further supported by recent maintenance work on M-3 in June 2023, shown in Figure 23. Subsequent to removal of the existing surface concrete, no noticeable water or moisture-related issues were found. However, it appeared that the joints were filled with trapped fines, which could be a contributing factor to the observed joint spalling.

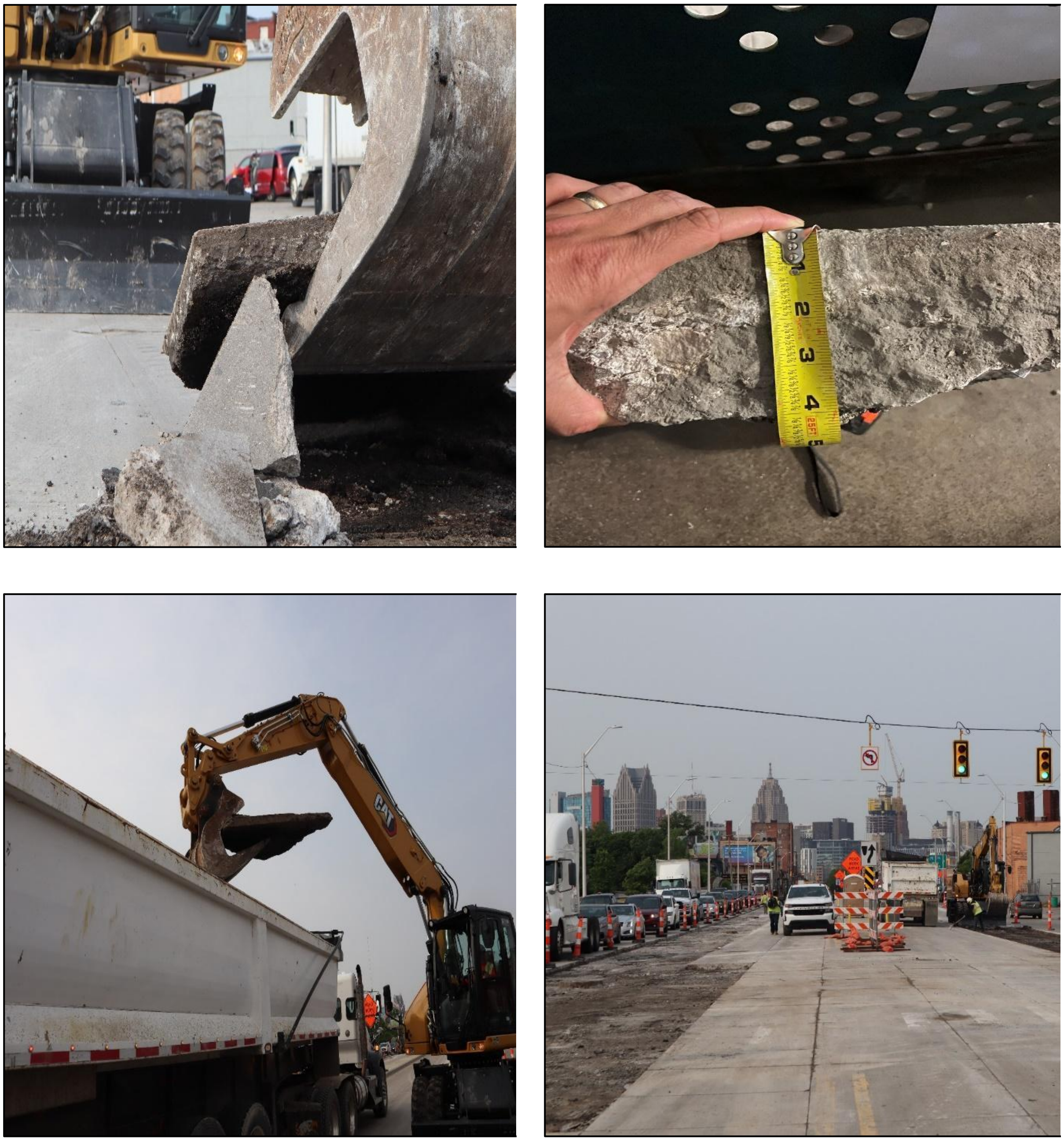

Figure 23. June 2023 Maintenance Repair Work on M-3

Cost Comparison

Costs included in this report will be adjusted to 2019 dollars for comparison with the standard costs included in the MDOT Pavement Selection Manual [4] by using the procedure as denoted in Chapter 6, Section F of that manual. The initial cost for construction was approximated by using unit prices (per 10/11/2022) and the estimation method for the pavement surface cost (including joints) as described in Chapter 2, Section A of the MDOT Pavement Selection Manual. Note that this method does not consider any base and subbase materials, rubblization, embankment, prerepair/prep work, or HMA separator layers. Accordingly, see Appendix Figure A19 for an example of the MDOT's LCCA cost estimation spreadsheet used to estimate the initial construction pavement cost for a treatment type.

The initial construction cost for the thin unbonded concrete overlay pavement used on M-3 and M-1 is estimated at $91,567 per lane-mile. In contrast, the pavement cost for a standard unbonded concrete overlay would be estimated at $155,631 per lane-mile. Therefore, approximately $ 64,064 per lane-mile, or about 41% of the initial cost, is saved using a thin unbonded concrete overlay versus the standard unbonded concrete overlay. Still, it should be noted that a thin unbonded concrete overlay has a design life of 15 years, whereas a standard unbonded concrete overlay has a 20-year design life.

A key component of total pavement cost is the cost of maintenance activities. One contracted preventative maintenance activity for this demonstration project was conducted on M-3 in 2020 (age 15 years). This project included partial and full-depth panel replacement with joint sealing. Adjusting this to 2019 dollars, the cost per lane-mile of this maintenance activity is $43,267. In addition to these contracted activities, annual MDOT maintenance has been conducted for minor repair work on M-3 since 2015. This type of minor repair work is commonly conducted on other routes throughout the state but is not typically conducted at the same project location each year, so this amount of work may be relatively high. It isn't easy to compare or assess the relative amount of this work per route because this type of minor repair work is not fully tracked for every roadway segment. Therefore, to determine the maximum cost potential of the maintenance work, the work by MDOT maintenance will be estimated to be $11,340 per lane-mile. This value was based on the lowest maintenance cycle costs for the standard concrete overlay because non-contracted work is typically lower in cost than contracted work. Using this approach, the total maintenance cost is estimated to range from $43,267 to $122,647 or $2,545 to $7,215 per lane-mile per year (per its age in 2022 of 17 years) in 2019 dollars.

For the M-1 project, no major contracted preventive maintenance activity has been conducted since 2010. However, like M-3, annual MDOT maintenance forces have conducted minor repair work on M-1 since 2018. Therefore, the total cost of these maintenance events would be estimated to be up to $45,360, or $3,780 per lane-mile per year (per its age in 2022 of 12 years).

In comparison, per the MDOT Pavement Selection Manual, the MDOT standard unbonded concrete overlay projects (thickness 6 inches and above) indicate that, on average, preventive maintenance cycles occurred after 11, 13, 15, and 17 years of service, with a reconstruction or major rehabilitation (R&R) estimated to occur after 23 years. Accordingly, the cost per lane-mile of these maintenance fixes is estimated at $19,702, $11,340, $21,219, and $20,241, respectively, so their total cost is $72,502, or $3,152 per lane-mile per year in 2019 dollars. To account for the design life, the total cost is divided by the number of years the project was designed for. The cost per design life of the demonstration project on M-3 is $2,885 to $8,177. For M-1 it is $3,024. The MDOT standard overlay has a cost-per-design life of $3,625.

Therefore, the range of estimated yearly maintenance costs of the demonstration projects is similar to the cost of standard unbonded concrete overlay maintenance activities (per year or per design life). Hence, with the lower initial construction costs for the thin unbonded concrete overlay projects and comparable maintenance costs relative to a standard concrete overlay, thin concrete overlays provide a reasonably cost-effective pavement fix type.

Performance Comparison

The DI values of the demonstration projects and the average DI performance curve for standard concrete overlays are shown in Figure 24. Since the DI values of the demonstration projects are not a broad average of statewide project values, these will have more variability. Therefore, it is difficult to estimate their growth trends compared with average performance curves. Nevertheless, the DI trends for the thin concrete overlay demonstration projects are anticipated to be slightly worse than the standard thickness fix type because their design life is 5 years less (15 years vs 20 years). Furthermore, as previously noted, the estimated service life of the standard concrete overlays is 23 years (when a subsequent R&R would occur). M-3 and M-1 are anticipated to meet or exceed a service life of 23 and 17 years, respectively. Although an R&R project may be initiated prior to these timeframes, the pavements have performed satisfactorily, and there are currently no plans for R&R projects at either location within the next five years.

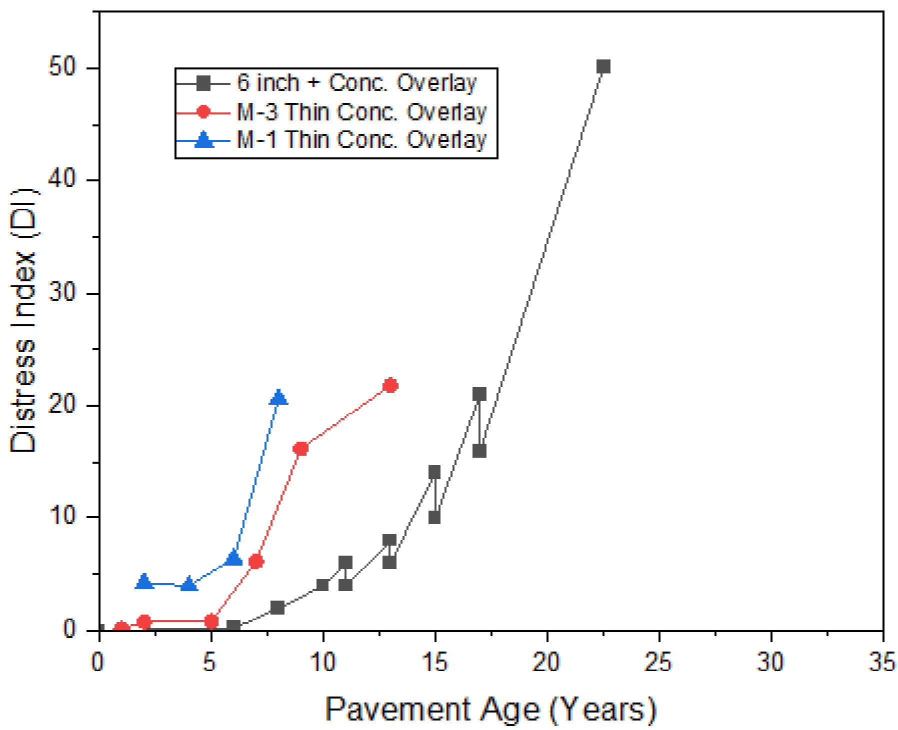

Figure 24. Deterioration Curve of Pavement Preservation Strategy

Conclusions

The overall performance of both thin unbonded concrete overlay demonstration projects is considered acceptable. Both projects were designed for a 15-year design life. After 18 years of service, M-3 is in fair condition. M-1 was constructed in 2010, and the pavement has fair performance after 13 years of service. Joint sealing of sections 2 and 3 on M-3 did not significantly improve performance compared to unsealed sections. Using dense or open-graded mixtures for separator layers also showed a negligible effect on performance in these demonstration projects. Overall, this demonstration project has established that a 4-inch unbonded concrete overlay rehabilitation procedure can achieve a service life proportional to standard 6-inch or thicker concrete overlays with lower initial construction costs and similar maintenance costs over the project's service life. Since most of the severe distress can potentially be attributed to poor drainage and construction variability, it is vital that proper drainage be provided and QC/QA be conducted to ensure the overlay depth is achieved to ensure the longevity of the unbonded overlay section.

Recommendations and Best Practices

Since an adequate amount of time has passed and enough data is available to fully evaluate this project and its experimental aspects (unsealed joints and HMA interlayer), MDOT recommends that monitoring of this demonstration project end and be considered complete. Per the findings and conclusions of this report, thin concrete overlays are a suitable fix type for MDOT’s use where appropriate. This fix type is recommended for non-freeway routes. A thin concrete overlay may not be appropriate for freeways due to the small panel size requiring twice as many joints as a standard overlay, which may lead to increased noise and potential for joint faulting. Furthermore, since the thin concrete overlays do not have dowels, load transfer distresses, such as faulting or spalling, may occur on routes with high traffic volume and larger truck classes.

While the demonstration projects did not show a significant difference between sealed and unsealed joints, best practices developed from experiences elsewhere indicate that thin unbonded concrete overlays should have sealed transverse and longitudinal joints to limit the ingress of water and incompressible materials which could cause erosion of supporting layers and joint spalling. These adequate provisions are required to ensure proper drainage of the HMA interlayer. Based on the results of this study, the choice of separator mix had a negligible effect on performance. However, it is standard practice in Michigan to use open-graded asphalt mixtures to ensure stable and drainable foundation layers for the concrete surface layer. Below are some additional best practices based on the Guide to Concrete Overlay Report [5] by the National Concrete Pavement Technology Center.

- The incorporation of macro fibers should be considered in future projects. They provide moderate resistance to crack formation, improve joint load transfer through aggregate interlock, restrain the opening of joints, and hold cracks tight in the event of cracking to ensure better ride quality and limit distress progression.
- The cause of most joint spalling in concrete pavement is the timing of saw cutting after construction. Thin unbonded overlays have a larger surface area-to-volume ratio than conventional concrete pavement resulting in rapid cooling and drying contraction. Therefore, saw cutting must be done immediately after construction. Joint filling is encouraged in wet climates to avoid early-age buckling (i.e., blowups).
- Good construction practices:
    - ***Pre-overlay Repairs:*** Before constructing a thin concrete overlay, existing medium- to high-severity distresses must be fixed. If asphalt patching has been used in repairs, it is recommended to replace it with concrete before the concrete overlay is done to promote consistency throughout the project. Likewise, if the existing

pavement is composite, with asphalt surface pavement, then any voids or repair work should be filled using a similar asphalt material.

- ***Separation Layer***: An HMA separation layer is required to prevent the reflection of cracks. Geotextiles are also a viable alternative. The separator layer should be drainable and prevent adhesive bond of the two concrete layers.
- ***Curing***: A curing compound should be thoroughly applied immediately after surface texturing to promote proper hydration of the concrete layer and limit early age shrinkage at the surface.
- ***Joint Saw Timing***: The joint should be sawed at an appropriate time, given the PCC mix type and paving conditions. Early saw cutting may cause spalling at joints, while delayed cutting can facilitate random cracking in panels.

