Design and Performance of Unbonded Concrete Overlays on Concrete Pavement - A Synthesis

NRRA RIGID TEAM

Authors: Joseph Korzilius, Spencer Neff and Renae Kuehl,
SRF Consulting Group, Inc

A pooled fund project administered by the Minnesota Department of Transportation

Report No. NRRA202006

NRRA
National Road Research Alliance

DEPARTMENT OF TRANSPORTATION

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.	
NRRA2020006			
4. Title and Subtitle Design and Performance of Unbonded Concrete Overlays on Concrete Pavement – A Synthesis		5. Report Date October 2020 6.	
7. Author(s) Joseph Korzilius, Spencer Neff, and Renae Kuehl		8. Performing Organization Report No.	
9. Performing Organization Name and Address SRF Consulting Group, Inc. 3701 WAYZATA BLVD STE 100 MINNEAPOLIS, MN 55416-3791		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. (C) 1029498	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation Office of Research & Innovation 395 John Ireland Boulevard, MS 330 St. Paul, Minnesota 55155-1899		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code	
15. Supplementary Notes http://mndot.gov/research/reports/2020/NRRA202006.pdf			

16. Abstract (Limit: 250 words)

Due to increased traffic congestion and reduced budgets, National Road Research Alliance (NRRA) states are seeking effective rehabilitation techniques for older concrete pavements. Unbonded concrete overlays have a successful history as a rehabilitation option, and there is interest by NRRA member states to assemble information on best practices for the design, construction, and maintenance that relate to field performance.

The goal of this project is to produce a brief technical document synthesizing the design, construction, maintenance, best practices, and performance observations of unbonded concrete overlays in NRRA member states.

17. Document Analysis/Descriptors	18. Availability Statement		
Concrete overlays, pavement interlayers, geotextiles, pavement distress	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312		
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 27	22. Price

DESIGN AND PERFORMANCE OF UNBONDED CONCRETE OVERLAYS ON CONCRETE PAVEMENT – A SYNTHESIS

FINAL REPORT

Prepared by:

Joseph Korzilius
Spencer Neff
Renae Kuehl
SRF Consulting Group Inc.

OCTOBER 2020

Published by:

Minnesota Department of Transportation

Office of Research & Innovation

395 John Ireland Boulevard, MS 330

St. Paul, Minnesota 55155-1899

ACKNOWLEDGMENTS

We wish to thank the National Road Research Alliance for the financial support to make this important report a reality. The Technical Advisory Panel that steered this project was helpful in identifying key issues and concerns related to diamond grinding and the resources needed at the national level. Panel members were also very generous with their time in providing input on their states standard practices, attending meetings, and reviewing and providing content and oversight for this final document.

The authors would like to thank the following individuals and organizations for their contributions to this document:

- Tim Andersen, MnDOT
- Chris Brakke, Iowa DOT
- Thomas Burnham, MnDOT
- John Donahue, Missouri DOT
- Gerald Geib, MnDOT
- Robert Golish, MnDOT
- Bernard Izevbekhai, MnDOT
- Leo Mahserelli, CalTrans
- Maria Masten, MnDOT
- Thomas Murphy, NDDOT
- Clayton Schumaker, NDDOT
- John Stanton, Michigan DOT
- Peter Taylor, Iowa State
- Charles Wienrank, Illinois DOT
- Jim Wilde, MSU
- Ben Worel, MnDOT
- Zhanping You, MTU
- Matt Zeller, CPAM

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LIST OF ABBREVIATIONS

CP Tech Center – Pavement Technology Center

CRCP – Continuously Reinforced Concrete Pavement

DOT – Department of Transportation

FHWA – Federal Highway Administration

HMA – Hot Mix Asphalt

JPCP – Jointed Plain Concrete Pavement with Dowels

NRRA – National Road Research Alliance

PCC- Portland Cement Concrete

UBCO – Unbounded Concrete Overlay

EXECUTIVE SUMMARY

Due to increased traffic congestion and reduced budgets, National Road Research Alliance (NRRA) states are seeking effective rehabilitation techniques for older concrete pavements. Unbonded concrete overlays have a successful history as a rehabilitation option, and there is interest by NRRA member states to assemble information on best practices for the design, construction, and maintenance that relate to field performance.

The goal of this project is to produce a brief technical document synthesizing design, construction, maintenance, best practices, and performance observations of unbonded concrete overlays in NRRA member states.

