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National Road Research Alliance

Concrete Pavement Restoration for Bonded Concrete Overlay of Asphalt Synthesis

NRRA PREVENTIVE MAINTENANCE TEAM

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16. Abstract (Limit: 250 words)

Bonded concrete overlay of asphalt (BCOA) pavements, also known as whitetopping, can help enhance the structural capacity and rideability of existing asphalt pavement. In this report, the generic term “BCOA” is used to describe all overlays that are between 3-inches and 7-inches thick and placed on an asphalt layer a minimum of 3-inches thick. BCOA is typically designed for a 20-year design life. Rehab should be considered when the distresses in a BCOA are causing ride quality issues or the panels have deteriorating cracks. Agencies have generally utilized concrete pavement restoration (CPR) techniques used for standard concrete pavements on grade to repair such overlays. However, these techniques may or may not be the appropriate repairs to address similar distresses in BCOA pavements. Over the past decade, the popularity of BCOA pavements has grown in many states and many of these projects are now reaching an age where rehab is needed. This has prompted the National Road Research Alliance (NRRA) to compile a synthesis of current practices of repairs being used on BCOA projects by the contributing state agencies. The most common type of repair of a BCOA pavement is to conduct a full-depth removal and replacement of the concrete panels when the area of distresses is localized. The main supporting factor is the BCOA pavement has such a thin overlay that it is more cost effective to perform this type of rehabilitation method as compared to the others.

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Concrete Pavement Restoration (CPR) for Bonded Concrete Overlay of Asphalt (BCOA)

FINAL REPORT

Prepared by:

Andrea Blanchette, P.E.
Sheue Torng Lee
Tom Wood
WSB

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Prepared for:

NRRA Preventive Maintenance Team

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CHAPTER 1: BACKGROUND

1.1 INTRODUCTION

Bonded concrete overlay of asphalt (BCOA) pavements, also known as whitetopping, can help enhance the structural capacity and rideability of existing asphalt pavement. Historical references often considered two types of BCOA pavements: thin whitetopping (TWT) pavements and ultra-thin whitetopping (UTW) pavements. The *National Cooperative Highway Research Program (NCHRP) Synthesis of Highway Practice 338: Thin and Ultrathin Whitetopping* defined TWT as a concrete bonded overlay pavement that is greater than 4-inches but less than 8-inches thick and UTW as a concrete bonded overlay pavement that is 2-inches to 4-inches thick (National Academies of Sciences, Engineering, and Medicine, 2004).

Recently, there has been a trend toward referring to these systems either as "whitetoppings," or "bonded concrete overlays" or "unbonded concrete overlays," defined according to whether they consider the underlying asphalt to contribute to reducing structural stresses in the overlay. In this report, the generic term BCOA (bonded concrete overlay of asphalt) is used to describe all overlays that are between 3-inches and 7-inches thick and placed on an asphalt layer with a minimum of 3-inches thick. Typically, BCOA has a design life of approximately 20 years (Han, 2005) depending on traffic and climate. Rehab should be considered when the distresses in a BCOA are causing ride-quality issues or when the panels have deteriorating cracks.

Typical load-related distresses observed on BCOA pavements include transverse cracking on larger-sized panels, longitudinal or diagonal cracks on medium-sized panels, corner breaks on smaller-sized panels, and reflective cracking from the underlying asphalt pavements (Sachs & Vandenbossche, 2013). Joint faulting is also one of the main distresses in BCOA, and this distress is mainly caused by truck traffic and vertical temperature gradients (Mateos et al., 2019). A study performed by the University of California Pavement Research Center (UCPRC) discovered that the loss of load transfer efficiency (LTE) in some of the joints of BCOA sections was the main concern. The loss of LTE happened in sections with larger joint spacing (12 x 12 slabs) or in sections where the asphalt base was too thin (2 inches) or in bad condition (presence of fatigue cracking or delamination).

To repair such overlays, agencies have typically utilized concrete pavement rehabilitation (CPR) techniques used for standard concrete pavements on grade. However, these techniques may or may not be the appropriate repairs to address similar distresses in BCOA pavements.

This report focuses on the different repair techniques that have been applied to BCOA pavements or similar concrete overlay sections. The general performance of such BCOA repairs has been included in this report. Performance data collected includes the improvements and extension of service life, and costs related to the type of repair. Other related information gathered under this synthesis includes time taken for the existing distresses to reflect through. A literature review on the repair of BCOA has also been summarized in this report.

1.2 WHY NRRA MEMBERS WANTED THIS

1.2.1 NRRA Members Involved

There are eight state agencies that participated in the repair of BCOA synthesis: the California Department of Transportation (Caltrans), Illinois Department of Transportation (DOT), Iowa DOT, Michigan DOT, Minnesota DOT, Missouri DOT, North Dakota DOT, and Wisconsin DOT.