References

1. Ingle J. The Plan Review Meeting Report on JN 72407C, M-3 Gratiot Ave. CN RR Structure (R01 of 82072) to I-94, City of Detroit, Wayne County. Michigan Department of Transportation Office Memorandum. 2004.
2. Proposed Thin Unbonded Concrete Overlay Demonstration Project, Field Investigation Report CS 82131 JN 79673 M-1 (Woodward Avenue) from Tuxedo to I-94 Detroit, Michigan.
3. Schenkel J. Pavement Demonstration Program Status Report Public Act 457 of 2016 [Internet]. 2022. Available from: https://www.michigan.gov/mdot/about/governmental-affairs
4. Michigan Department of Transportation Pavement Selection Manual. Pavement selection. 2021.
5. Fick G, Gross J, Snyder MB, Harrington D, Roesler J, Cackler T. Guide to Concrete Overlays (Fourth Edition) [Internet]. 2021. Available from: https://intrans.iastate.edu/app/uploads/2021/11/guide_to_concrete_overlays_4th_Ed_web.pdf

Appendix A: Construction/Pavement Performance Documents and Photos

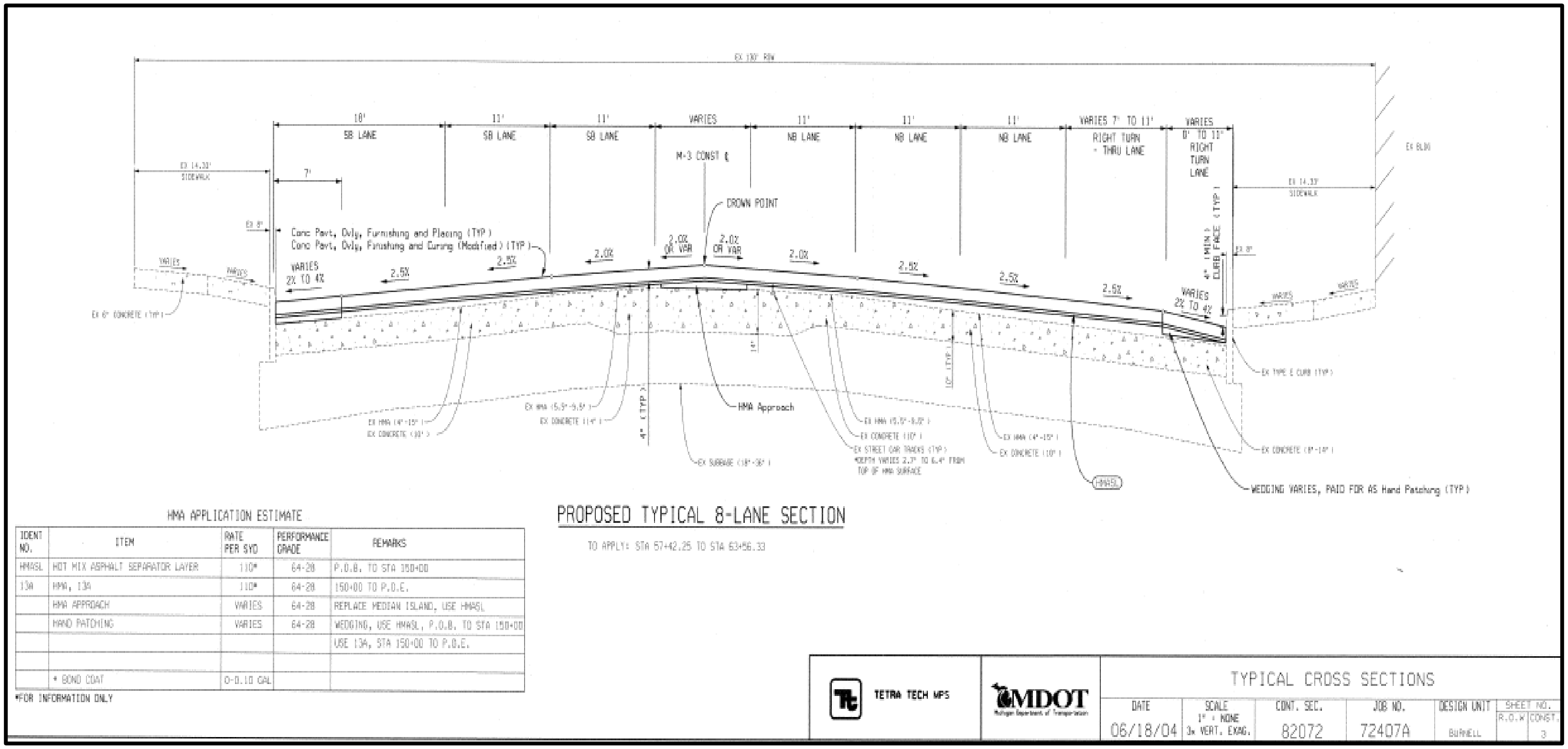

Figure A 1. JN 72407 Typical Normal Cross-Section for M-3 (8-Lane)

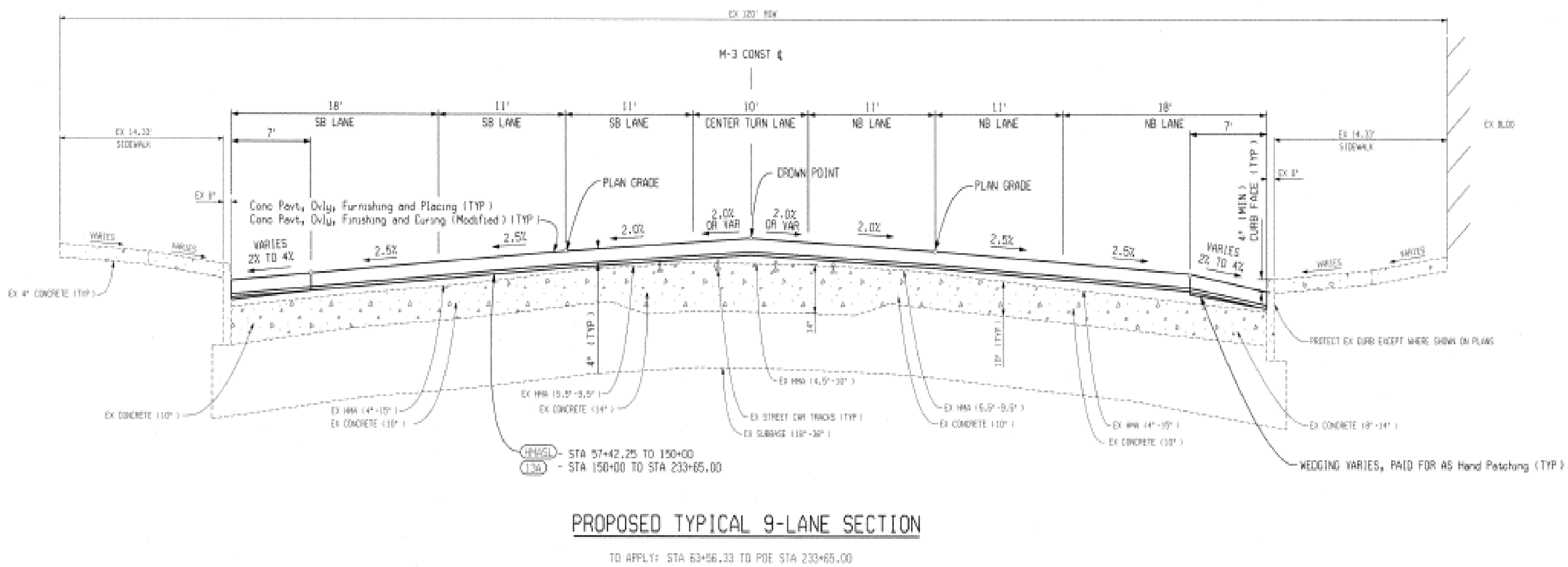

Figure A 2. JN 724074 Typical Normal Cross-Section for M-3 (9-Lane)

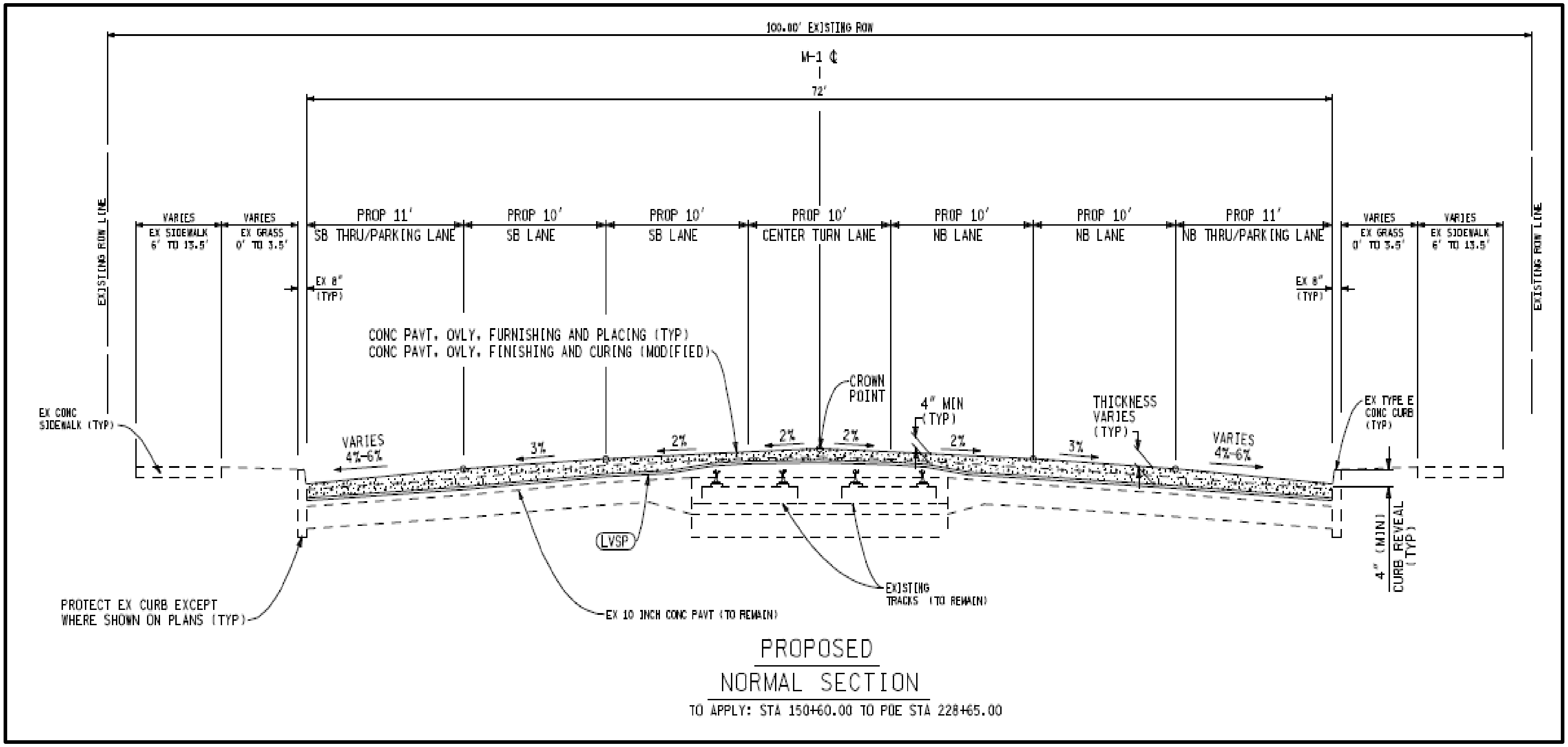

Figure A 3. JN 79673A Typical Normal Cross-Section for M-1

Figure A 4. Asphalt Separator Layer for M-3

Figure A 5. Asphalt Separator Layer for M-1

Field Evaluation Report

Sheet 1 of 2

Michigan Department of Transportation
Construction Field Services Division
Pavement Management Section

Research Proj.:	**Date:** 4/20/21	**Weather:** 42°F, overcast	
Proj. Manager:	**Control Sec./Job No.:**		**Attendance:**
Item(s) Surveyed: Thin Unbonded Overlay Demonstration Project			J. Schenkel J. Trudelle
Location: Gratiot Avenue (M-3) in Wayne County			
Contractor(s):			
Objective: Yearly visual evaluation			

Observations:
Started on northbound side. Only counting distressed and repaired panels in the three mainline lanes in each direction, (not including the center left turn lane). Note that repairs were conducted per CPM JN 204328 ($1.325 million) in 2020 in all lanes, both directions, consisting of full and partial depth slab replacement and joint sealing.

Northbound:

Section 1 (Unsealed Joints)
Number of Cracked Panels = 116
Number of repairs = 353

Section 2 (Sealed Joints)
Number of Cracked Panels = 68
Number of repairs = 134

Section 3 (Sealed Joints) - *Started at Forest Avenue*
Number of Cracked Panels = 15
Number of repairs = 728

Section 4 (Unsealed Joints)
Number of Cracked Panels = 41
Number of repairs = 408

Southbound:

Section 4 (Unsealed Joints)
Number of Cracked Panels = 27
Number of repairs = 197

Section 3 (Sealed Joints)
Number of Cracked Panels = 38
Number of repairs = 174

Section 2 (Sealed Joints) - *Started at Forest Avenue*
Number of Cracked Panels = 46
Number of repairs = 561

Section 1 (Unsealed Joints)
Number of Cracked Panels = 122
Number of repairs = 412

Figure A 6. April 2021 Field Evaluation Report for M-3, Page 1

Field Evaluation Report

Sheet 2 of 2

Michigan Department of Transportation
Construction Field Services Division
Pavement Management Section

A lot of joint raveling and spalling intermittently throughout the limits, particularly in the south end (Section 1). This distress continues to get worse. The longitudinal joint in the NB rightmost lane, middle of the lane is widening due to spalling. It is worse in Sections 2 and 3 but improves in Section 4. Some asphalt repair has been used in this joint, but much of the joint is not repaired.

These areas of worst distress or most repairs are usually at intersections, manholes, transitions, and near commercial drives.

New repairs continue to be applied within the limits of this project. Generally, older repaired slabs are cracked and those that are new are not cracked. Repaired slabs are a mix of HMA and PCC repairs.

Conclusions:
Overall, cracked/repaired slabs increased from 2140 to 3440 this year (~6.0% to 9.7% of all slabs). NB increased by 852 and SB increased by 448. There is increase in cracking/repaired slabs in all sections. The number of cracked/repaired slabs of sealed and unsealed was 1764 and 1676, respectively. Last year these were 830 and 1310, respectively. The number of cracked/repaired slabs of dense-graded and open-graded HMA interlayer sections were 1628 and 1812, respectively. Last year these were 796 and 1344, respectively. Joint raveling/spalling continues to be a problem.

A 2004 HMA multicourse resurface on the composite section directly adjacent to the north end of this project (north of I-94) was being used as an approximate comparison section. This section has had three contracted repair projects since being constructed (crack treatments in 2008 and 2019, and a single course HMA resurface in 2014). Currently, this location has sealed and unsealed cracking.

Future Work:
Continue with annual evaluations and/or draft the final report for this demonstration project (as previously recommended by the Pavement Demonstration Program Project Evaluation report).

Notes taken by: *Justin Schenkel*

Figure A 7. April 2021 Field Evaluation Report for M-3, Page 2

Field Evaluation Report

Sheet 1 of 2

Michigan Department of Transportation
Construction Field Services Division
Pavement Management Section

Research Proj.:	**Date:** 4/20/21	**Weather:** 42°F, overcast	
Proj. Manager:	**Control Sec./Job No.:**		**Attendance:**
Item(s) Surveyed: Thin Unbonded Overlay Demonstration Project			J. Schenkel J. Trudelle
Location: Woodward Avenue (M-1) in Wayne County			
Contractor(s):			
Objective: Yearly visual evaluation			

Observations:

Started at the south end of the project, driving in the NB direction. We are reviewing two lanes in each direction - not the center left turn lane and not the parking lane (shoulder/lane).