CHAPTER 1: INTRODUCTION

1.1 WHAT IS AN UNBONDED CONRETE OVERLAY

Within the scope of this report, an unbonded concrete overlay (UBCO) consists of constructing a new Portland cement concrete (PCC) layer over an existing concrete or composite (concrete with asphalt overlay) pavement, with an interlayer beneath the new PCC. The design philosophy for an UBCO includes an interlayer or "bond-breaker" consisting of a hot mix asphalt (HMA) or geotextile fabric layer designed to eliminate or reduce the potential for distresses to be reflected into the new concrete overlay (see Figure 1). Asphalt interlayers can consist of newly paved material or an existing HMA overlay, often milled to reduce profile gains. The underlying concrete pavement serves as a stable supporting base.

An UBCO can be successfully constructed over severely distressed concrete pavements with minimal preparation work. Even though the UBCO is considered a pavement rehabilitation alternative, design and construction methodologies have similarities to that of new concrete pavements.

Traditionally, an UBCO is designed for thickness, width, and load transfer with no or little contribution provided from the support given by the old underlying concrete pavement. The performance of bond breakers, HMA or geotextile fabric, however, are believed to have significant influence relative to performance of the concrete overlay. There is interest by NRRA member states in understanding interlayer experience including type, design, and performance of interlayers being used with respect to the overlay's performance. Emerging UBCO design procedures [i.e., UBOL design created under Pooled Fund Project TPF 5(269)] are expected to better characterize both the contribution of the interlayer, as well as supporting base layers.

Not included in this report are concrete overlays typically identified as bonded concrete overlays over an existing asphalt pavement, known historically as whitetopping.

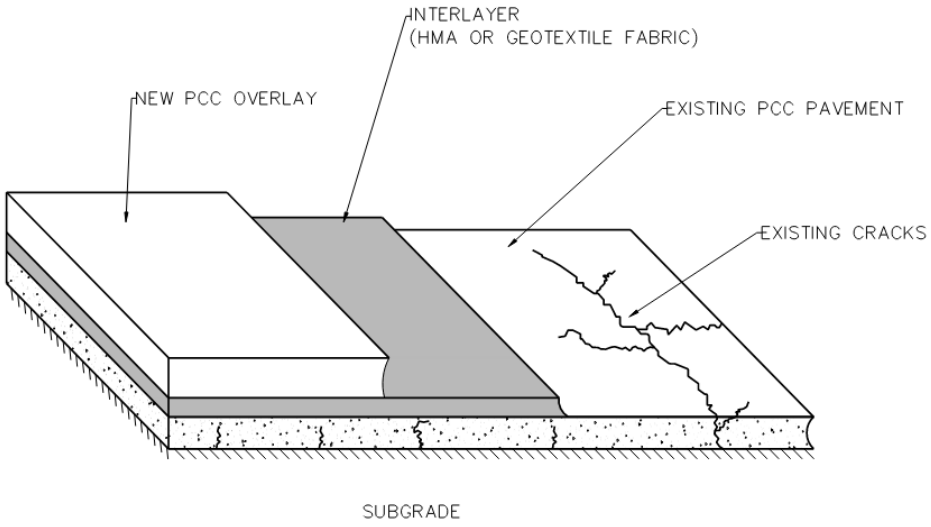

Figure 1 Typical section of pavement with an interlayer and new PCC overlay

1.2 FHWA GUIDANCE

The Federal Highway Administration's (FHWA's) Concrete Overlay Field Application Program is currently administered by the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University. The goal of the program is to provide technical assistance to agencies in the overall concrete overlay process, from the selection of candidate projects through design and construction. The CP Tech Center addresses questions often posed regarding concrete overlay technology and is charged with increasing awareness and knowledge among states, local agencies, and contractors regarding how to apply concrete overlay technology successfully.

1.3 WHY NRRA MEMBERS WANTED THIS STUDY

1.3.1 NRRA Members Involved

Eight state agencies currently requesting and contributing to this report are California DOT, Illinois DOT, Iowa DOT, Michigan DOT, MnDOT, Missouri DOT, North Dakota DOT, and Wisconsin DOT.