1.2.2 Why This Effort Was Undertaken

Concrete pavement restoration (CPR) techniques have been used widely to repair traditional concrete pavements, but these techniques may be or may not be applicable to BCOA. Over the past decade, the popularity of BCOA pavements has grown in many states and many of these projects are now reaching an age where rehab is needed. The purpose of this project is to compile a synthesis of current practices of repairs being used on BCOA projects by the contributing states.

CHAPTER 2: SURVEY RESULTS

A preliminary online survey was distributed across the agencies to collect information on repairs of BCOA. A follow-up survey was distributed to agencies that had experience in repairing BCOA to gather the type of repairs and the performance.

The first survey questions distributed were as follows.

1. Are there any BCOA constructed roadways or test sections in your state?
2. If yes, have you needed to repair the BCOA?
3. If yes, what type of repairs have been completed?
4. Why were repairs needed (e.g. construction errors, fatigue, etc.)?
5. Does your agency have any standard plates or specifications on the repair?
6. Are there any performance measurements being conducted on the repair?
7. If yes, what type of performance measurements have been collected?
8. Do you know of any other agencies that will be able to provide information on this research topic synthesis?

The follow-up survey questions were as follows.

1. Can you expand or provide more details such as locations and/or pictures of the BCOA repair work?
2. What was the cost of the repair?
3. What improvements were done and what is the anticipated extension of service life?
4. Do you have any performance measurements such as ride data before and after the repair on these sections?
5. What is the amount of time before the distresses starting to resurface after the repair?
6. In your opinion, what would be the best time to apply the repair work?

Responses that were not included in this section of the report can be found in the Appendix.

2.1 IOWA

The projects in Iowa are typically considered as unbonded concrete overlays, however, the interlayers are thick enough to behave like BCOA pavements, which justify their consideration as BCOAs. Thus, repairs are equitable. Most of the projects in Iowa have been built just within the last 10 to 15 years, so there have been few distresses to date related to long-term performance or fatigue that have required repair or rehabilitation. However, a few projects have developed relatively early-age cracking related to design and construction issues.

These distresses are not always prevalent throughout entire projects and/or sometimes confined to isolated areas, so they do not always appear to have a significant impact on pavement performance measurements such as Pavement Condition Index (PCI) and International Roughness Index (IRI). However, in some cases they have been significant enough to require repairs to maintain the overlay in good condition.

Iowa Infrastructure Condition Evaluation Highway Planning Report 2015-2016 stated that "PCI is a numerical index developed by the United States Army Corps of Engineers and used to indicate the condition of pavement. The index is based on a field survey of the pavement and is expressed as a value between 0 and 100, with 100 representing excellent condition." IRI is a "numerical roughness index that is commonly used to evaluate and manage road systems. It is calculated using measured longitudinal road profile data to determine units of slope of a roadway segment." The higher the IRI, the rougher the road.

2.1.1 U.S. 18 and U.S. 65

The most common distress that has been observed on several BCOAs in Iowa is longitudinal cracking in the outer wheel path and/or paved shoulder. This cracking has been observed in overlays with integral widening. When it occurs, this cracking usually appears within the first few years of service. An integral widening is a 2- to 3- foot widening of the mainline slab which helps to decrease edge stresses. The widenings are generally tied to the mainline overlay and constructed with increased thickness. Examples of this cracking are shown in **Figure 2.1** and **Figure 2.2.**

Figure 2.1 Longitudinal cracking in thin overlay with widening (Source: Kevin Merryman, Iowa DOT).

The longitudinal cracking is sometimes isolated to individual panels in the outer wheel path, but also sometimes runs continuously through a series of panels and extends into panels closer to the centerline.

In some cases, the existing pavement was a composite pavement with an 18-foot-wide original Portland cement concrete (PCC) pavement and then an asphalt overlay that itself had widening units on either side, and the concrete overlay was then widened further. It should also be noted that this issue has also been observed in both thin and thick unbonded overlays with integral widening as well in Iowa.

Figure 2.2 Longitudinal cracking in thin overlay with widening (Source: Kevin Merryman, Iowa DOT).

For the most part, these longitudinal cracks are not severe and have not appeared to have much impact on PCI and/or IRI values measured for these overlay projects. However, most of these projects are still at an early age, so the condition of the overlays and cracked slabs must be monitored. On some of the relatively older projects, patching efforts have begun in some areas where cracks are beginning to spall and/or cause deterioration at joint intersections. Some details on the projects that have been patched in recent years are shown in **Table 2.1**.

Table 2.1 U.S. 18 and U.S. 65 project details.