Northbound:

- Number of Cracked Panels = 89, 63 in right lane and 26 in left lane
- Number of Repaired/Replaced Panels = 481, 396 in right lane and 85 in left lane

Southbound:

- Number of Cracked Panels = 118, 91 in right lane and 27 in left lane
- Number of Repaired/Replaced Panels = 155, 102 in right lane and 53 in left lane

There is still some black staining at joints which may indicate pumping of the HMA interlayer, (moisture related damage). Most staining noticed on the north end of the limits but is also observed intermittently throughout the limits.

It appears that a more full-depth slab repairs were conducted in the rightmost shoulder/lane (not tracked in the evaluation due to parking) since the last field review in 2020. As mentioned last year, the previously observed cracking and faulting is no longer present.

Conclusions:

There is an increase in the total number of distressed and/or repaired slabs (572 to 843). This is about ~8% of all slabs in the reviewed lanes. Most distressed or repaired slabs are noted around manholes or at driveways. Overall, there is minimal to no spalling. While staining exists, the associated slabs do not show much distress - continue to monitor. Many slabs were repaired/replaced after the 2019 review and additional repairs were conducted after the 2020 review. The right lane, (next to the shoulder/lane) has more distressed slabs than the left lane. This may be due to a water drainage issue in the base (as the water drains to the outside of the pavement). Alternatively, this may be due to the shoulder/lane poor condition and spread of its cracks. The outer shoulder/lanes appear to be constructed at a different time and may be of different material type (due to its color difference from the rest of the mainline pavement) and its distresses may be material related. Overall, this location is in fair condition.

Figure A 8. April 2021 Field Evaluation for Report M-1, Page 1

Field Evaluation Report

Sheet 2
of 2

Michigan Department of Transportation
Construction Field Services Division
Pavement Management Section

Future Work:
Continue with annual evaluations and/or draft the final report for this demonstration project (as previously recommended by the Pavement Demonstration Program Project Evaluation report).

Notes taken by: *Justin Schenkel*

Figure A 9. April 2021 Field Evaluation for Report M-1, Page 2

Figure A 10. April 2022 Field Evaluation Pictures of M-3

Figure A 11. April 2022 Field Evaluation Pictures of M-1

Figure A 12. April 2022 Field Evaluation Picture Examples of Joint Spalling and Raveling in Sections 2 and 3 on M-3

Figure A 13. April 2022 Field Evaluation Picture Example of Corner Cracking and Raveling on M-1

Figure A 14. April 2008 Concrete Pavement Blowup North of Van Dyke Street on M-3

Figure A 15. April 2008 Core from M-3 Blowup Location (overlay is about 3.5”)

Figure A 16. April 2008 Deteriorated Panel at the Intersection of McDougal and M-3

Figure A 17. April 2008 Core from M-3 Deteriorated Panel Location (overlay is about 1.5")

Figure A 18. Repaired Panels on M-1 at Manhole, Google Maps Image 2022

Life-Cycle Cost Analysis Cost Criteria Estimate

LCCA Cost Threshold Met?	***NO***	Prepared By:	
		Date:	

Control Section	00000	**Job Number**	000000	**Region**	6 & 7
CSBMP	0.000				
CSEMP	1.000				
No. of Lanes	1				
Lane Width	12				

Total Miles	Total Feet	Total Yards
1.000	5280	1760

Total Lane Width	
Ft	12
Yd	4

Total Surface Area	
sft	63,360
syd	7,040

If Green, fill in cell	*Prices, shown in yellow cells, fill in automatcially*

Alternative 1: Flexible Construction

Course	Mixture	Thickness (in)	Minimum Application (lbs/syd)	Total Tons	Price	Total Cost
Top Course	5EMH	0	0	0	$104.47	$0.00
Leveling Course	4EMH	0	0	0	$95.27	$0.00
Base Course	3EMH	0	0	0	$90.82	$0.00
	Total	0				
						$0.00

Alternative 2: Rigid Construction

Concrete Pavement Type	Thickness (in)	Price	Total Cost
Thin PCC Overlay - Fibers	4.0	$104.89	$82,047.29

No. of Mid-Panel Long. Joints	Transv. Joint Spacing (ft)	No. of Transv. Joints	Total Length of Joints (ft)	Price	Total Cost
1	6	880	15840	$0.73	$11,563.20

	Price	Total Cost
Conc Pavt, Ovly, Finishing and Curing	$2.03	$14,291.20
		$107,901.69

Figure A 19. MDOT LCCA Cost Estimation Spreadsheet

Appendix B 1: MDOT Reference Material: Field Investigation Report of M-1

Proposed Thin Unbonded Concrete Overlay Demonstration Project

Field Investigation Report

CS 82131 JN 79673
M-1 (Woodward Avenue) from Tuxedo to I-94
Detroit, Michigan

Purpose

The purpose of this report is to evaluate M-1 (Woodward Avenue) from Tuxedo to I-94 as a suitable candidate for a thin unbonded concrete overlay demonstration project. If selected, this will be the second demonstration project of this type in the Metro Region.

Project Description

The project is located on M-1 (Woodward Avenue) from Tuxedo to I-94 in the City of Detroit in Wayne County. The project length is approximately 2.31 miles. M-1 from I-94 to Grand Blvd. has three lanes in each direction with a center turn lane and a parking lane on each side. Brick pavers exist on the parking lanes between I-94 and Grand Blvd. M-1 from Grand Blvd. to Tuxedo consists of three lanes in each direction with a center turn lane.

Field Evaluation

The existing condition of the pavement was evaluated using the following methods;

- Visual Pavement Evaluation to determine the existing pavement condition
- Pavement Coring and Soil Borings and Review of As Built Plans to determine the thickness and condition of the existing pavement layers and underlying soils
- Falling Weight Deflectometer Testing to determine exiting structural condition of the pavement layers and subgrade

The results of our field evaluation program are summarized below.

Visual Pavement Evaluation

Existing pavement distresses along M-1 (Woodward Avenue) from I-94 to Tuxedo include longitudinal and joint reflection cracking, alligator cracking, rutting, localized settlements and failures around drainage structures. Majority of distresses were limited to the parking lane. The following pictures show general condition of the pavement and some specific distressed areas.

Figure 1: General View of M-1 Showing Cracking

Figure 2: Rutting near a Bus Stop

Figure 3: Failures around Structures

Figure 4: General Deterioration of Outside/Parking Lane

Figure 5: Brick Pavers on the Parking Lane (South of Grand Blvd.)

Figure 6: Localized Settlements


Figure 7: Steel Plates to cover Distresses

Results of Pavement Cores and Review of As Built Plans

A total of 13 cores and soil borings were obtained through the project limits. The core data revealed following mainline pavement layer thicknesses within the project limits.

Table 1: Pavement Core Results

Core Location	Core Number	NB M-1 Parking Lane					
		Brick	HMA	Concrete	Agg. Base	Sand	Subgrade
NB M-1 Parking Lane	8	3.0	-	9.6	-	1.6	Firm sandy clay
NB M-1 Parking Lane	9	-	5.2	7.4	-	30.6	Firm silty clay
NB M-1 Parking Lane	12	-	4.1	10.9	-	24.6	Firm silty clay
NB M-1 Parking Lane	24	-	6.6	8.8	-	5.0	Firm silty clay
NB M-1 Parking Lane	26	-	7.2	10.4	-	7.2	Firm silty clay
M-1 Center Turn Lane	34	-	6.6	18.0	6.6	8.4	Stiff silty clay
M-1 Center Turn Lane	39	-	6.1	-	-	-	Refusal at 0.8'
SB M-1 Parking Lane	27	-	8.4	9.6	-	3.6	Firm silty clay
SB M-1 Parking Lane	29	-	6.0	7.9	-	-	Refusal at 1.2'
SB M-1 Slow Lane	31	-	4.2	10.3	-	-	Firm silty clay
SB M-1 Fast Lane	28	-	11.0	9.4	-	3.6	Sandy top soil
SB M-1 Fast Lane	30	-	8.4	10.8	-	-	Firm silty clay
SB M-1 Fast Lane	38	-	5.8	11.3	-	-	Firm silty clay
Average		**3.0**	**6.6**	**10.3**	**6.6**	**10.6**	
Minimum		**3.0**	**4.1**	**7.4**	**6.6**	**1.6**	
Maximum		**3.0**	**11.0**	**18.0**	**6.6**	**30.6**	

The existing M-1 (Woodward Avenue) pavement section from I-94 to Tuxedo mainly consists of HMA overlay over reinforced concrete pavement except along parking lanes from I-94 to Grand Blvd. where brick pavers over reinforced concrete pavement were encountered.

Only one core was taken along NB M-1 parking lane between I-94 and Grand Blvd. Our field review indicated brick pavers exist along parking lane of this section of the roadway. The core taken on the parking lane shows 3-inch brick pavers were placed on a 0.25-inch thick sand cushion over a 9.6-inch thick reinforced concrete pavement. A 1.5-inch thick sand subbase layer exists directly under the concrete layer. No brick pavers were encountered along parking/outside lanes between Grand Blvd. and Tuxedo.

In general, The HMA overlay consists of three different layers; 2"-inch thick HMA (minimum 0.96", maximum 4.2"), 1.4"-inch layer of sheet asphalt (minimum 0.36", maximum 2.4") and 4.2"-inch HMA (minimum 2.9", maximum 5.4"). However, at 4 core locations (31% of core locations) only one HMA layer over concrete was encountered.

The reinforced concrete layer thickness ranged from 7.4 inches to 18.0 inches with an average thickness of 10.3 inches. Core logs show deteriorated concrete at 2 core locations (15% of core locations). An aggregate base was encountered only at 1 location (8% of core locations).

The soil descriptions and properties, in addition to the moisture conditions observed by the driller, are graphically presented in the soil boring logs. Individual boring logs must be consulted for specific information related to a particular location. These boring logs present approximate pavement layers and soil stratification with detailed soil descriptions. A copy of our soil boring log is attached for reference.

A review of As Built plans shows, two sets of rail tracks exist under the pavement along the center of the roadway. Approximately, 3.5 inches of cover (2 inches of sheets asphalt and 1.5 inches of asphalt binder course) exist from the top of the rails.

Falling Weight Deflectometer (FWD) Testing

Deflection testing was performed along each lane of M-1(except parking lanes on NB M-1 from I-94 to Tuxedo and SB M-1 from Grand Blvd. to I-94) using Michigan Department Transportation's KUAB Falling Weight Deflectometer. Each test location was loaded 3 times with three load levels, 6,000 lbs, 9,000 lbs and 15,000 lbs. The load was applied through a circular load plate with 5.91 inch radius. Under each load, the resulting pavement deflections were recorded at various fixed distances from the center of the load plate. These distances were 0, 8, 12, 18, 24, 36 and 60 inches.

A summary of measured deflections at an approximate load level of 9,000 lbs are shown in the following table.

Table 2: Summary of FWD Deflection Values

Test Line	Summary Value	Deflections at Various Distances from the Center of the Load Plate (mills)						
		D1 (0")	D2 (8")	D3 (12")	D4 (18")	D5 (24")	D6 (36")	D7 (60")
NB SL	Average	4.15	3.24	2.99	2.73	2.43	1.98	1.17
	Min.	2.69	2.00	1.91	1.76	1.54	1.27	0.84
	Max.	15.85	13.01	11.57	9.26	7.38	4.51	1.71
NB 2nd L	Average	3.13	2.42	2.32	2.23	1.87	1.63	1.03
	Min.	2.71	1.86	1.75	1.64	1.25	0.92	0.63
	Max.	3.77	3.02	2.93	2.85	2.33	2.13	1.34
NB FL	Average	4.77	3.54	3.16	2.82	2.46	1.99	1.27
	Min.	2.79	1.96	1.81	1.73	1.61	1.35	0.84
	Max.	10.54	8.85	7.95	6.57	5.40	3.75	2.24
TL	Average	4.27	2.84	2.31	2.02	1.82	1.57	1.10
	Min.	2.01	0.98	0.83	0.78	0.73	0.67	0.54
	Max.	11.27	9.67	8.95	8.11	7.10	5.64	3.21
SB SL	Average	4.63	3.60	3.30	2.96	2.58	2.03	1.24
	Min.	2.84	2.16	2.11	1.96	1.77	0.95	0.53
	Max.	10.61	8.20	7.02	5.61	4.50	3.08	2.00
SB FL	Average	4.19	3.23	3.00	2.72	2.44	2.00	1.29
	Min.	2.58	1.93	1.81	1.67	1.50	1.25	0.82
	Max.	8.54	7.04	6.53	5.74	4.97	3.82	2.35
SB PL	Average	8.40	6.73	6.05	5.13	4.24	2.91	1.41
	Min.	5.06	3.89	3.20	2.59	2.16	1.63	0.91
	Max.	16.70	14.09	12.66	10.13	8.01	4.91	1.77

The deflection profiles for each lane are shown below.

- NB M-1 Slow Lane (Figure 8)
  Deflection testing along NB M-1 slow lane was started at the northern edge of the I-94 bridge and continued to Tuxedo at 200 feet intervals. As shown in Figure 8, deflection profile for M-1 NB slow lane is fairly consistent with number of localized areas with high deflections. Extremely high deflections were observed at the north end of the project (near Tuxedo). Generally, the deflection profile indicates a fairly uniform support for the pavement structure along NB slow lane except at some isolated areas.

- NB M-1 Second Lane (Figure 9)
  Deflection testing along NB M-1 second lane was started at the northern edge of the I-94 bridge and continued to Grand Blvd at 400 feet intervals. As shown in Figure 9, deflection profile for M-1 NB second lane is fairly consistent. Generally, the deflection profile indicates a fairly uniform support for the pavement structure along NB inner lane.

- NB M-1 Fast Lane (Figure 10)
  Deflection testing along NB M-1 fast lane was started at the northern edge of the I-94 bridge and continued to Tuxedo at 400 feet intervals. As shown in Figure 10, deflection profile for M-1 NB fast lane is fairly consistent with number of localized high deflection locations. Generally, the deflection profile indicates a fairly uniform support for the pavement structure along NB fast lane except at some isolated areas.

- M-1 Turn Lane (Figure 11)
  Deflection testing along M-1 turn lane was started at the northern edge of the I-94 bridge and continued to Tuxedo at 500 feet intervals. As shown in Figure 11, deflection profile for M-1 turn lane is fairly consistent with few high deflection locations. Generally, the deflection profile indicates a fairly uniform support for the pavement structure along M-1 turn lane except at some isolated areas.

- SB M-1 Slow Lane (Figure 12)
  Deflection testing along SB M-1 slow lane was started at the centerline of Tuxedo and continued to I-94 at 200 feet intervals. As shown in Figure 12, deflection profile for SB M-1 slow lane is fairly consistent with number of high deflection locations. Generally, the deflection profile indicates a fairly uniform support for the pavement structure along SB M-1 slow lane except at some isolated areas.