1.3.2 Why this Effort is Being Done

Due to increased traffic congestion and reduced highway construction budgets, emphasis has been placed on seeking effective rehabilitation techniques for older pavements. Unbonded concrete overlays have a successful history as a rehabilitation technique for distressed concrete pavements and NRRA member states and associates are looking to compile a synthesis of best practices.

The goal of this effort is to compile a synthesis of best practices and performance related to the design, construction, and maintenance of UBCOs constructed in participating NRRA member states. Inconsistencies or contradictions in the understanding or approach of best practices can be discussed and further evaluated, possibly during the next round of investigation at MnROAD.

CHAPTER 2: DESIGN PRACTICES BY STATE

Unbonded concrete overlays are used to improve the structural capacity and functional condition of existing concrete pavements ranging from moderately to significantly deteriorated. The term "unbonded" identifies that bonding between the overlay and the underlying concrete pavement is not desired or needed to achieve design performance. Thus, the overlay is designed to perform as new pavement with the existing pavement providing a stable base. There are several benefits of using unbonded concrete overlays, including the solution's cost-effectiveness. According to the CP Tech Center, "dollar for dollar, they are one of the most effective long-term pavement preservation and major rehabilitation options for existing pavements[1]." Other benefits of unbonded concrete overlays include their quick construction, ease of maintenance, and sustainability assets.

In general, unbonded concrete resurfacing is highly reliable, offering longer design life than road rehabilitation with asphalt. UBCO's have been successfully constructed by NRRA member states with older projects demonstrating more than 30 years of good-to-excellent performance, according to the CP Tech Center[2]. Table 2.1 summarizes the main design practices.

[1] "Guide to Concrete Overlays" Third Edition May 2014, Chapter 1: Introduction, Page 3; Benefits of Concrete Overlays.

[2] "Guide to Concrete Overlays" Third Edition May 2014, Chapter 3: Overlay Options, Pages 39 and 47; Performance.

Table 2.1 – Unbonded Concrete Overlay Design Practices by State

Agency	California DOT	Illinois DOT	Iowa DOT	Michigan DOT	Minnesota DOT	Missouri DOT	North Dakota DOT
State Design Procedure	X	X		X	X		
MEPDG		X				X	X
≥8-inch Thick Overlay	X	X	X	X	X	X	X
<8” Thick Overlay		X		X	X	X	
Dense HMA Interlayer	X	X	X	X	X	X	X
Drainable HMA				X	X		
Geotextile Interlayer		X	X[1]	X	X	X	
Transverse Joint Spacing (Feet)	15’	15’	5’	12’	15’	15’	6.5’
Saw Cut Width x Depth (inches)	1/8"	(3/16” – 1/4") x T/3	1/4" x Full Depth	1/4" x 1.5”	3/16" x T/3	1/8” x T/3	1/8” x T/3

* T = thickness of the overlay

[1] = Local agencies in Iowa have experience with Geotextile

The Wisconsin DOT has not constructed a UBCO as of the writing of this report.

CHAPTER 3: STATE PERFORMANCE AND SPECIFICATIONS

Performance and specification data summarized in this section are from the eight NRRA member state agencies: California DOT, Illinois DOT, Iowa DOT, Michigan DOT, Minnesota DOT, Missouri DOT, North Dakota DOT, and Wisconsin DOT.

3.1 CALIFORNIA DEPARTMENT OF TRANSPORTATION

3.1.1 Description, Performance and Maintenance

California has constructed unbonded PCC overlays consisting of new JPCP (Jointed Plain Concrete Pavement with Dowels) and CRCP (Continuously Reinforced Concrete Pavement). HMA is the typical interlayer used as a bond breaker. The UBCO overlay alternatives specify minimum thicknesses of 0.75 feet (9.0 inches) for CRCP and 0.85 feet (10 inches) for JPCP to be constructed over severely distressed JPCP in areas where there is no impact to clearances at overcrossings in highways with no more than 2 lanes in each direction.

No performance issues nor benefits were mentioned in the state's response to our survey. Interstate 80 in Nevada County has had concrete overlays that have been performing well. However, ruts in the wheel paths due to chain wear are addressed by concrete diamond grinding across the entire pavement width or construction of a polyester concrete inlay over the worn areas is performed. On Interstate 8, in Imperial County, in the desert area of southern California, two new CRCP UBCO projects were completed in 2019.