Project	U.S. 18	U.S. 65
Location	Chickasaw/Fayette County	Worth County
Construction Year	2011	2009
PCC Overlay Thickness	4 inches	5 inches
Panel Size	5 feet by 5 feet	4.5 feet by 4.5 feet
Existing Pavement Thickness	6-10 inches of asphalt over old 7 inches of PCC	5 inches of asphalt over old 7 inches of PCC
Annual Average Daily Traffic (AADT)	1,800 - 3,050	2,660
Percent of Trucks	22% - 33%	13%

On these projects, patching has been performed to the original depth of the overlay within individual panels or partial width of panels. These overlays are largely still in good condition, so the goal is to preserve condition and prevent distresses from becoming disruptive. A few examples of areas being prepared for patching on the U.S. 18 project are shown in **Figure 2.3** and **Figure 2.4**. Although the two projects highlighted (U.S. 18 and U.S. 65) are not typically considered as BCOAs, the significant thicknesses of the HMA interlayers justify their consideration as BCOAs.

Figure 2.3 Example of patch area on U.S. 18 Project (Source: Kevin Merryman, Iowa DOT).

Figure 2.4 Example of patch area on U.S. 18 Project (Source: Kevin Merryman, Iowa DOT).

The U.S. 18 project repairs were done by contract and were spread out over the 19 total miles of the overlay project. While the total project cost for all of the repairs (including mobilization, flagging, pavement markings, etc.) totaled $300,110, a breakdown of more specific line items are as follows: For full depth finish patching there were 599 square yards at a unit price of $160.05 per square yard. For full depth finish patching (50 feet or greater in length) there were 88.9 square yards at a unit price of $227 per square yard. For full depth patching by count, there were 206 at a unit price of $109.82 per patch.

The U.S. 18 project has maintained stable ride quality in its most recent performance measurements from the Iowa Pavement Management Program (IPMP). The IRI in 2016 was 72.6 inches per mile and in 2018 was 76.0 inches per mile. PCI improved slightly over that time, from 82 percent to 86 percent. This improvement may be related to the repairs, as a decrease in longitudinal cracking and increase in count of patched slabs were observed in the IPMP data. Overall the cracking and repairs do not appear to have a major impact on ride quality, but patching activities may have helped improve PCI.

Only a small amount of patching appears to have been completed on the U.S. 65 project between 2016 and 2018. Most of the patches were in the outer 3 feet of the driving lane adjacent to the integral widening, so in the course of this patching they established an additional longitudinal contraction joint over the point at the painted edge line. This saw cut was placed at sufficient depth to ensure that the existing tie bar at the bottom of the PCC overlay would be completely severed.

While the total project cost for all of the repairs on US 65 (including mobilization, flagging, etc.) totaled $102,240.50, a breakdown of more specific line items are as follows: For full depth finish patching there were 337.9 square yards at a unit price of $225 per square yard. For full depth patching by count, there were 80 at a unit price of $100 per patch.

Performance of the U.S. 65 project has followed a stable trend, with IRI and PCI values of 85.4 inches per mile and 83 percent in 2016, and 90.4 inches per mile and 79 percent in 2018. That said, an increase in longitudinal cracking was measured between 2016 and 2018. The next data point on U.S. 65 may help indicate whether the patching might improve PCI or ride quality.

These repairs have only been done in recent years, so traffic levels have been stable, and the repairs are believed to be in good condition. Iowa DOT is considering adjustments to its widening designs to prevent this cracking from occurring in future projects, including placing special backfill underneath the widening or not placing a tie bar at the joint between the overlay and widening unit.

2.1.2 IA 175

In a few cases, significant cracking has occurred on BCOA projects in Iowa in areas of the overlay that were constructed thinner than designed. The most prominent example of these distresses has been on IA 175 in Sac County. The details of the project can be found in **Table 2.2**.

Table 2.2 IA 175 project details.

Project	**IA 175**
Location	Sac County
Construction Year	2006
PCC Overlay Thickness	4.5 inches
Panel Size	7 feet by 7 feet
Existing Pavement Thickness	4 inches of asphalt over old 7.5 inches of PCC
AADT	1,860
Percent of Trucks	25%

Examples are pictured in **Figure 2.5** and **Figure 2.6**. Note that the overlay is as thin as 3 inches (compared to 4.5-inch design thickness) in some areas where it has been removed. These thin areas were primarily concentrated in the portion of the project near the City of Odebolt. Similar isolated cracked slabs have been observed in thin spots in a short overlay project on Washington Street in the City of Iowa Falls as well.

Slab cracking was severe in these thin areas, so patching was required to improve the condition of the pavement. Since the overlay had been constructed too thin in these locations, an additional amount of asphalt had to be removed so that the patched portion of the overlay could be placed back at the design thickness. However, in areas where thickness was not a problem, only the overlay was patched.

Figure 2.5 Distressed area and overlay removal on IA 175 project (Source: Kevin Merryman, Iowa DOT).

Figure 2.6 Removal showing thin area in overlay on IA 175 project (Source: Kevin Merryman, Iowa DOT).