- SB M-1 Fast Lane (Figure 13)
  Deflection testing along SB M-1 fast lane was started at the centerline of Tuxedo and continued to I-94 at 400 feet intervals. As shown in Figure 13, deflection profile for SB M-1 fast lane is fairly consistent with few high deflection locations. Generally, the deflection profile indicates a fairly uniform support for the pavement structure along SB

M-1 fast lane except at some isolated areas.

- SB M-1 Parking Lane (Figure 14)
  Deflection testing along SB M-1 parking lane was started at the centerline of Tuxedo and continued to Grand Blvd. at 400 feet intervals. As shown in Figure 14, deflection profile for SB M-1 parking lane is higher than the other lanes with three distinctive high deflection locations close to intersections. Generally, the deflection profile indicates a fairly uniform support for the pavement structure along SB M-1 parking lane except at some isolated areas.

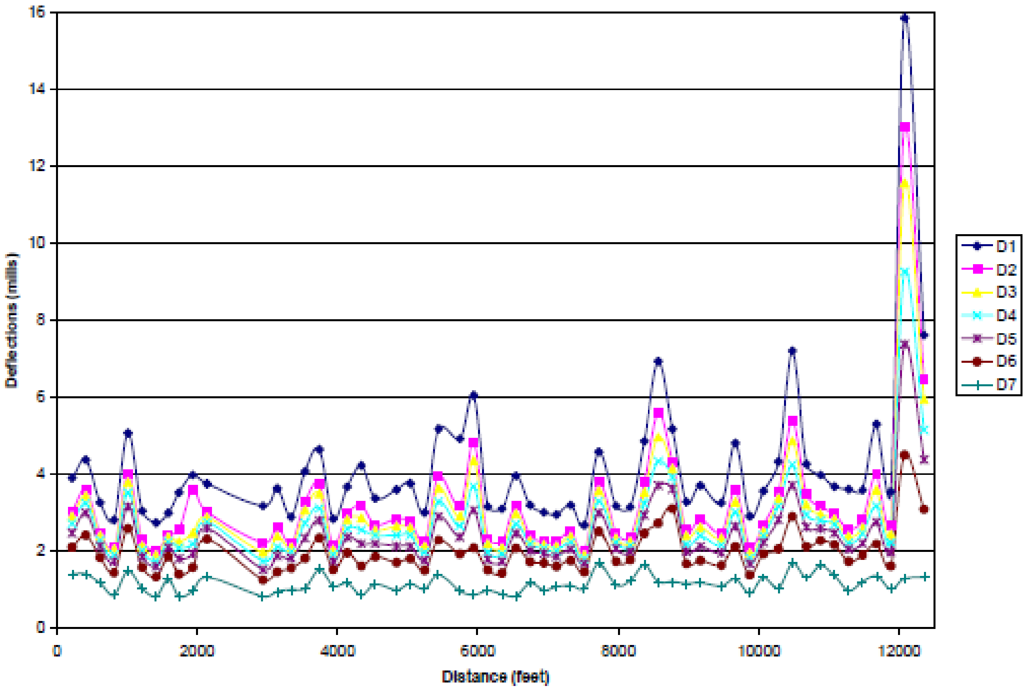

Figure 8: Deflection Profile for NB M-1 Slow Lane

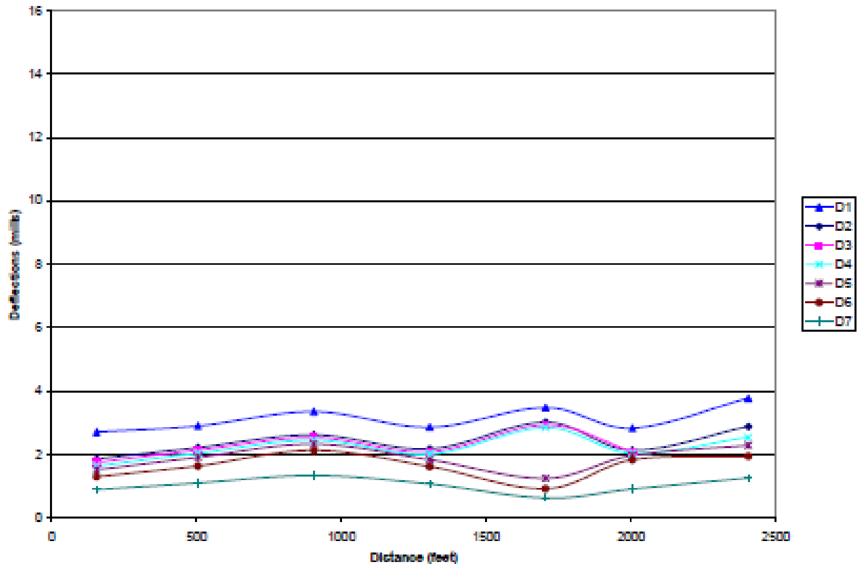

Figure 9: Deflection Profile for NB M-1 Second Lane

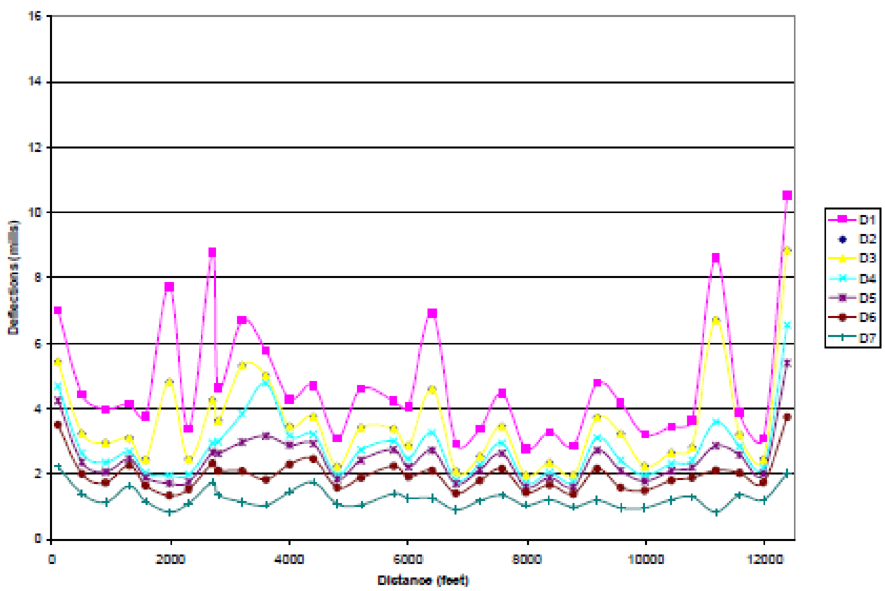

Figure 10: Deflection Profile for NB M-1 Fast Lane

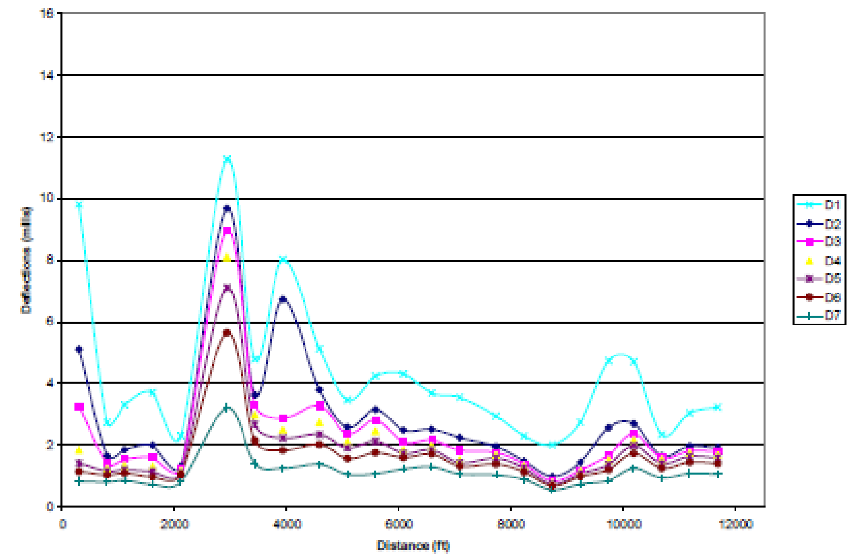

Figure 11: Deflection Profile for M-1 Turn Lane

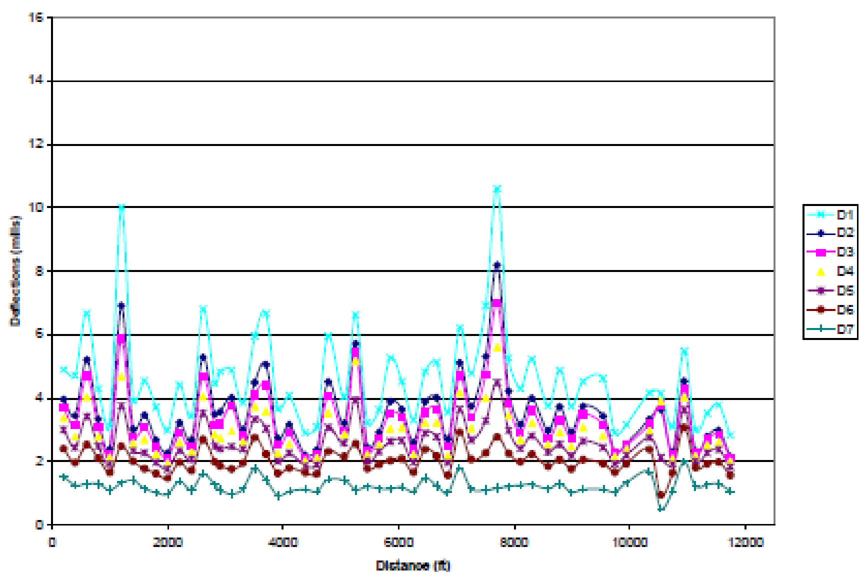

Figure 12: Deflection Profile for SB M-1 Slow Lane

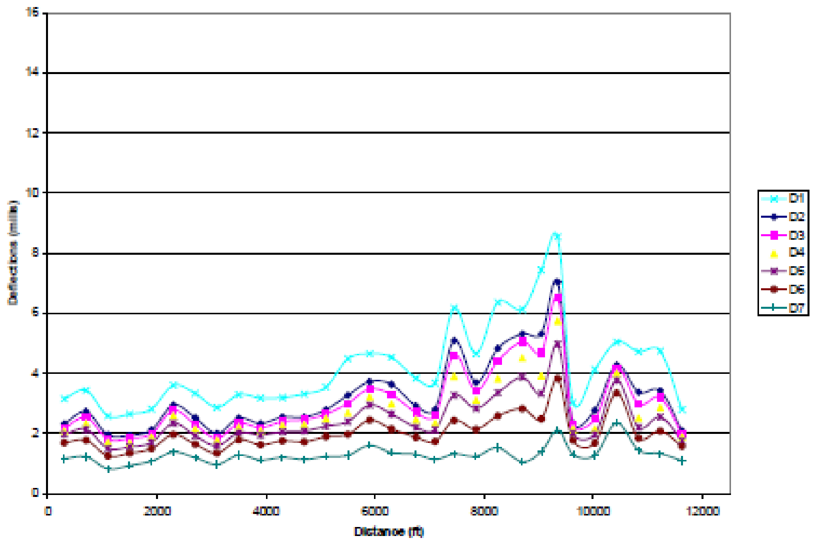

Figure 13: Deflection Profile for SB M-1 Fast Lane

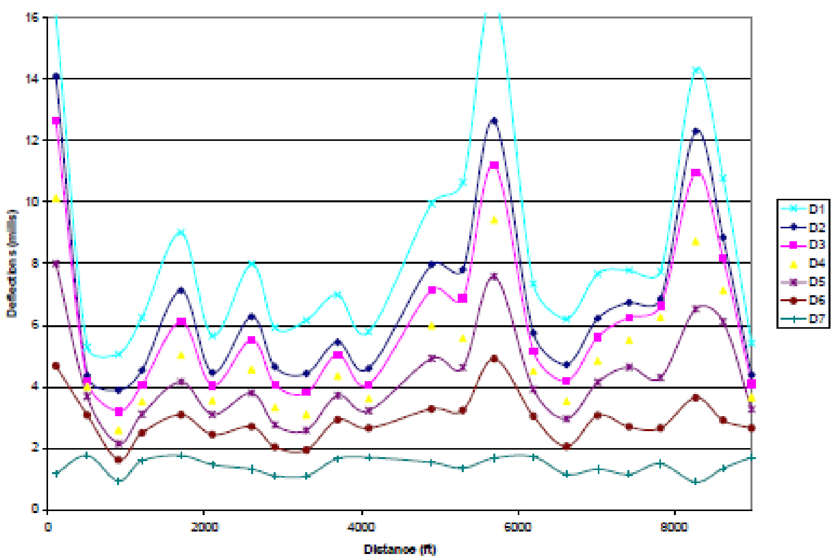

Figure 14: SB M-1 Parking Lane

Void Determination based on FWD Data

The variable load deflection analysis procedure given in the 1993 AASHTO Pavement design guide was used to determine whether there are any voids under the existing concrete slabs. In this procedure, the deflections measured at three load levels were plotted against corresponding load levels. At each test location the y-intercept is calculated and used to determine voids. Typically y-intercept of more than 0.002 inches (2 mills) indicates a void beneath the pavement. Y-intercept values for different test lines in NB and SB directions are shown in Figure 15 and Figure 16.

It can be seen for the Figures 15 and 16, typically the intercept values along both NB and SB M-1 are less than 2 mills indicating no suspected voids beneath the pavement.