3.1.2 Pre-Treatments

Specifications recommend repair of existing pavement distresses or that a crack and seat pre-treatment be performed when constructing over existing JPCP pavement. Distresses such as cracking, spalling, or loss of underlying support should be repaired or filled with HMA. The benefits of surface grinding or using an increased HMA interlayer design thickness are considered to address extensive surface irregularities. Existing poor subgrades with moisture-related drainage problems can also be addressed as part of the design.

3.1.3 Design of Unbonded Concrete Overlay

The design thickness of an UBCO, JPCP or CRCP, follow the standard design mechanistic empirical analysis and considers climatic region, subgrade type, applied traffic loads, and a performance period of 20 or 40 years. All unbonded PCC overlays are a minimum 9 inches thick. JPCP construction includes dowel bars as a standard.

The typical saw cut pattern is perpendicular to the longitudinal joint at a spacing of 15 feet. Transverse and longitudinal joints are sawcut to a 1/8-inch width and to a depth that allows at least ½-inch clearance to any dowel or tie bar.

3.1.4 Type and Performance of Interlayer

Interlayer types used in California are newly placed dense graded HMA with the option for milling on aged HMA over concrete pavement for quality control and bond. HMA type interlayers are constructed to a thickness ranging between 0.10 feet and 0.20 feet (1.2 to 2.4 inches) thick. Thicker interlayers account for existing pavement surface undulations and rough surfaces and further to cost effectively modify cross slopes. The HMA interlayer improves smoothness, reduces reflecting cracking, and provides flexibility to accommodate concrete pavement curling and warping stresses.

Some overlays may be designed with a geosynthetic pavement interlayer (GPI) to help retard reflective cracking in the UBCO. When required by design, a geosynthetic pavement interlayer is placed over a coat of asphalt binder and in compliance with the manufacturer's instructions.

3.1.5 Construction of Interlayer

Prior to construction of the geosynthetic or HMA interlayer, cracks 1/4 inch and wider, spalls, and holes in the pavement are repaired, then the pavement is cleaned of loose and extraneous material. After repairs and cleaning interlayer is constructed. An HMA (Type A) interlayer and any levelling that may be required shall have a tack coat applied to the existing concrete surface prior to HMA placement to improve bonding to the existing concrete pavement.

When a geosynthetic interlayer is constructed 0.25 ± 0.03 gal of asphalt binder (PG 64-10, PG 64-16, or PG 70-10) is applied per square yard of interlayer or until saturated the width of the interlayer plus 3 inches on each side. The geosynthetic material must comply with the specifications for pavement fabric, paving mat, paving grid, paving geocomposite grid, or geocomposite strip membrane. The geosynthetic layer is placed over the coat of asphalt binder and in compliance with the manufacturer's instructions.

The payment method is paid by cubic yards for HMA and square yard for geosynthetics.

3.2 ILLINOIS DEPARTMENT OF TRANSPORTATION

3.2.1 Description, Performance and Maintenance

UBCO’s have a proven history in Illinois and consist of an existing concrete pavement over which an interlayer and JPCP or CRCP surface is constructed. Research in Illinois has shown that UBCO’s are a viable alternative to reconstruction when a pavement has deteriorated beyond the point that a standard patch and and/or HMA overlay will not perform. UBCO’s are not experimental; however, an economic justification is required for approval.

The Illinois Department of Transportation (IDOT) constructed three unbonded CRCP overlays in the late 1960’s and early 1970’s over existing Jointed Reinforced Concrete Pavement (JRCP). The CRCP overlays ranged from 6 to 9 inches in thickness. All three overlays performed well for over 20 years before requiring major rehabilitation. Four additional unbonded CRCP overlays ranging from 9 to 12 inches in thickness were constructed over existing CRCP in the period from 1995 to 2014. These overlays have all

performed well and remain in service. An experimental 9.75-inch unbonded JPCP overlay was constructed in 2016 over existing JRCP. All of the aforementioned projects were constructed on interstate highways.

A recent thin UBCO with 6-foot x 6-foot x 6-inch thick panels was constructed on I-72 east of Springfield in 2015, and after 5 years of service has performed well. The concrete used on this project included synthetic fibers.

Conventional PCC overlays have been repaired using standard IDOT materials and methods. There have been no repairs yet to the 6-foot x 6-foot x 6-inch overlay. IDOT would likely use conventional concrete without fibers or HMA if doing a quick repair that was needed to minimize traffic closures.