The IA 175 project repairs were done by contract and consisted of both full depth and partial depth patching and was a spot repair concentrated in one area of the project. While the total project cost for all of the repairs (including mobilization, flagging, traffic control, etc.) totaled $34,773.72, a breakdown of more specific line items are as follows: For full depth finish patching there were 74.7 square yards authorized at a unit price of $184 per square yard. For full depth patching by count, there were 5 authorized at a unit price of $180 per patch. For partial depth patching there were 343 square feet authorized at a unit price of $20.44 per square foot.

As of 2016, the Iowa Pavement Management Program (IPMP) data showed that the IA 175 project had a PCI of 52 percent and IRI of 101.9 inches per mile. By the next measurement in 2018, IRI remained steady at 101.8 inches per mile, but PCI increased to 65 percent with a corresponding decrease in the amount of observed cracking, so patching appears to have improved PCI while ride quality remained stable. These repairs have only been done in recent years, so traffic levels have been stable, and the repairs are believed to be in good condition.

2.1.3 Business Highway 75

One other observed distress in Iowa BCOAs has been cracking at the pavement edge when the overlay is built as an inlay to match existing curb and gutter (**Figure 2.7**). When it occurs, this cracking tends to appear within the first few years of service life. The details of the project can be found in **Table 2.3**.

Table 2.3 Business Highway 75 project details.

Project	Business Highway 75
Location	Le Mars
Construction Year	2017
PCC Overlay Thickness	4 inches
Panel Size	6 feet by 6 feet
Fiber Reinforcement	3 pounds per cubic yard of macrofibers
Existing Pavement Thickness	4-7 inches of asphalt over old 7-9 inches of PCC (varying)
AADT	7100-9500

One of the causes of this cracking may stem from the different movement or restraint at the curb. The overlay was not tied to the existing curb and the existing curb was thicker than the overlay. Half-inch expansion joints have been added in the course of patching and repair. In some areas of this project, no curb was present or the existing curb was removed, and new integral curb was constructed with the overlay. In these areas, no distresses have been observed to date.

Another cause of this cracking may be due to the failure of geotextile fabric installed. The fabric was placed in areas where all existing HMA was milled out or chunked out during milling, which was more common on the outside edges of the pavement. There appeared to be voids underneath the fabric in some areas where cracking occurred, indicating the fabric may have been too thick in these areas to properly cover the existing pavement or relieve stresses. When patching slabs in areas where there had been fabric, in some cases fabric was not replaced, but instead curing compound was used to prevent bond, and in some cases the overlay patch was allowed to bond to the underlying concrete.

Figure 2.7 Longitudinal cracking adjacent to curb along Business Highway 75, Le Mars (Source: Iowa DOT).

2.2 KANSAS

Kansas has only a few bonded thin concrete overlays of 3- to 4-inches thick over roughly 10 to 12 inches of asphalt pavement. Kansas DOT has experienced good results in terms of expected life. For BCOA pavements of 3- to 4-inches thick, the DOT anticipated 10 years of service life and in most situations the BCOA pavements have achieved that. The primary distresses observed include corner breaks and fractured or shattered slabs. According to the DOT, these surface distresses were indications that the BCOA has exceeded its life.

In terms of repairs or rehabilitation of BCOA pavements, the DOT has not done much. In some cases, the DOT has performed patching with asphalt, either full or partial depth with spray patches, as a short-term fix. A long-term strategy that has been considered includes removing the thin concrete overlay, following by milling the existing underlying asphalt (2 to 3 inches) and repaving with a structurally designed hot mix asphalt overlay or a bonded concrete overlay that is a minimum of 6-inches thick with 6 feet by 6 feet panels. However, this strategy is dependent on the situation and distresses which have occurred.

2.3 MICHIGAN

Four BCOA projects were constructed along Patterson Avenue in Grand Rapids from 2006 to 2009, as reported by the Michigan Concrete Association. In 2016, 4-inch deep concrete repairs, which were full panel removal and replacement, were conducted with a majority of the repairs located in the oldest section built in 2006. The size of the panels was 4 feet by 4 feet. There were areas of contiguous panels needing replacement, and those were sawcut to re-establish the 4 feet by 4 feet joint pattern throughout the repair areas. Expansion joints were created in the existing BCOA, and at some locations near or adjacent to the repair areas, due to indications of pressure and expansion caused by unsealed joints. The repairs done were 3.5 percent of the total area of these four BCOA projects. The BCOAs were originally designed for a 20-year life. The repairs were expected to last 8 to 10 years before additional repairs would be needed, essentially preserving the original design life of the BCOAs.

2.4 MINNESOTA

2.4.1 Freeborn County, MN

In 2009, Freeborn County constructed a BCOA on CSAH 46 from Alden to Albert Lea. Paving took place in cold weather. The design called for milling the existing bituminous surface to the correct profile and cross section irregularities, followed by paving with a 6-inch concrete overlay with three dowel bars in the outside wheel path and sawing the joints at a 15-foot spacing.