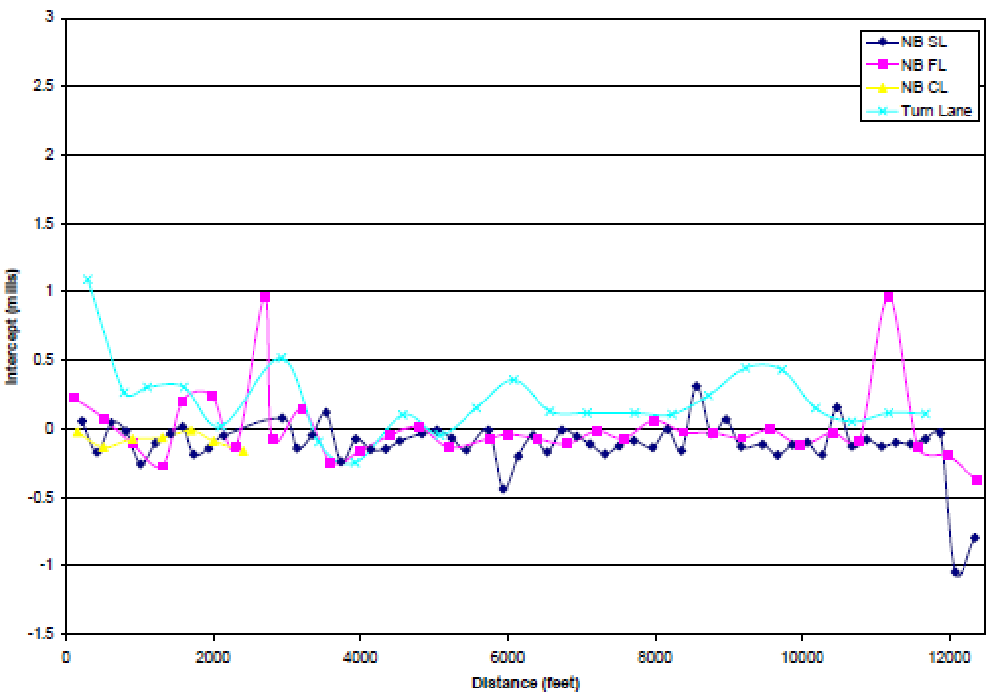

Figure 15: NB M-1 Void Determination Profile

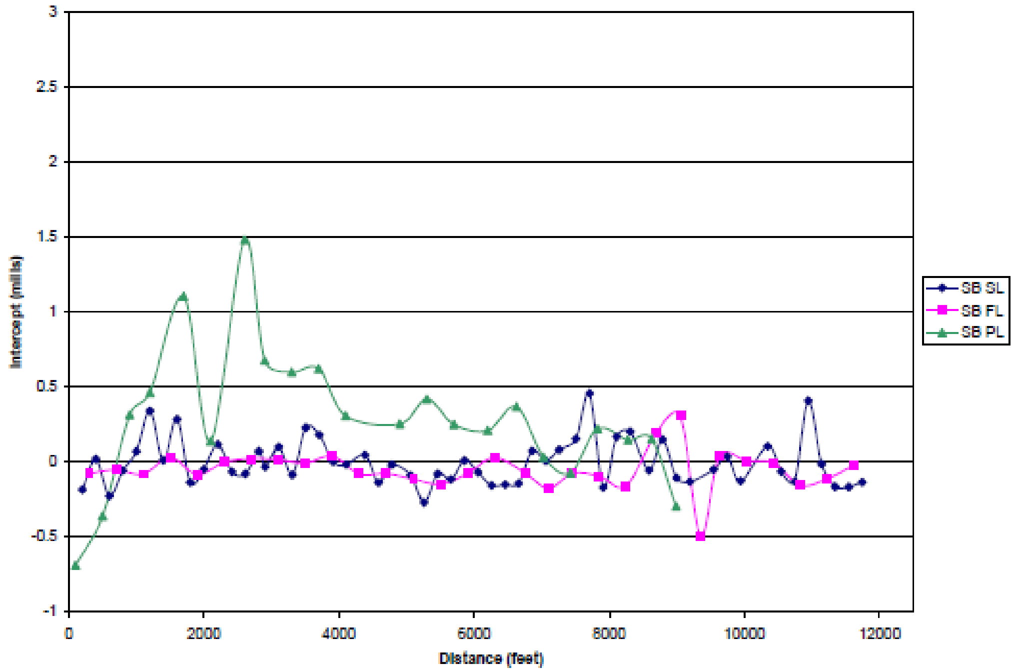

Figure 16: SB M-1 Void Determination Profile

Pavement Layer Moduli Values

Pavement layer moduli values were back calculated based on the measured deflections using MODULUS back calculation program. MODULUS is a widely used layer moduli back calculation program based on FWD deflection data. This program was developed by Texas Transportation Institute and used in the SHRP LTTP program for FWD data analysis. Pavement layer thickness values obtained from coring together with FWD measured deflection data were used for pavement layer moduli back calculation.

The existing pavement structure was simplified to a three layer system for the back calculation process; HMA overlay, Concrete pavement and subgrade. The existing sub base layer was combined to the subgrade due to similar layer moduli values within the two layers.

Back calculated pavement layer moduli values are summarized in the following table.

Table 3: Summary Pavement Layer Moduli Values

Test Line	Summary Value	Pavement Layer Moduli Values (psi)		
		HMA	Concrete	Subgrade
NB Slow Lane	Average	495,497	2,479,162	25,939
	Min.	50,000*	143,834	14,380
	Max.	941,607	6,999,984	37,817
NB 2nd Lane	Average	714,277	4,746,768	25,948
	Min.	425,052	100,000*	16,201
	Max.	1,652,053	7,117,193	56,015
NB Fast Lane	Average	467,757	1,706,528	26,099
	Min.	79,194	100,000*	14,317
	Max.	1,017,030	6,758,182	44,719
Center Turn Lane	Average	312,905	3,799,506	18,984
	Min.	80,006	100,000*	5,845
	Max.	587,524	11,999,970	42,508
SB Slow Lane	Average	458,943	2,711,537	24,978
	Min.	196,011	100,000	16,932
	Max.	1,439,333	9,687,767	46,828
SB Fast Lane	Average	579,638	1,691,669	25,623
	Min.	243,926	100,000*	11,895
	Max.	959,671	4,014,617	40,437
SB Parking Lane	Average	378,982	439,974	21,688
	Min.	57,977	100,000*	13,653
	Max.	984,230	1,796,350	35,999

*Default minimum value

The back calculated layer moduli values at each test point at different lanes are shown in Figure 17 through 23 and discussed below.

- NB M1 Slow Lane
  As seen in Figure 17 and Table 3, the back calculated HMA layer moduli varies from 50,000 psi (minimum default value used in the back calculation) to 941,607 psi with an average of 495,497 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 143,834 psi to 6,999,984 psi with an average of 2,479,162 psi with high variability along the lane. Concrete moduli values were less than 500,000 psi for approximately 14% of the pavement area showing deteriorated concrete. The subgrade moduli vary from 10,449 psi to 37,817 psi with an average value of 24,592 psi showing good subgrade support for the pavement structure.

- NB M1 2nd Lane
  As seen in Figure 18 and Table 3, the back calculated HMA layer moduli vary from 425,052 psi to 1,652,053 psi with an average of 714,277 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 100,000 psi (minimum default value used in the back calculation) to 7,117,193 psi with an average of 4,746,768 psi with only one low moduli

value area. Concrete moduli values were less than 500,000 psi for approximately 12% of the pavement area showing deteriorated concrete. The subgrade moduli vary from 16,201 psi to 56,015 psi with an average value of 25,948 psi showing good subgrade support for the pavement structure.

- NB M1 Fast Lane
  As seen in Figure 19 and Table 3, the back calculated HMA layer moduli vary from 79,194 psi to 1,017,030 psi with an average of 467,757 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 100,000 psi (minimum default value used in the back calculation) to 6,758,182 psi with an average of 1,706,527 psi with high variability along the lane. Concrete moduli values were less than 500,000 psi for approximately 26% of the pavement area showing deteriorated concrete. The subgrade moduli vary from 14,317 psi to 44,719 psi with an average value of 26,099 psi showing good subgrade support for the pavement structure.

- M1 Center Turn Lane
  As seen in Figure 20 and Table 3, the back calculated HMA layer moduli vary from 80,006 psi to 587,524 psi with an average of 312,905 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 100,000 psi (minimum default value used in the back calculation) to 11,919,970 psi with an average of 3,799,505 psi with high variability along the lane. Concrete moduli values were less than 500,000 psi for approximately 8% of the pavement area showing deteriorated concrete. The subgrade moduli vary from 5,845 psi to 42,508 psi with an average value of 18,984 psi showing good subgrade support for the pavement structure.

- SB M1 Slow Lane
  As seen in Figure 21 and Table 3, the back calculated HMA layer moduli vary from 196,011 psi to 1,439,333 psi with an average of 458,943 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 100,000 psi (minimum default value used in the back calculation) to 9,687,767 psi with an average of 2,711,537 psi with high variability along the lane. Concrete moduli values were less than 500,000 psi for approximately 15% of the pavement area showing deteriorated concrete. The subgrade moduli vary from 16,932 psi to 46,828 psi with an average value of 24,978 psi showing good subgrade support for the pavement structure.

- SB M1 Fast Lane
  As seen in Figure 22 and Table 3, the back calculated HMA layer moduli vary from 243,926 psi to 959,671 psi with an average of 579,678 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 100,000 psi (minimum default value used in the back

calculation) to 4,014,617 psi with an average of 1,691,669 psi with high variability along the lane. Concrete moduli values were less than 500,000 psi for approximately 19% of the pavement area showing deteriorated concrete. The subgrade moduli vary from 11,895 psi to 40,437 psi with an average value of 25,623 psi showing good subgrade support for the pavement structure.

- SB M1 Parking Lane
  As seen in Figure 23 and Table 3, the back calculated HMA layer moduli vary from 57,977 psi to 984,230 psi with an average of 378,982 psi. The variation of the HMA moduli along the lane seems within the acceptable range except at few isolated locations. The concrete moduli range from 100,000 psi (minimum default value used in the back calculation) to 1,796,350 psi with an average of 439,974 psi, which can be considered as very low moduli for concrete. Approximately 79% of the concrete moduli values are less than 500,000 psi showing deteriorated concrete. The subgrade moduli vary from 13,653 psi to 35,999 psi with an average value of 21,688 psi showing good subgrade support for the pavement structure.