3.2.2 Pre-Treatments

Construction of an UBCO typically requires minimal surface preparation of the existing pavement. However, severe distresses such as punchouts, failed patches, and areas of pumping should be repaired prior to the concrete overlay construction.

For existing concrete pavements with an existing HMA overlay milling is typically performed for surface correction prior to construction of the concrete overlay.

3.2.3 Design of Unbonded Concrete Overlay

Illinois considers the existing concrete pavement as the subbase with minimal structural contribution to the new overlay. For a CRCP unbonded overlay, the design thickness is determined following the full-depth CRCP design procedure then one inch of thickness is deducted as structural credit for the existing PCC. The design life is typically 20 years. One project was designed for an extended life of 30 years. The design steel percentage should be the same as for new CRCP pavements.

IDOT does not currently have a standard design procedure for an unbonded JPCP overlay. For the experimental project the design thickness was determined following the standard IDOT design procedure with one inch of thickness subtracted from the design thickness for a new JPCP in the same fashion as CRCP UBCO overlay design.

3.2.4 Type and Performance of Interlayer

HMA is identified as an effective interlayer material with a minimum thickness of 1.25 inches. Existing HMA overlays have been left in place as a bond breaker and as a separation layer on most projects.

On the 6-Foot x 6-Foot x 6-inch experimental overlay, a geotextile fabric was used as the interlayer in one direction of travel and 1.25 inches of new HMA material was used in the other direction.

3.2.5 Construction

For both CRCP and JPCP overlay construction, no special equipment is necessary. Steel placement and concrete paving are the same as for new concrete pavement construction and are done in accordance with Sections 420 and 421 of IDOT's *Standard Specifications for Road and Bridge Construction*.

The basis of payment for concrete overlays is per square yard.

3.3 IOWA DEPARTMENT OF TRANSPORTATION

3.3.1 Description, Performance and Maintenance

The main performance issue for Iowa DOT has been longitudinal cracking associated with widening the new concrete overlay beyond the width of the underlying concrete pavement being overlain. Many of Iowa's old PCC pavements were constructed 18 to 22 feet wide and were widened to 24 feet with then overlain with HMA. Widening adjacent to the existing overlain pavement has been with HMA. Subsequent PCC overlays are typically 28 feet wide to provide for a partially paved shoulder area. Longitudinal cracking has been observed along the widenings and is attributed to heaving during the winter months. When an existing 24 foot pavement is overlaid with no widening the longitudinal cracking issue appears to be minimal. Iowa DOT has tried many different locations for the longitudinal joints and most have had some degree of cracking.

3.3.2 Pre-Treatments

No specific pretreatments were described as part of the survey.

3.3.3 Design of Unbonded Concrete Overlay

For design, Iowa uses multiple procedures including ACPA, BCOA-ME (if they have a thick composite pavement with >6-inches of asphalt), PCA and then compare results to get comfortable with a design thickness. For unbonded PCC overlays of less than 6 inches, Iowa prefers ACPA and BCOA procedures.

3.3.4 Type and Performance of Interlayer

Iowa typically mills on HMA over concrete pavement for quality control as well as bond. They also have experience with dense graded HMA interlayers. Geotextiles have been used by local agencies in Iowa, but not on state DOT projects.

3.3.5 Construction

The typical saw cut pattern is based on the thickness of the overlay. Spacings of 4.5 feet x 4.5 feet or 5 feet x 5 feet has been typical. Iowa has built some projects with 6-foot x 6-foot spacing, especially if the

thickness is 6 inches. The depth and width of the saw cut are 1 ¼ inches deep by 1/8-inch wide. Hot poured asphalt sealant is used for current projects.

Tie bars are used within longitudinal joints. Dowel bars are used across transverse joints in overlays having a thickness of 8 inches and greater. No joint transfer devices are used for thinner overlays. Iowa does not use "structural" fibers (synthetic or steel) in PCC overlays.

The payment method for UBCO is in cubic feet for furnishing and in square yards for placing. Iowa provides construction incentives for smoothness.

3.4 MICHIGAN DEPARTMENT OF TRANSPORTATION

3.4.1 Description, Performance and Maintenance

UBCO's have been used in Michigan with varying degrees of success. US-23 in Livingston County has an overlay approaching 20 years of service with very little distress identified and continues to provide a good quality ride.