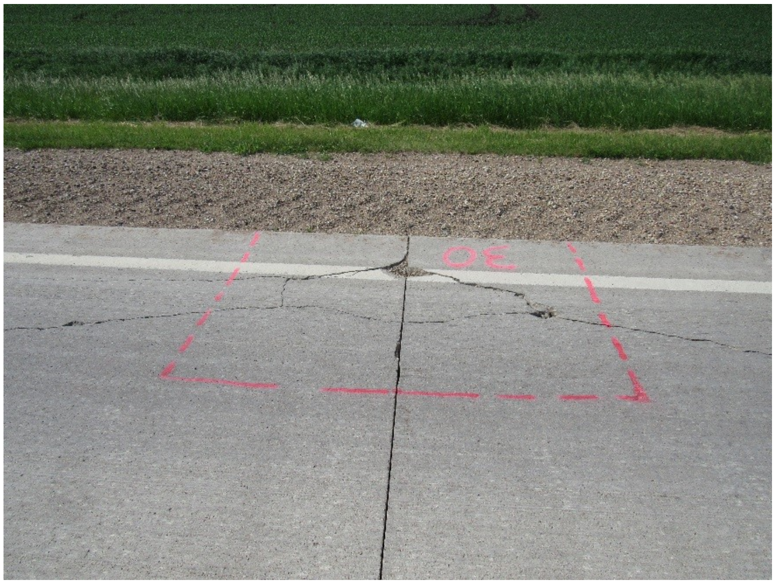

Figure 2.8 Longitudinal cracks observed on BCOA panels (Source: Freeborn County, MN).

Several transverse cracks appeared right after paving and they were repaired in the spring of 2010 with typical concrete pavement full depth repairs. One year after the repair (2011), longitudinal cracks started to form along the inside dowel bar which then migrated to the mid-panel continuing longitudinally down the road each way. In 2014, pressure generated from the summer expansion on areas where dowel baskets were located was causing concrete to break loose at the cracks (**Figure 2.8**).

Figure 2.9 Repairs performed on BCOA panels (Source: Freeborn County, MN).

Repairs were performed by sawing out the bad areas, approximately 2- to 3-feet from each side of the transverse joint, and the corners of the removed area would match to the existing longitudinal cracks (**Figure 2.9**). The full-depth repairs included removing the existing dowel baskets with no replacement, followed by sawing the transverse joint to match the old joint (**Figure 2.10**). This repair project was performed from Alden heading east for about 1.3 miles, with a cost about $75,000 per mile.

Figure 2.10 Full-depth repairs performed on BCOA panels (Source: Freeborn County, MN).

In 2015, the longitudinal cracks had extended the entire length of the road, so the decision was made to cross-stitch and seal the longitudinal cracks (**Figure 2.11**). The plan was to start the repairs from CSAH 14 heading west, repairing approximately one mile of roadway per year in 2015, 2017, and 2018. The pavement has not moved as much in the areas of stitching and the cost was about $100,000 per mile. From the pavement management data in 2018, the international roughness index (IRI) was 80- to 90-inches per mile in the affected area, which was equivalent to a MnDOT Ride Quality Index (RQI) values of 3.3 to 3.5. The ratings indicated the road was in good condition according the MnDOT's performance categories. Due to the thickness of the overlay (6"), standard concrete pavement repair techniques were used.

Figure 2.11 Longitudinal cracks sealed and cross-stitched (Source: Freeborn County, MN).

2.4.2 McLeod County, MN

McLeod County has done repairs to address early joint faulting of BCOA, as well as buckled slabs and cracked panels (**Figure 2.12**). Full width panel replacement was performed as a repair (**Figure 2.13**).

Figure 2.12 Cracked panels on CSAH 7 in Hutchinson, McLeod County (Source: McLeod County, MN).

Figure 2.13 Full width panel replacement on cracked panels as shown in Figure 2.12 (Source: McLeod County, MN).

2.4.3 Olmsted County, MN

Olmsted County experienced faulting of the transverse joints that were caused by high truck traffic (Burnham et al., 2019). The BCOA segment was along CSAH 22 constructed in 2011, with a concrete overlay of 6.5 inches over 8 inches of existing asphalt. The panel size was 12 feet by 12 feet. Coring results showed that the cores exhibited debonding at interface between the concrete overlay and the underlying asphalt.

Due to excessive faulting at transverse joints, this BCOA segment had repairs performed in 2016. Repairs consisted of retrofitting dowel bars and diamond grinding to improve ride quality. Since the thickness of BCOA is thinner than typical concrete pavement, one-inch diameter dowel bars were selected to be used (IGGA, 2017). One-inch diameter dowel bars, due to their smaller size, enables the placement of sufficient concrete cover to achieve effective load transfer at the pavement joints. In order to hold the dowels in place during the backfill operation, they must be fitted with expansion caps and seated in chairs. The repairs were well received by the road users as improvements were recognized after the repairs.