CS82111-JN79673
Page 19 of 23

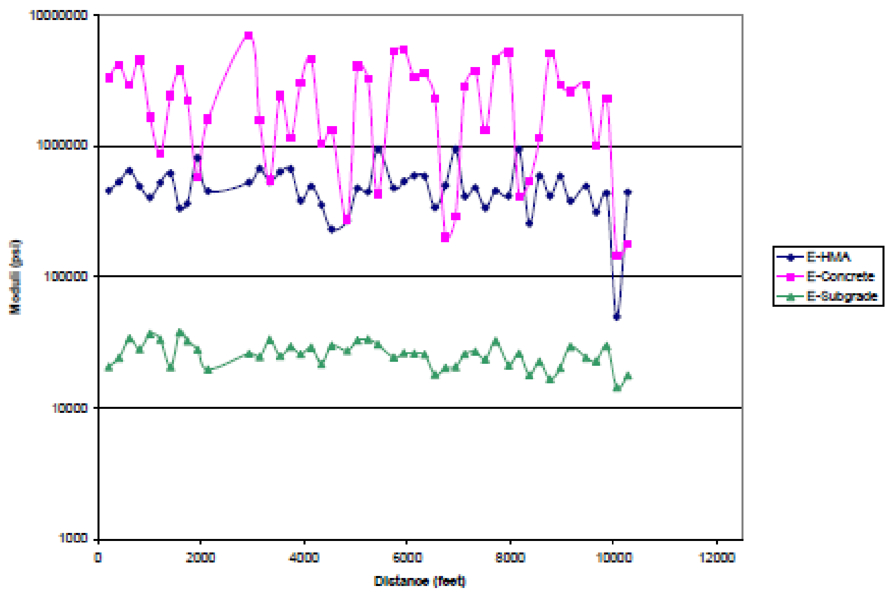

Figure 17: Back Calculated Pavement Layer Moduli Values – M1 NB Slow Lane

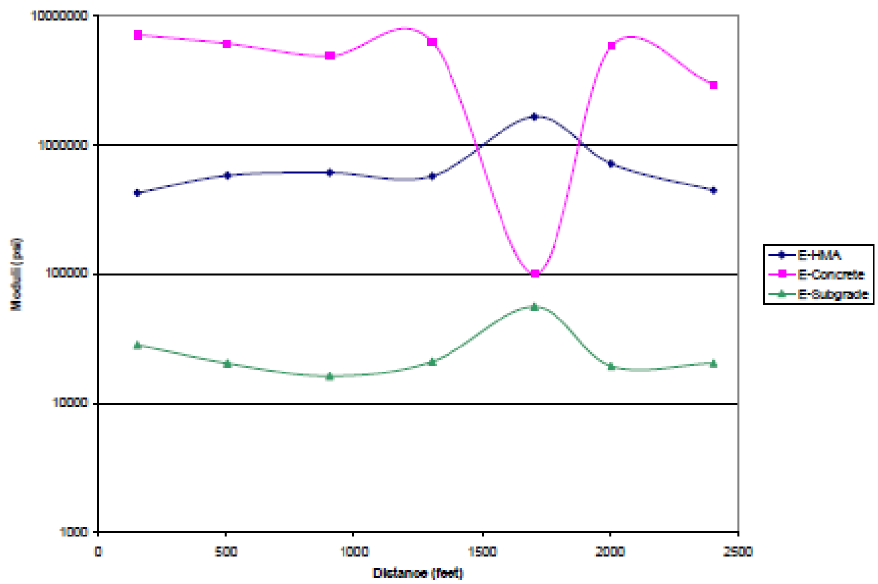

Figure 18: Back Calculated Pavement Layer Moduli Values – M1 NB 2nd Lane

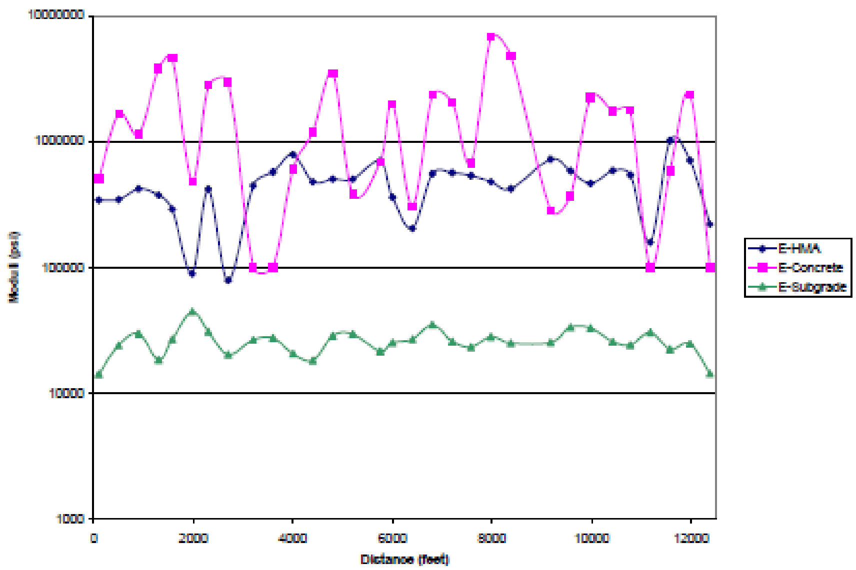

Figure 19: Back Calculated Pavement Layer Moduli Values – M1 NB Fast Lane

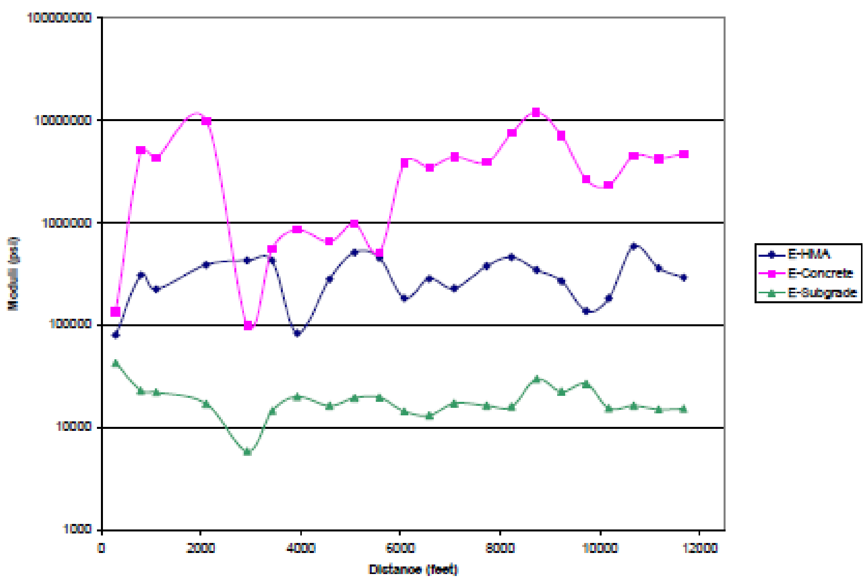

Figure 20: Back Calculated Pavement Layer Moduli Values – M1 Center Turn Lane

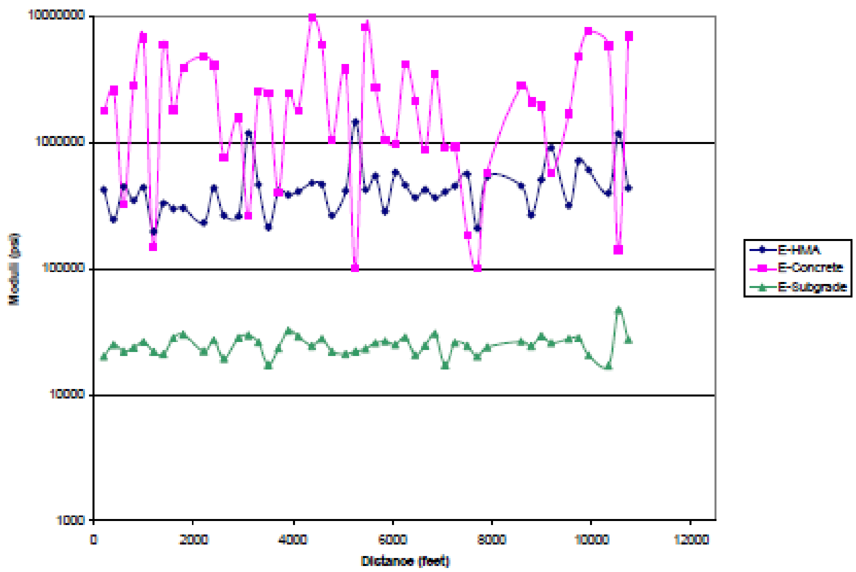

Figure 21: Back Calculated Pavement Layer Moduli Values – M1 SB Slow Lane

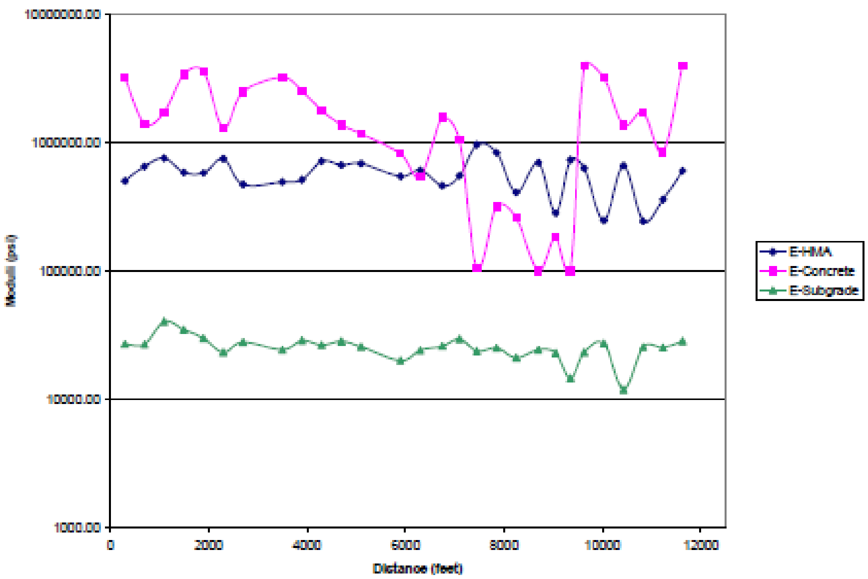

Figure 22: Back Calculated Pavement Layer Moduli Values – M1 SB Fast Lane

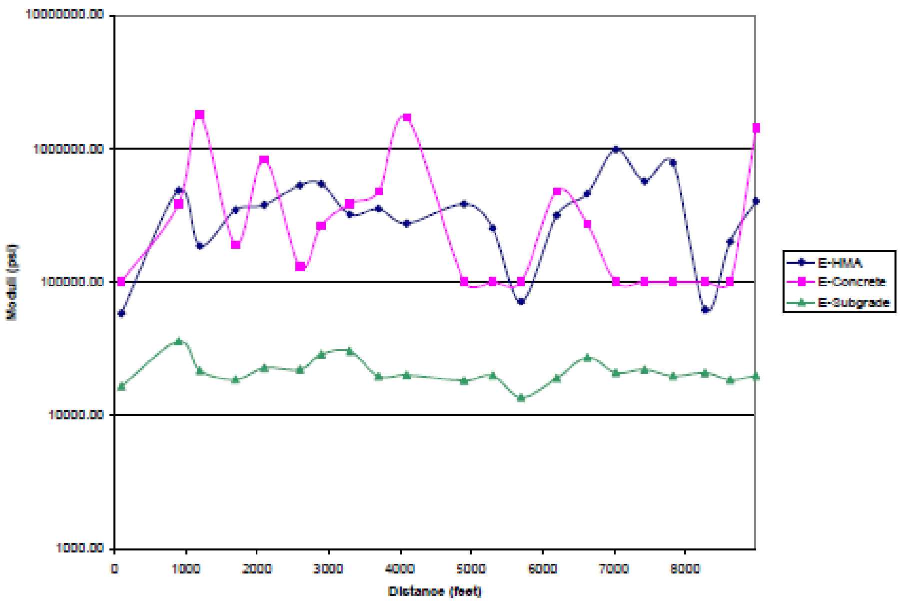

Figure 23: Back Calculated Pavement Layer Moduli Values – M1 SB Parking Lane

Conclusions

The existing condition of the M-1 pavement from I-94 to Tuxedo was evaluated using the following methods;

- Visual Pavement Evaluation to determine the existing pavement condition
- Pavement Coring and Soil Borings to determine the thickness and condition of the existing pavement layers and underlying soils
- Falling Weight Deflectometer Testing to determine exiting structural condition of the pavement layers and subgrade

A summary and conclusion of our results are given below.

1. The existing pavement of M-1 from I-94 to Tuxedo show various pavement distresses including longitudinal and joint reflection cracking, alligator cracking, rutting, localized settlements and failure around drainage structures. Majority of these distresses can be corrected with surface milling and Detail 7 repairs. However some isolated areas may need full depth patches.

2. The pavement section mainly consists of 6.5 inches of HMA over 9.9 inches of reinforced concrete pavement over a sand subbase. In general, The HMA overlay consists of three different layers; 2"-inch thick HMA (minimum 0.96", maximum 4.2"), 1.4"-inch layer of sheet asphalt (minimum 0.36", maximum 2.4") and 4.2"-inch HMA (minimum 2.9", maximum 5.4"). However, at 4 core locations (31% of core locations) only one HMA layer over concrete was encountered.

   Due the existing sheet asphalt layer, the pre-treatment milling thickness should be increased to 3.5". However, according to the as-built plans two sets of rail tracks exist under the pavement along the center of the roadway, approximately, 3.5 inches below the pavement surface. Determination of rail depths along the project limits is needed prior to pre-treatment milling.

3. Paving bricks over reinforced concrete pavement was encountered along the parking lane from I-94 to Grand Blvd. Deteriorated concrete was encountered at two locations (15% of core locations) indicating majority of concrete pavement cores are in good condition. An aggregate base was found at one boring location. The subgrade is mainly consists of firm silty clay.

4. The deflection measurements along different lanes indicated fairly uniform support for the pavement structure except at few isolated areas. Higher deflections were noticed along M-1 SB Parking Lane from Tuxedo to Grand Blvd.

5. Voids under the concrete pavement were investigated using variable load deflection approach as given in the 1993 AASHTO Pavement Design Guide. No suspected voids were encountered along any of the test lines.

6. Pavement layer moduli values were back calculated using MODULUS back calculation program. Average back calculated layer moduli values for HMA, Concrete and subgrade materials were generally within acceptable ranges. However, at some isolated areas, lower concrete pavement moduli values were noticed showing deteriorated concrete under the HMA overlay. Majority of these areas may be corrected with Detail 7 repairs after surface milling. However some isolated areas may need full depth patches.

7. Based on our visual, pavement coring and Falling Weight Deflectometer testing results, it appears that M-1 (Woodward Avenue) from I-94 to Tuxedo is a good candidate for a Thin Concrete Overlay treatment demonstration project.

Appendix B 2: MDOT Reference Material: Plan Review Report for M-3

MDOT
Michigan Department of Transportation

OFFICE MEMORANDUM

DATE: May 3, 2004

CS 82072
JN 72407

TO: Mark Van Port Fleet
Engineer of Design and Support Services

FROM: Joel Ingle
Quality Assurance Engineer

SUBJECT: **The Plan Review Meeting Report on JN 72407C, M-3 Gratiot Ave. CN RR structure (R01 of 82072) to I-94, City of Detroit, Wayne County.**

The Plan Review Meeting for this project was held on April 13, 2004. The following people attended:

*Joel Ingle -	MDOT Quality Assurance
Tim Smith -	MDOT Metro Region
Veena Jasuja -	Detroit TSC Utilities/Permit Engineer
Stanley Quinney -	MDOT/ MITS
Ken Mazurek -	Tetra Tech
Bob Kangas -	Tetra Tech
Chris Burnell -	MDOT Metro Region
Roger Teale -	Detroit TSC Resident Engineer
Mark Grazioli -	MDOT Metro Region
Cedric Dargin -	MDOT Metro Region

*Attended field review

The following is a summary of comments and recommendations made at the meeting:

General

- This project is programmed for cold milling and resurfacing with concrete white topping of Gratiot Avenue from CN RR structure (R01 of 82072) to I-94, approximately 3.17 miles.
- M-3 is a NHS route. The current speed limit on M-3 is posted at 35 mph. The design speed on M-3 is 40 mph.

General Cont.

- The programmed construction cost estimate is $7,200,000. The current estimate is $7,300,000. The CE amount is $720,000.

- The plan completion is May 2004 with an August 2004 letting. The construction time frame was discussed and should begin construction in September 2004 and complete during the spring of 2005. The project will be staged in 4 segments with the maximum work limits based upon 2 continuous segments. The segments are: Segment 1 – CNRR structure (R01 of 82072) to north of St. Joseph Street. Segment 2 – North of St. Joseph Street to north of Concord Street. Segment 3 – North of Concord Street to north of Parker Street. Segment 4 – North of Concord Street to I-94.

- This project will be let separately from the M-3 project on Randolph from Jefferson Street to Macomb Street (CS 82072 (82132)- JN 78780).

Pavement

- The existing pavement on M-3 from the POB to POE is a 9 lane roadway. The existing 9 lane roadway is 90' face to face with 3 thru lanes 3 - 10'lanes' in each direction, a 10.5' thru/parking lane in each direction and an existing 9' center left turn. The existing pavement has approximately 4.5"-10" of HMA over 8.5"-15" of concrete over 18"-36" subbase. The existing thru/parking lane has approximately 2"- 9" of HMA over 3" brick pavers over 8"-14" of concrete over 18"-36" subbase. In the center of Gratiot Avenue are two encased trolley car tracks under approximately 5.5"-9.5" of HMA over 13.5"-19" of concrete over 18"-36" subbase. The existing curb is Detail E curb.

- The proposed pavement on M-3 from POB to POE will be profile cold milled at 2% slope for 16 feet each side of centerline at a depth of 0.42', the next 22' will be profile cold milled at 2.5% slope and the remaining 7 feet (parking area) will be cold milled to obtain a minimum 4" curb face at 2% - 4% slope. The outside 7' of pavement (brick pavers over concrete in poor condition) will be removed to the bottom of the concrete and replaced with concrete base course (variable thickness, cyd.) The curb will be replaced with detail E-4 curb. The outside 7' of pavement (brick pavers over concrete in with concrete in good condition) will be removed to the bottom of the pavers and replaced with HMA wedging to the top of the milled surface. The existing curb will be saved. Only the outside lanes with brick pavers will be removed. The remaining outside pavement will be cold milled as stated above. The remaining pavement will have the pavement

Pavement Cont.

- repaired with Detail 7 Joint repairs and hand patching. A miscellaneous quantity of concrete pavement repairs are placed on the note sheet. The pavement will then be either surfaced with 110lbs/syd of HMA Separator Layer (PG 64-28) for Segments 1 and 2 or the pavement will be surfaced with 110lbs/syd of HMA 36A (PG 64-28) for Segments 3 and 4. The pavement will then be overlayed with the pay item of Concrete Pavement, Overlay, Furnishing and Placing (Modified). The concrete will be finished with the pay item of Concrete Pavement, Overlay, Finishing and Curing. Joints will be non-sealed in Segments 1 and 4. Joints will be sealed in Segments 2 and 3.

- Epoxy anchored lane ties will be used to tie the existing curb to the proposed concrete base course.

- All side road approaches will be cold milled at 0.42' and resurfaced as stated above for the respective Segment.

- Some areas with bad sidewalk will be replaced. Driveways will not be impacted.

Traffic & Safety

- The general plan for maintaining traffic along M-3 for the cold milling, HMA separator surfacing and concrete white topping is to stage the work part width. The staging is :

- Stage 1 consists of shifting traffic to the east side of the road and maintaining 2 lanes in each direction with a center left turn lane (55' width). Construct the west side (29' width) of pavement to top of concrete white topping.

- Stage 2 consists of shifting traffic to the south side of the road and maintaining 2 lanes in each direction with a center left turn lane (55' width). Construct the east side (29' width) of pavement to top of concrete white topping.

- Stage 3 consists of shifting two lanes in each direction to the outside lanes (22' width each direction) and construct the center lanes (32'width) to top of concrete white topping.

- Tetra Tech will spell out the suggested staging in the Maintaining Traffic special provision. Tetra Tech will also prepare staging plans and staging typical cross sections to show the traffic shifts and the limits of work per stage.

Traffic & Safety Cont.

- Permanent pavement marking plans and permanent signing plans are shown as project work.

- The City of Detroit will address all the parking restriction signs.

- Plastic drums will be lighted.

- Temporary traffic control typical details will be incorporated into the maintaining traffic special provision.

- Tetra Tech will incorporate the recommendations made by Georgina McDonald dated April 9, 2004, April 27, 2004 and May 3, 2004.

- Tetra Tech to update permanent signing plans reflecting Tim Smith's comments on permanent signing. Need pay item for Post Hole Through Concrete for Steel and Wood Post.

- No Design exceptions are required at this time. Tetra Tech will provide a copy of the crash analysis for the CA form as part of the OEC submission.