Conversely, an unbonded overlay constructed on Interstate 95 near Jackson required replacement after only 15 years of service. When reconstructed it was observed that the HMA interlayer was stripped of asphalt. The stripping of the asphalt is attributed to insufficient vertical drainage at the lane/shoulder interface and is thought to be a contributor to the early distress.

There were no survey responses regarding maintenance of unbonded concrete overlays.

3.4.2 Pre-Treatments

No specific pretreatments were described as part of the survey.

3.4.3 Design of Unbonded Concrete Overlay

For typical unbonded PCC overlays the Michigan DOT design procedure is to use DARwin software which is based on the AASHTO 1993. Michigan DOT does not have a design procedure for unbonded overlays less than 6 inches deep, and the Michigan DOT currently does not construct unbonded concrete overlays less than 6 inches in depth.

1-inch diameter smooth dowels are standard for PCC overlays 6 inches to 8 inches thick.

MDOT has not used structural fibers for unbonded PCC overlays greater than 6 inches. Some experimental use of non-structural synthetic has been implemented for thin concrete BCOA overlays.

3.4.4 Type and Performance of Interlayer

Michigan DOT used dense graded HMA as an interlayer from 1984 to 2003 on all PCC overlays. Presently it is a project by project decision to use either a dense or open graded HMA, where the

existing pavement condition and drainage are considered. The state began using open-graded asphalt interlayers in 2003 to address failures on previous overlays where stripping/scouring of HMA interlayer led to cracking distress. The open graded HMA with drains is believed to limit water ingress into the base therefore is preferred on pavement exhibiting freeze-thaw distresses prior to overlay.

MDOT has performed profile milling on composite pavement sections for grade control with some projects receiving an additional 1-inch thick HMA overlay after milling.

Michigan has constructed two small experimental sections using geotextile fabric as an interlayer. Geotextile fabric was used on a local agency project and within a 600' foot long test section on a state project in 2013. A second geotextile interlayer experimental section on a state route was installed in 2019. These test sections are being evaluated in relation to open-graded interlayers used as a standard on projects.

The original interlayers installed prior to 2003 were dense-graded very sandy HMA mixtures. After stripping of the interlayer was identified as the root cause of distress on some projects the use of a drainable open-graded HMA interlayer was adopted in 2003 and continues to be used on most projects. The minimum thickness for the HMA interlayer is 1 inch. It has been observed that thicker dense-graded HMA interlayers could be unstable and subject to shoving and punching. For most projects the target thickness is a uniform 1 inch with wedging to address crown or superelevation corrections generally made up by the PCC overlay. Some projects allow the interlayer thickness to be variable to accommodate surface variations as the specifications require a smooth and uniform HMA surface.

3.4.5 Construction

Saw cut patterns are typically based on the thickness of the overlay. 6-inch to 8-inch thick concrete overlays are typically cut to be 12 feet by 12 feet which covers most PCC overlays constructed in Michigan. The depth and width of the saw cut are 1 3/8 inches to 1 ½ inches deep by ¼-inch (plus or minus 1/16-inch) wide. Backer rods are used per sealant depth, and hot poured sealant is used for current projects. A neoprene joint sealant was the standard until approximately 2003.

The method of payment is in cubic yards.

3.5 MINNESOTA DEPARTMENT OF TRANSPORTATION

3.5.1 Description, Performance and Maintenance

In general, UBCO's are some of the best performing and longest lasting pavements in Minnesota. They have been constructed for over 30 years with great success, owing to the strong foundation beneath them. They generally require little maintenance, and are maintained using standard concrete pavement repair techniques.

3.5.2 Pre-Treatments

No specific pretreatments were described as part of the survey.

3.5.3 Design of Unbonded Concrete Overlay

In the past UBCOs have performed very well in Minnesota's extreme climate. MnDOT has developed and is using their own design procedure, MNPAVE RIGID. MnDOT is the lead state on a pooled fund that has recently developed a new UBCO design procedure named "UBOLDesign". [3]

For UBCO when the overlay is thicker than 6 inches, dowel bars are typically used across transverse joints and tie bars are installed across longitudinal joints.

Synthetic fibers have been used experimentally in MnROAD test sections in quantities that provide various residual strengths according to ASTM C 1609.

A Life Cycle Cost Analysis (LCCA) is performed to determine if an Unbonded Concrete Overlay of Concrete Pavement is an economical option.