2.4.4 Minnesota Department of Transportation (MnDOT)

MnDOT has experimented with BCOA repairs at MnROAD. Test sections of ultra-thin whitetopping with a panel size of 4 feet by 4 feet were constructed in 1997 at MnROAD. The longitudinal edges of the panels were located along the wheelpaths due to the size of the panel, which resulted in high edge stresses. By November 2003, the corner cracks that developed were severe and extensive. Asphalt patching was performed on the distressed panels during the summer of 2004 (**Figure 2.14**). The ride quality was becoming a concern, thus live interstate traffic was removed from these test sections in 2004 (Burnham, T., 2005).

In 2004, new test sections of 4-inch whitetopping were built at MnROAD, with a panel size of 6 feet by 5 feet. Panels that failed were scheduled for repair in 2011 (**Figure 2.15**) and the causes for the distress were a combination of fatigue cracking due to inadequate overlay thickness and loss of panel bonding with the HMA due to lack of joint seals.

Figure 2.14 BCOA panels, constructed in 1997, failed at MnROAD in 2003 and asphalt patching was performed on the distressed panels in 2004 (Source: MnDOT).

Figure 2.15 Panel replacement performed at MnROAD in 2011 on BCOA panels, which were constructed in 2004 (Source: MnDOT).

Rebars were installed at an angle into the underlying asphalt pavement to aid bonding and strips of roofing fabric was installed to retard reflective cracking (**Figure 2.16**). **Figure 2.17** showed the performance of repair two years later (in 2013). The leading-edge distress on the repaired panel may be caused by the rebar, while the strip of roofing fabric seems to be effective in mitigating reflective cracks.

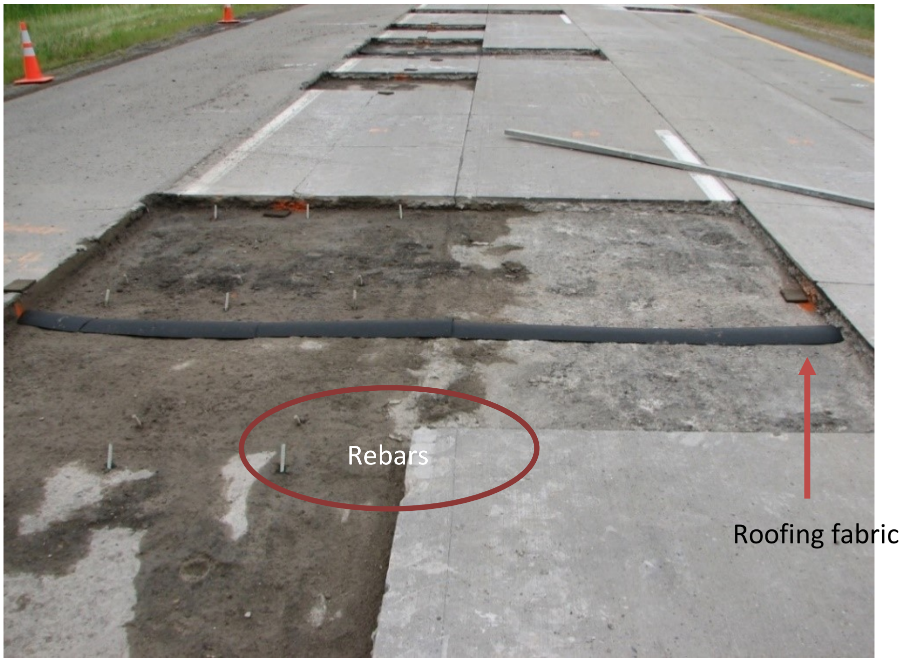

Figure 2.16 Repair included rebars installed into the asphalt to enhance bond, and a strip of roofing fabric placed to mitigate reflective cracks (Source: MnDOT).

Figure 2.17 Performance of repairs after 2 years (Source: MnDOT).

2.4.5 MnDOT District 7

MnDOT District 7 had constructed a BCOA project along TH 30 from County Road 24 E to 518th Avenue near Amboy, MN in 1993. The BCOA pavement was 6 inches of concrete overlay on 4.25 inches of remaining asphalt. The panel size was 12 inches by 12 inches with skewed transverse joints. The 20-year design Equivalent Single Axle Loads (ESALs) were 576,000, with an Average Daily Traffic (ADT) of 385 in 1993 and projected 2013 Heavy Commercial Average Daily Traffic (HCADT) of 110.