- *Subsequent to the meeting:* It was decided to remove the raised island over the structure R01 of 82072 and the raised island southerly to the I-75 Connector. This will allow for shifting traffic prior to the north reference line of the structure R01 of 82072 to construct the concrete white topping. The island will be replaced with HMA Approach and be painted out as an island after the concrete white topping is completed.

- Permanent pavement markings will be sprayable thermoplastic for lane lines and polyurea for special markings.

- Tetra Tech will follow up on the comments from Geometrics, Najim Salam, dated April 7, 2004.

- Signals will be replaced throughout the corridor and interconnected via radio waves. Mark Graziolli will obtain signal pole borings once the final signal poles are located.

- Plans for the signal work should be coordinated with Paula Corlett. Plans for Maintaining Traffic should be coordinated with Georgina McDonald. Plans for the

Traffic & Safety Cont.

- permanent signing should be coordinated with Burton Smith.

Real Estate

- No additional ROW is required for the project.

Drainage

- Tetra Tech will detail the Adjust Drainage Structure Cover Case 1-Modified and modify the special provision. Adjust Additional depth drainage structures quantity will be added to the plans.

- Tetra Tech videoed the sewer cross leads. Sewer repairs will be detailed on the plans. Tetra Tech will detail the pavement repair for the sewer repairs.

Utilities

- No utilities are shown on the plans. The utility coordination process has not started. Chris Burnell will schedule a utility meeting for the project. Tetra Tech will send plans to Chris Burnell for the utility meeting. Tetra Tech will write up the utility coordination clause and draft up the utility clearance.

- The drainage structures owned by the private utility companies will be shown as ADJ-By others.

Environmental

- Erosion control items should be shown on the plans.

- The TSC will get a form 1775 for the OEC. A Re-Study may be required for removing the island south of the R01 of 82072 to the I-75 Connector. No permits are required.

- A miscellaneous quantity of 200 cyd of non-hazardous material will be added to the plans for the signal pole work.

- The City of Detroit has a noise ordinance. A Notice to Bidders will state that the Contractor shall follow the local ordinance.

Miscellaneous

- No Slope restoration is anticipated for this project. A note should be added to the note sheet stating that if slope restoration (identify the individual items and rates) is required, it is included in other items of work.

- An Act 51 agreement is needed for the project with the City of Detroit.

- Tetra Tech will draft up a CPM to help in determining the progress schedule. The project will be on an expedited schedule with no incentives. Standard liquidated damages will apply.

- The progress clause will state that any longitudinal HMA wedging along the longitudinal joint will be at contractor expense. Additional temporary HMA wedging quantities for transverse segments of paving will be included on the note sheet. Tetra Tech will detail out a temporary wedge for transverse segments.

- All sidewalks crossings without sidewalk ramps need to have Sidewalk Ramp, ADA. *Subsequent to the meeting*: All existing sidewalk ramps should be retrofitted to meet ADA specifications. Use the pay item Sidewalk Ramp, Detectable Warning, Retrofit. The FUSP 03SP803(A) is currently being revised and should be used for this project.

- Detail 7 joint repairs and HMA hand patching will be used on this project prior to surfacing.

- The Region Soils will provide undercutting quantities and review the erosion control items.

- On the field review, approximately a 20' length by 90' width of concrete patch will be needed to set up for cold milling concrete. This patch is located south of Bellevue Street.

- No MITS work will be included in the project.

- Additional comments and recommendations are noted on the plans, which have been returned to the Chris Burnell.

Quality Assurance Engineer

DD:JI:ej

cc: K. Schuster
S. Urda
B. Zielinski
E. Burns
T. Killingsworth
B. Kelley
A. Lawrie
S. Bates
I. Gedaoun
R. Brenner
T. Eldridge
G. Croskey
L. Felsing
B. Brooks
C. Burnell
C. Dargin
M. Eustice
D. Gould
H. Hicks
R. Hepfer
V. Jasuja
T. Jay
G. Johnson
V. Judnic
T. Kratofil
G. Krueger
A. McDonald
J. Meister
T. Mullin
A. Punjabi
S. Rapp
A. Sahlool
R. Screws
M. Silver
G. Taneja
R. Teale
B. Wells
J. Williams
P. Williams
M. Chynoweth
S. Ferman
M. Grazioli
T. Smith
S. Quinney
K. Mazurek – Tetra Tech
B. Kangas – Tetra Tech
T. Vanden Berg