An unbonded concrete overlay is a feasible rehabilitation alternative for PCC pavements for nearly all conditions. The following are conditions where a PCC unbonded overlay would not be considered feasible:

1. The amount of deteriorated slab cracking and joint spalling is not large and other alternatives such as CPR would be much more economical.
2. Vertical clearance of bridges is inadequate for required overlay thickness.
3. A thicker overlay may necessitate added costs due to raising signs and guardrails as well as flattening side slopes and making side road connections, or is within an urban design section with curb and gutter.
4. The existing pavement is susceptible to large heaves or settlements.
5. Alignment changes resulting in short overlay segments.

Where the above conditions occur infrequently or in discrete short segments accommodations can be made such as transitioning to removals and or a deeper full-depth concrete section.

Unbonded overlays are not intended to bridge localized areas of non-uniform support.

For severely deteriorated concrete pavement with major structural deficiencies and other durability related problems that can cause future problems in the overlay, fracturing the existing pavement is considered for achieving uniform support and elimination of reflective cracking.

[3] Development of an Improved Design Procedure for Unbonded Concrete Overlays, Report 2020-08, February 2020

3.5.4 Type and Performance of Interlayer

MnDOT has used a range of interlayer types on projects that include milling of an existing HMA overlay to control quantity and cross slope grades or use of non-woven geotextile fabrics specified at 14.7 oz. or greater per square yard of material. As an infrequent alternative, where a new bituminous interlayer is deemed appropriate, a 1-inch minimum thickness open graded HMA may be used. Some recent projects, utilizing a milled HMA surface as the interlayer, incorporated strips of geotextile placed only under the dowel bar baskets to provide an outlet for water to be directed to the shoulder edge or subsurface drainage.

3.5.5 Construction

Unbonded PCC overlays are used to rehabilitate distressed PCC pavements and consist of a new concrete layer, typically 7 to 8 inches deep. Joint standards call for sawcuts to be perpendicular to the roadway centerline spaced 15 feet for overlays 7 inches deep and greater.

The payment method for UBCO is in cubic yards up to 102 percent of the planned quantity. The payment method for geotextile fabric bond breaker interlayer is in square yards.

3.6 MISSOURI DEPARTMENT OF TRANSPORTATION

3.6.1 Description, Performance and Maintenance

Unbonded PCC overlays have been built in Missouri since the 1930's on an infrequent basis. Although a dozen or more projects were built before 1990 on the state system, they had all long since been either replaced or overlaid with HMA. The designs varied and there was never any attempt to standardize the method. They were usually short sections.

A well performing overlay project was located at I-44 WB in Greene-Webster Counties. The overlay was constructed in 1999, and it is MoDOT's oldest 8 inch UBCO and is still in very good condition. The current average international roughness index (IRI) is in the 70 inches/mile. Since completion, only a handful of patches have been placed along the 5+ mile long project.

Another well performing overlay project was located at Route D in Kansas City. Constructed in 2008, it was the first UBCO in the country that employed a geotextile for an interlayer. The existing 8 inch concrete pavement was badly D-cracked. The performance at ten years has been excellent so far with less than 2 percent of the 6-foot x 6-foot panels showing any distress along the 3.5 mile 2-lane corridor.

A poor performing UBCO was located at Interstate 35 in Daviess County. Constructed around 2005, this 8 inch UBCO with a 15-foot joint spacing had early age cracking. The early age cracking was attributed to factors such as the new 1-inch HMA interlayer being placed on an old 9-inch JRCP where the asphalt stripped from the aggregates. Additionally, a 2-foot widened slab was constructed over unstabilized shoulders with no dowels for load transfer being utilized. However, the poor performing Interstate 35 UBCO was fixed in 2013-14 under a repair contract that included full depth slab replacements, cross-

stitching and sawing into smaller 6-foot x 7.5-foot and 8-foot x 7.5-foot panels. The repair project received national ACPA CPR award[4].

For panel replacement, MoDOT has not used anything other than conventional cementitious-based patch materials.

To mitigate early age cracking on a few projects with full-size UBCO panels (15-foot joint spacing), the panels have been sawed into 'big block' sizes (ex. 6 feet x 7.5 feet). This technique seems to be working well as in the above Interstate 35 example description.

3.6.2 Pre-Treatments

No specific pretreatments were described as part of the survey.