Since it was originally constructed, there were a few maintenance and rehabilitations performed on the road. Maintenance patching was performed in 2010 and 2016, while major CPR and diamond grinding were performed in 2012. **Figure 2.18** showed pavement performance in terms of Ride Quality Index (RQI) and Surface Rating (SR) obtained from MnDOT District 7. RQI has a scale of 0 to 5, which higher RQI represents smoother road. SR is determined based on the pavement distresses and it ranges from a 0 to 4 scale. A higher SR represents road in better condition. Both RQI and SR have terminal values of 2.5. *MnDOT 2019 Pavement Condition Annual Report* stated that "Pavements are normally designed for a terminal RQI value of 2.5. When a road has reached its terminal RQI value it does not mean the road cannot be driven on, but rather that it has deteriorated to the point where most people feel it is uncomfortable and a major rehabilitation is likely needed."

The major CPR and diamond grinding conducted in 2012 improved the ride quality of the BCOA pavement to above the threshold of 2.5 for a few years before needing another minor repair (maintenance patching).

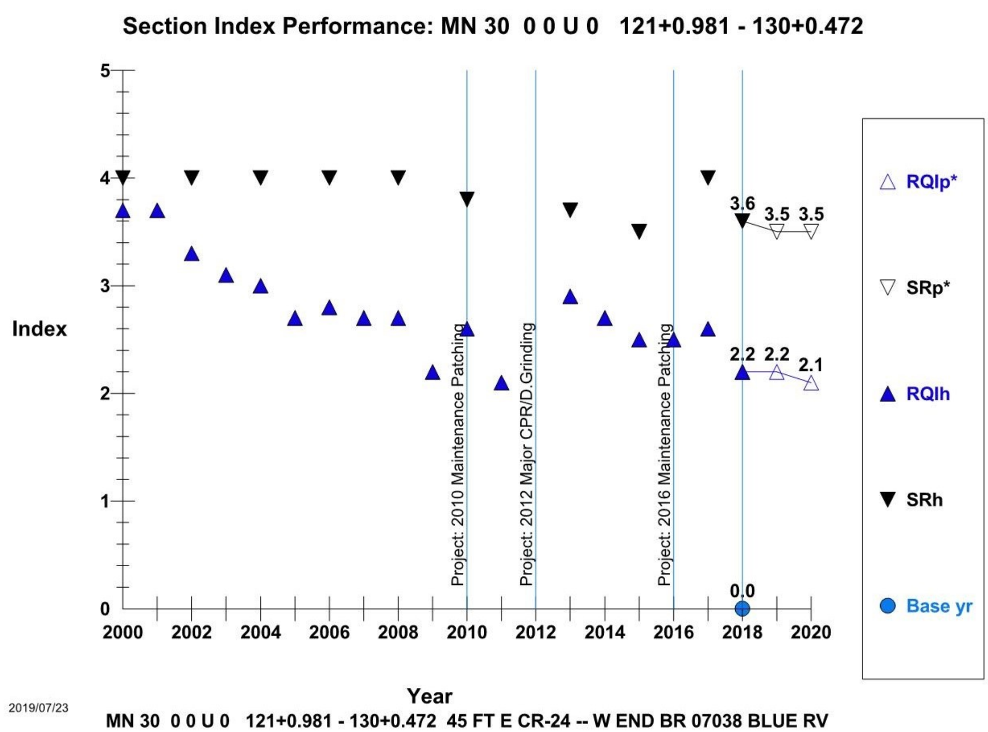

Figure 2.18 Pavement performance along TH 30 obtained from MnDOT District 7 (Source: MnDOT District 7).

2.5 MONTANA

Information on the repairs performed on BCOA were gathered in a combined effort of reviewing reports published as well as sending follow up email to the Montana DOT to obtain more details on the repairs.

2.5.1 Glendive, Montana

Highway 16 was rehabilitated in 2001, which involved placing 4 inches of concrete overlay over milled asphalt. The underlying existing asphalt after milling was 4-inches thick in average, which was the minimum asphalt depth as stated in the specifications. Polypropylene unfibrillated fibers were added to the PCCP mix to mitigate the development of cracks. The average joint spacing was 4 feet minimum with a maximum of 5-feet joint spacing.

Multiple panels at the north end and south end of the project were selected for repair. There were various causes for the development of cracks. Areas where cracks formed near curb edges might be due to the lack of support, and the turning motions of heavy trucks would have aggravated the issue. Cracks were initially recorded in 2002 and had continually deteriorated until repair was needed in 2005 (**Figure 2.19**).

Figure 2.19 Panels that needed repair in 2005 (Source: Montana DOT).

Repair conducted in 2005 involved the removal of the full depth of BCOA (including the concrete overlay and underlying existing asphalt) and the replacement with full depth PCC pavement. This repair section had been performing well to date from the follow up phone call with the DOT carried out in January 2020. The AADT for the past five years was at 4,380 with 15% truck traffic.