Appendix C: Concrete Overlay Depth Frequency Histograms and CESAL Tables

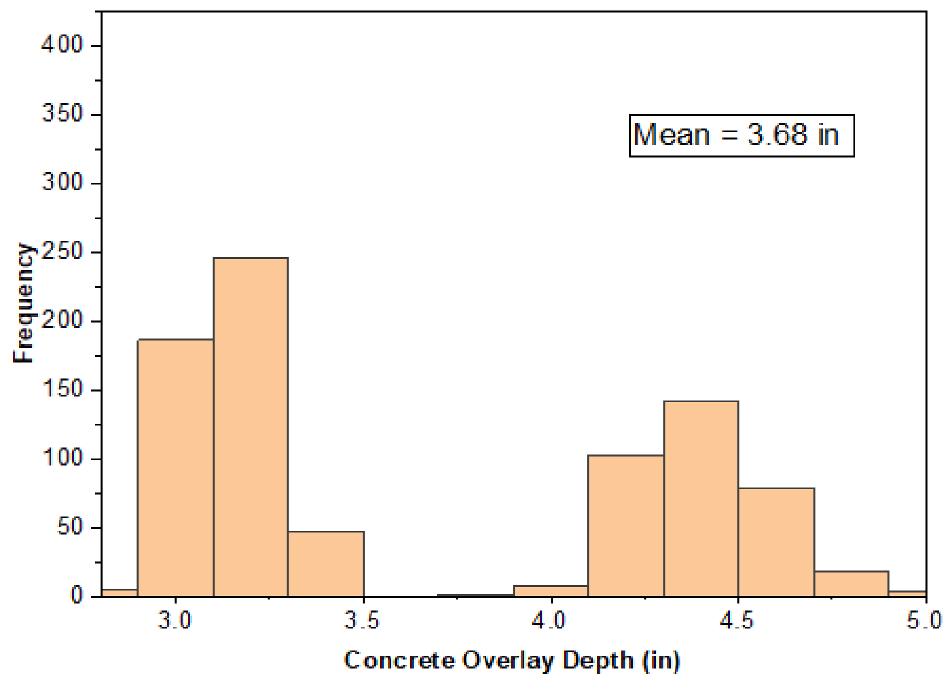

Figure C 1. Overlay Depth for Northbound Outside Lane M-1

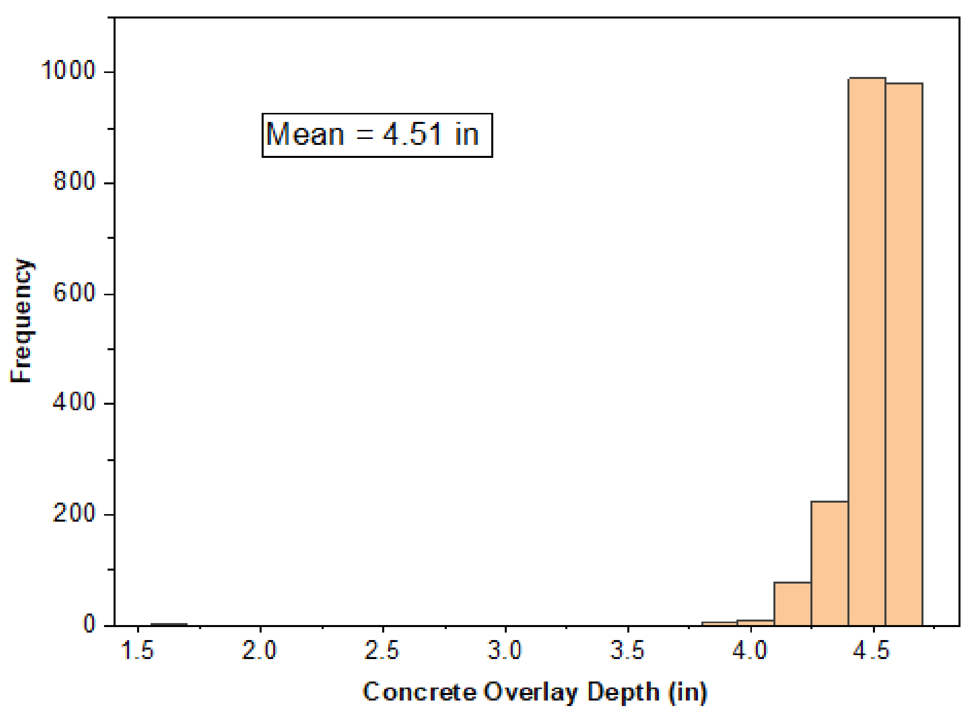

Figure C 2. Overlay Depth for Southbound Middle Lane M-1

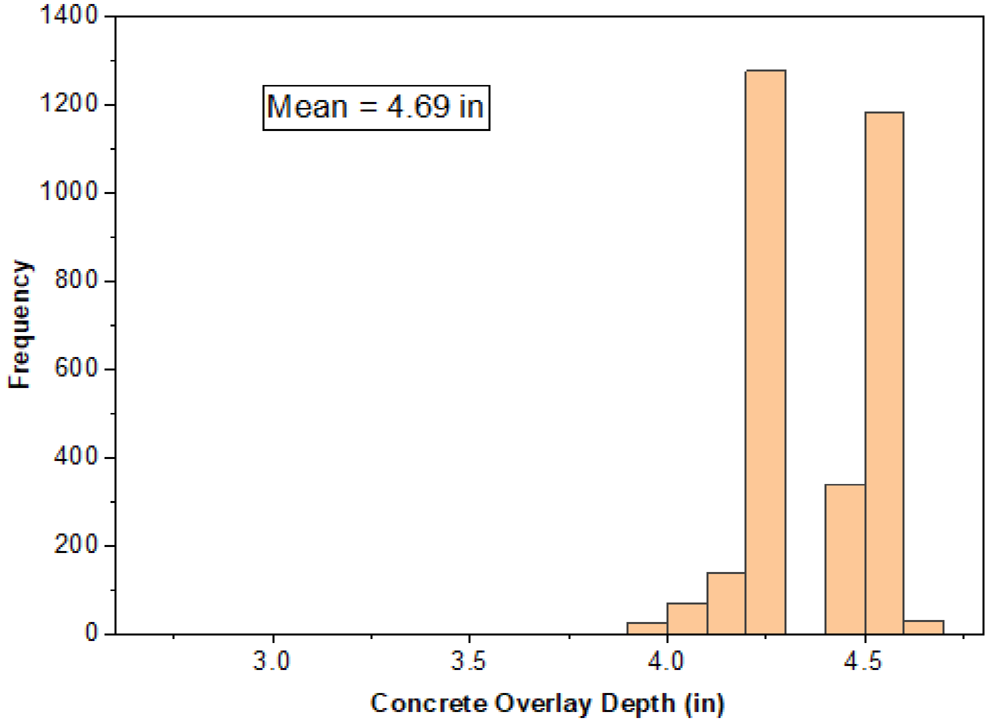

Figure C 3. Overlay Depth for Southbound Outside Lane M-1

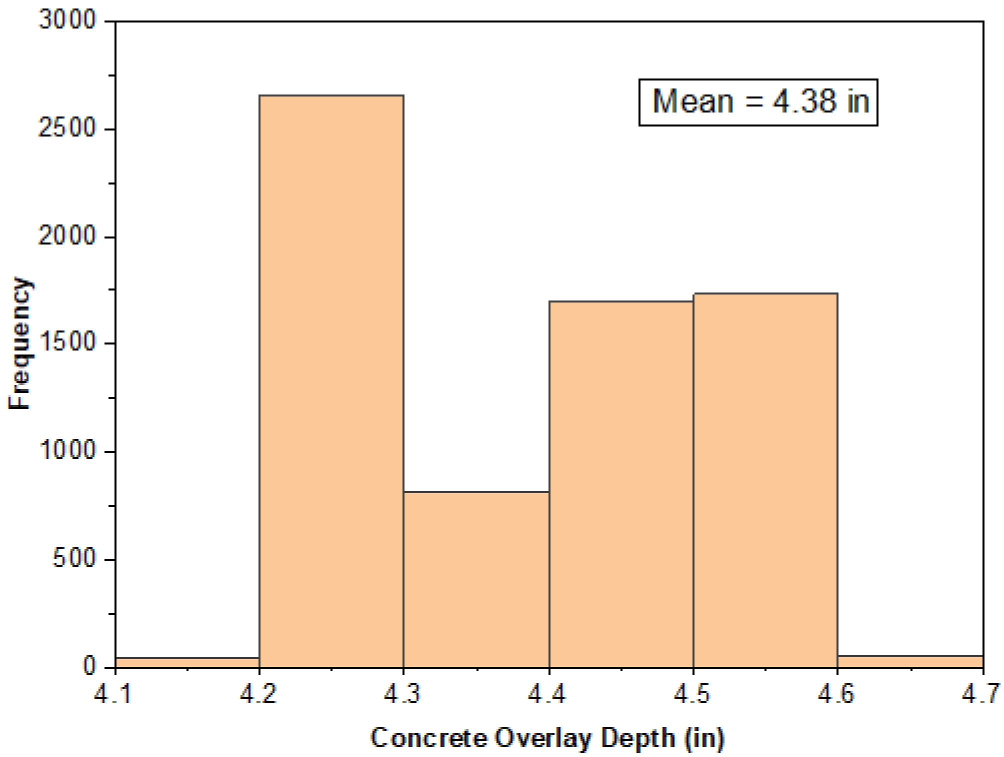

Figure C 4. Overlay Depth for Northbound Inside Lane M-3

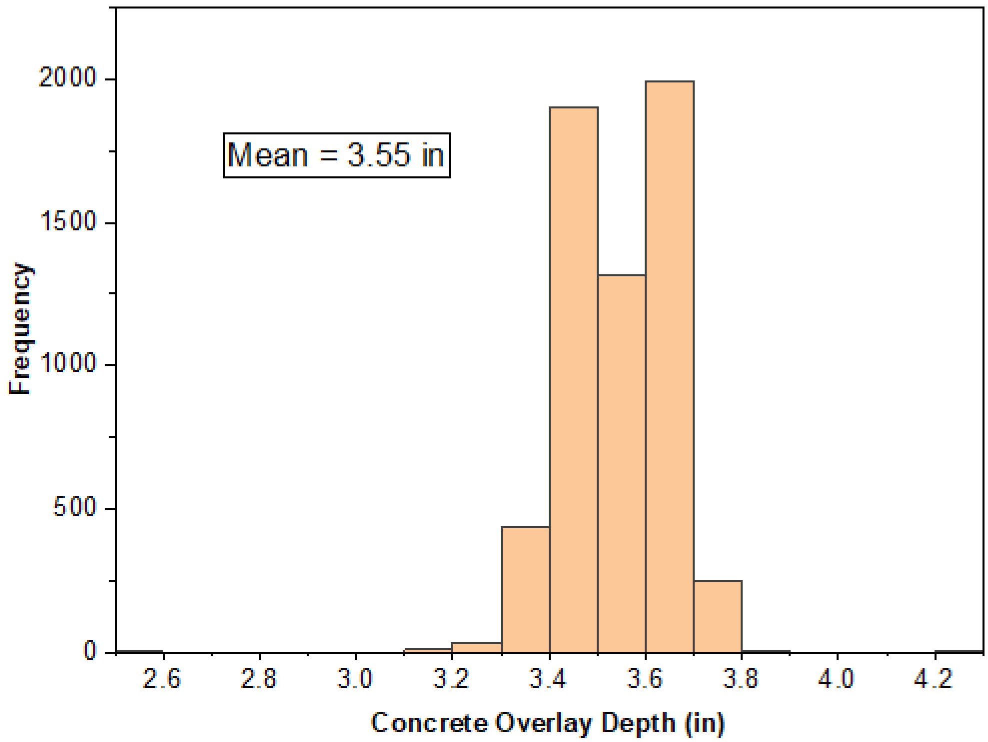

Figure C 5. Overlay Depth for Northbound Middle Lane M-3

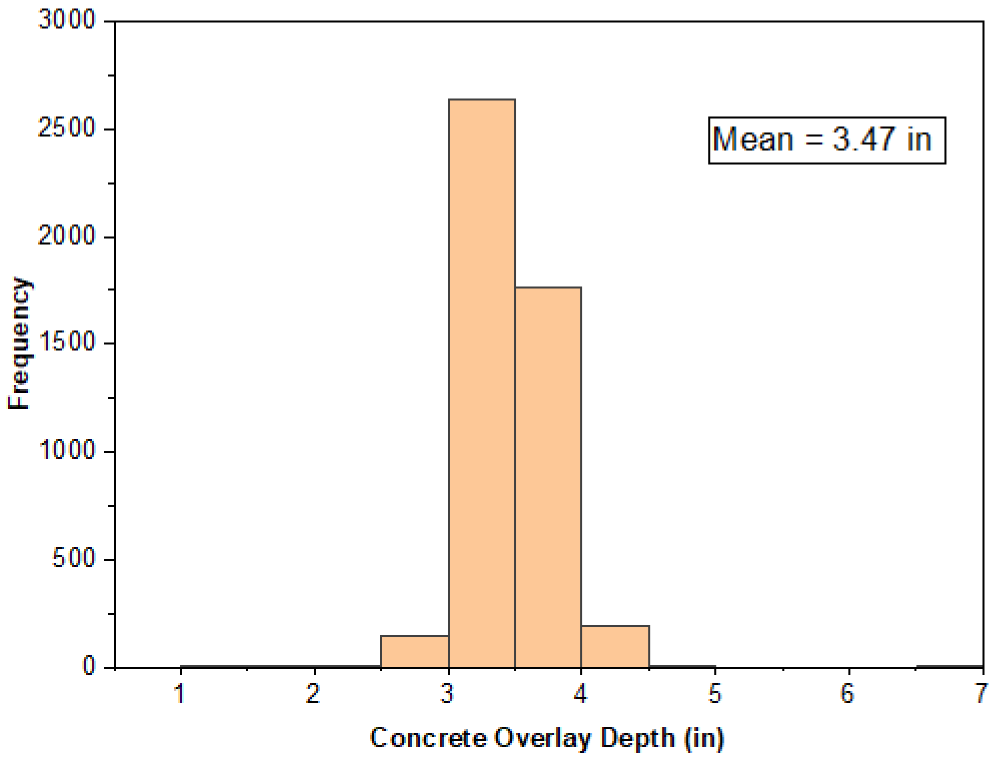

Figure C 6. Overlay Depth for Northbound Outside Lane M-3

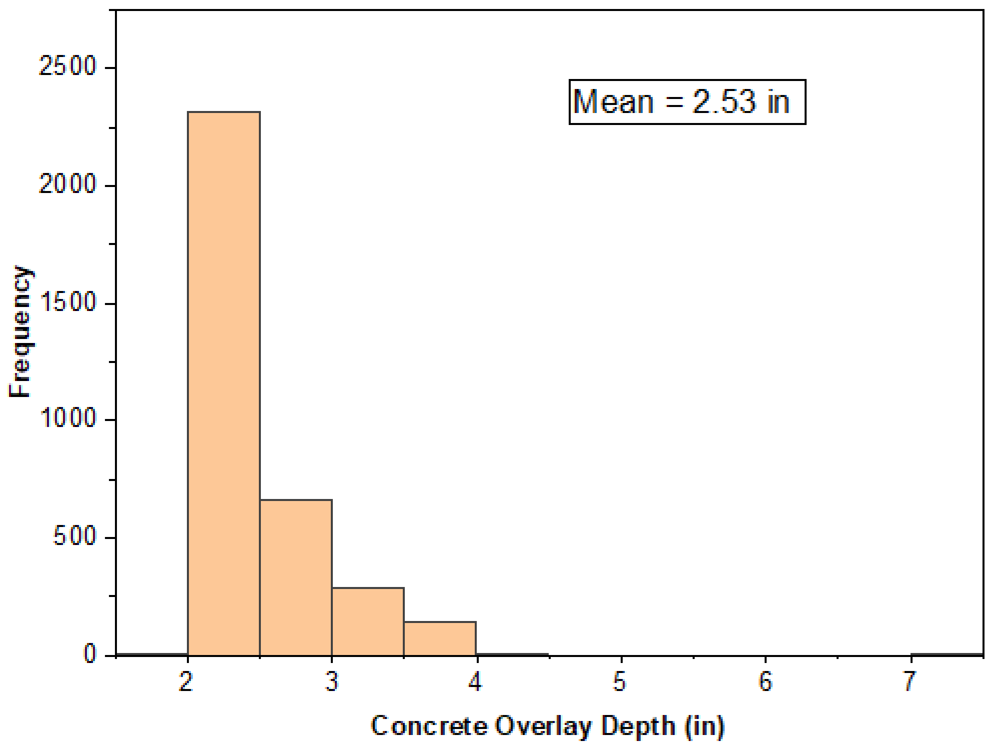

Figure C 7. Overlay Depth for Southbound Inside Lane M-3

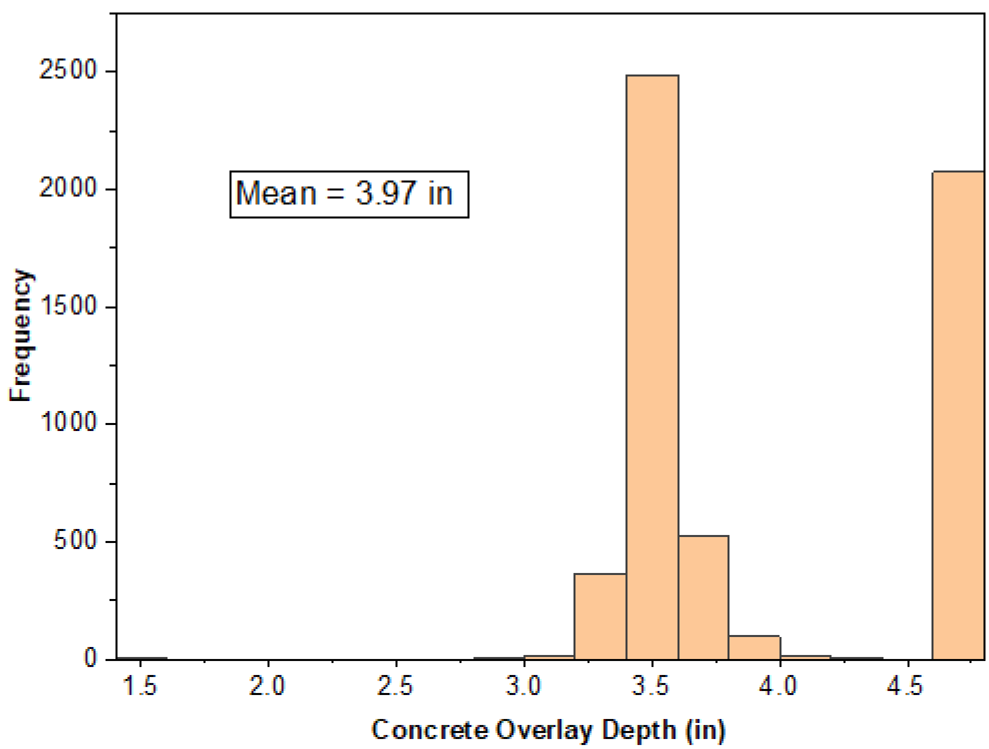

Figure C 8. Overlay Depth for Southbound Middle Lane M-3

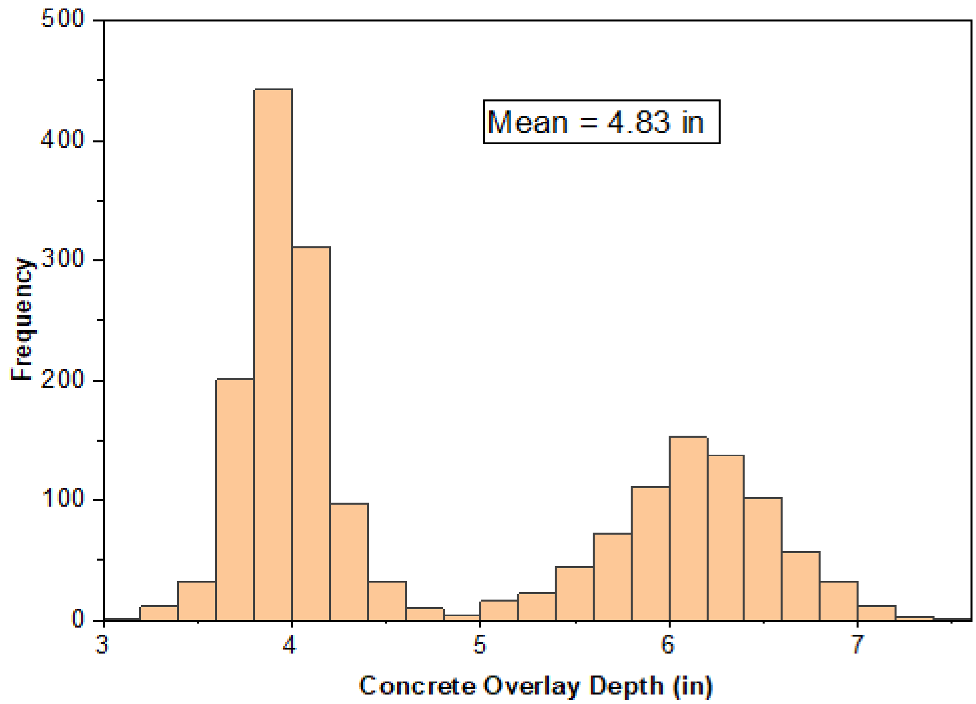

Figure C 9. Overlay Depth for Southbound Outside Lane M-3

Table C 1. M-3 Actual CESALs Data from St. Aubin Street to Elmwood Street

YEAR	CAADT	DD	LD	TF	CESALS
2022	675	0.56	0.9	0.74	91,888
2021	666	0.56	0.9	0.74	90,663
2020	712	0.6	0.9	0.74	103,848
2019	1421	0.6	0.9	0.74	207,259
2018	1428	0.6	0.9	0.74	208,280
2017	1533	0.6	0.9	0.74	223,594
2016	1253	0.6	0.9	0.74	182,755
2015	1077	0.6	0.9	0.74	157,085
2014	1242	0.6	0.9	0.74	181,151
2013	1213	0.6	0.9	0.74	176,921
2012	1186	0.6	0.9	0.74	172,983
2011	1170	0.6	0.9	0.74	170,649
2010	1129	0.6	0.9	0.74	164,669
2009	1088	0.6	0.9	0.74	158,689
2008	1222	0.6	0.9	0.74	178,234
				Cumulative CESALS	2,468,666

Table C 2. M-3 Actual CESALs Data from Elmwood Street to Van Dyke Street

YEAR	CAADT	DD	LD	TF	CESALS
2022	967	0.62	0.9	0.74	145,742
2021	953	0.62	0.9	0.74	143,632
2020	837	0.62	0.9	0.74	126,149
2019	1655	0.6	0.9	0.74	241,388
2018	1664	0.6	0.9	0.74	242,701
2017	1657	0.6	0.9	0.74	241,680
2016	1253	0.6	0.9	0.74	182,755
2015	1246	0.6	0.9	0.74	181,734
2014	1242	0.6	0.9	0.74	181,151
2013	1213	0.6	0.9	0.74	176,921
2012	1186	0.6	0.9	0.74	172,983
2011	1170	0.6	0.9	0.74	170,649
2010	1129	0.6	0.9	0.74	164,669
2009	1088	0.6	0.9	0.74	158,689
2008	1222	0.6	0.9	0.74	178,234
				Cumulative CESALS	2,709,078

Table C 3. M-3 Actual CESALs Data from Van Dyke Street to McClellan Street

YEAR	CAADT	DD	LD	TF	CESALS
2022	851	0.52	0.9	0.74	107,572
2021	838	0.52	0.9	0.74	105,929
2020	814	0.6	0.9	0.74	118,725
2019	1623	0.6	0.9	0.74	236,721
2018	1631	0.6	0.9	0.74	237,888
2017	1602	0.6	0.9	0.74	233,658
2016	1253	0.6	0.9	0.74	182,755
2015	1280	0.6	0.9	0.74	186,693
2014	1242	0.6	0.9	0.74	181,151
2013	1213	0.6	0.9	0.74	176,921
2012	1186	0.6	0.9	0.74	172,983
2011	1170	0.6	0.9	0.74	170,649
2010	1129	0.6	0.9	0.74	164,669
2009	1088	0.6	0.9	0.74	158,689
2008	1222	0.6	0.9	0.74	178,234
				Cumulative CESALS	2,613,237

Table C 4. M-1 Actual CESALs from Chandler Street to Tuxedo Street

YEAR	CAADT	DD	LD	TF	CESALS
2025	611	0.6	0.9	0.74	89,154
2024	599	0.6	0.9	0.74	87,406
2023	588	0.6	0.9	0.74	85,692
2022	576	0.59	0.9	0.74	82,612
2021	430	0.69	0.9	0.74	72,125
2020	378	0.69	0.9	0.74	63,403
2019	874	0.69	0.9	0.74	146,598
2018	544	0.6	0.9	0.74	79,345
2017	537	0.6	0.9	0.74	78,324
2016	622	0.66	0.9	0.74	99,793
2015	648	0.66	0.9	0.74	103,965
2014	674	0.66	0.9	0.74	108,136
2013	658	0.66	0.9	0.74	105,569
2012	643	0.66	0.9	0.74	103,163
2011	634	0.66	0.9	0.74	101,719
				Cumulative CESALS	1,407,002

Table C 5. Initial Design CESALs for M-3 and M-1

ROUTE	LOCATION	CAADT	DD	LD	TF	GF	CESALS
M-3	St. Aubin Street to Elmwood Street	1230	0.5	0.9	0.93	15.54	2,919,093
M-3	Elmwood Street to Van Dyke Street						
M-3	Van Dyke Street to McClellan Street						
M-1	Chandler Street to Tuxedo Street	736					1,746,709