3.6.3 Design of Unbonded Concrete Overlay

For the design procedure, MoDOT uses the Mechanistic Empirical Pavement Design Guide (MEPDG) as the basis for thicker (8 inches+) UBCO's. For thin UBCO's, MoDOT has constructed several 5-inch – 6-inch 'big block' overlays based on the nationwide design recommended practices.

Joint spacing is 15 feet for overlays 8 inches and greater in thickness, 6 feet x 6 feet spacing is used for 5-inch to 8-inch overlays.

3.6.4 Type and Performance of Interlayer

MoDOT has used HMA and geotextile as interlayers in constructing UBCO's.

As stated above, the geotextile interlayer worked well in the Route D project in Kansas City. Along the reported poor performing concrete overlay constructed on Interstate 35 in Daviess County in 2005, and other projects, an HMA interlayer was used. For that project the HMA mix type was not specified. Early age cracking was observed and attributed at least in part to stripping of the asphalt from the aggregates in the 1-inch HMA interlayer. Missouri believes requiring an HMA layer with a mix design, and potentially including the use of hydrated lime as an anti-stripping agent as part of the design, provides less susceptibility to the stripping of the HMA interlayer that has been observed and longer lasting unbonded concrete overlays.

3.6.5 Construction

The typical saw cut has a width of 1/8-inch to a depth 1/3 the thickness of the overlay. No sealants are used in joints.

[4] http://www.acpa.org/wp-content/uploads/2016/01/ACPA-Announces-2015-Excellence-Awards.pdf

Dowel bars and tie bars are used across transverse and longitudinal joints having a thicknesses of 8 inches and greater. No joint load transfer devices are used for thinner overlays.

If existing bridge clearances do not accommodate the UBOL thickness, then either (1) the existing pavement will be milled to the required depth, if it doesn't compromise the overall pavement structure, or (2) the existing pavement will be replaced with conventional concrete pavement on base until reaching an appropriate transition length upstream and downstream of the bridge.

At bridge ends and project termini, if the existing pavement cannot be milled to a depth that accommodates the overlay thickness without compromising the overall pavement structure, then the existing pavement will be replaced until reaching a point where it can instead be milled to the UBCO depth.

The payment method for UBCO is in cubic feet for furnishing and in square yards for placing.

3.7 NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

3.7.1 Description, Performance and Maintenance

The oldest UBCO overlay in North Dakota is 10 years old. The overlay is preforming well with no maintenance required. The UBCO was 7 inches thick, placed on milled existing HMA.

The survey responses did not indicate any poorly performing overlays.

3.7.2 Pre-Treatments

No specific pretreatments were described as part of the survey.

3.7.3 Design of Unbonded Concrete Overlay

For the design procedure, North Dakota uses the Mechanistic Empirical Pavement Design Guide (MEPDG) for UBCO's.

For overlays that are 7" to 8" thick a standard 15' joint spacing is installed with dowels. Longitudinal joints use tie bars. No reinforcement is used for overlays 6" thick or less.

Sawcuts are 1/8 to 3/16 wide to a depth of T/3. Joints are sealed with hot pour asphalt material.

3.7.4 Type and Performance of Interlayer

North Dakota uses dense graded HMA as an interlayer for constructing UBCO's. The survey responses did not indicate whether the interlayers affect the performance of the overlay, nor did the responses indicate any performance issues with the interlayers used.

3.7.5 Construction

The payment method for UBCO can be by cubic yards or square yards and is project dependent.

3.8 WISCONSIN DEPARTMENT OF TRANSPORTATION

Wisconsin has not use unbonded concrete overlay treatments.

CHAPTER 4: CONCLUSIONS AND RESEARCH TO CONSIDER

Unbonded concrete overlays have a successful history as a rehabilitation technique for distressed concrete pavements within NRRA member states. This project provides a brief technical document synthesizing design, construction, maintenance, best practices, and performance observations of unbonded concrete overlays within NRRA member states.

This brief summary provides a concise document with specifications and possible innovations other States may find useful. Any inconsistencies or contradictions in experience and understanding of best practices that are recognized can be discussed and further evaluated.

Topics for additional research to consider include:

- Potential durability issues caused by saturated fabric interlayers
- How best to deploy transverse joints when constructed on fabric interlayers (very little friction to engage concrete shrinkage)
- Determine how faulted the old PCC can be while still using a fabric interlayer without worrying about this distress reflecting up through the new PCC overlay

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