2.5.2 Great Falls, Montana

This whitetopping project was built in fall 1999 in Great Falls, Montana. The project involved the milling of 3.5 inches of existing asphalt followed the paving of 5 inches of concrete overlay onto the milled surface. The underlying existing asphalt after milling was 4-inches thick in average. The panel size was roughly 3 feet by 3 feet. The purpose of placing the whitetopping was to mitigate the effects of heavy rutting

developed on multiple panels (Source: Montana DOT).

and shoving of the existing asphalt pavement at the intersection. Late summer the next year (2000), multiple panels located on the right-turn lane exhibited severe cracking (**Figure 2.20**). The premature failure of the pavement was determined to be support issues where there was too much moisture in the subgrade and the subgrade material was not able to provide support for the structure. In addition to that, the existing asphalt pavement was observed to have extreme stripping issues.

Figure 2.21 Tar paper and rebar installed within the repair area (Source: Montana DOT).

A full depth panel removal and replacement was performed in 2001. Subgrade correction was conducted by removing several feet of the existing subgrade material followed by replacing it with 1.5-inch minus aggregate fill material. Geotextile fabric was installed prior to the placement of the new fill to minimize the contamination of fines into the fill material.

The new PCC slab was about 9 inches deep, which the size led to the decision that this slab could be a standalone, free-floating slab without joints. Bond breaker – tar paper – was used to line the interior of the repair area as shown in **Figure 2.21**. This created a separation between the new slab and the existing BCOA pavement. Number 4 rebar was placed at an 18-inch grid spacing, 4-inch from the base. PCC pavement placed was Type II air-entrained concrete with polypropylene fibers.

A correspondence was sent to the Montana DOT to follow up on the performance of the repair in January 2020. The annual average daily traffic (AADT) for the past five years was at 21,522 with 14 percent truck traffic, no ESAL had been calculated for this corridor. According to the DOT, the repair had held quite well with no distress to date (close to 19 years since the repair). However, the surrounding whitetopping showed distresses mainly along the wheel paths, but even that had yet to reach medium severity.

2.5.3 Kalispell, Montana

This project was performed in Kalispell, Montana in 2000, which consisted of placing 5 inches of fiber reinforced PCC pavement over milled asphalt. The underlying existing asphalt after milling was 4-inches thick in average, which was the minimum asphalt depth as stated in the specifications. The joint spacing was approximately 6 feet by 6 feet, with a saw cut depth of an inch. During construction, there was a small area that exhibited lack of consolidation (**Figure 2.22**).

Figure 2.22 The unconsolidated spot during construction (Source: Montana DOT).

The unconsolidated section was removed. Two alternative repairs were to remove and replace the full depth of BCOA (both concrete overlay and underlying existing asphalt) with PCC pavement or to just replace the layer of concrete overlay with epoxy-coated reinforcing bars installed. The latter (**Figure 2.23**) was selected to promote transfer of loading between the panels. Joints were established the same as prior to removal.

During 2010 evaluation, this repair section was observed to be performing well with no visual distresses observed and exhibiting no faulting or movement of the slab. This repair section had been performing well to date from the follow up phone call with the DOT carried out in January 2020. The AADT for the past five years was at 24,770 with 18 percent truck traffic.

Figure 2.23 Repair performed on the unconsolidated spot (Source: Montana DOT).

CHAPTER 3: REPAIR RECOMMENDATIONS FROM LITERATURE SEARCH

This section contains a summary of repairs and recommendations for BCOA repairs based on a literature search in a chronological order. Note that these rehab recommendations were based on the period when the repairs had been done and may have changed over time as experience has been gained.

3.1 REPAIR OF ULTRA-THIN WHITETOPPING (PA397P), AMERICAN CONCRETE PAVEMENT ASSOCIATION (ACPA), 2000

Repairs of UTW (defined in the ACPA guide as 2-inches to 4-inches thick BCOA), are usually full panel replacement, using a process similar to repairing traditional concrete pavement but without the installation of load transfer devices such as smooth dowel bars. Below is a summary of procedures to repair UTW pavements.

1. Identify panels that need to be removed. Cracks in the panels do not warrant a repair, however, if the panels have broken up and start moving, repairs are required.
2. Saw cut the full depth of panels using diamond or abrasive-bladed saws. It should be noted that extra care is needed during the sawing operation so that this operation does not cause damage to the underlying asphalt. In order to prevent damaging the adjacent panels during the removal of panels, a second saw cut approximately six inches inside the panel joint is beneficial in many instances.
3. Remove panels by breaking up the concrete using a jackhammer. A 30 lb. maximum is recommended for interior concrete while a 15 lb. is recommended near concrete joints and repair borderlines. Small front-end loader can be used to remove broken pieces of concrete.
4. Clean patch area by air blasting or sand blasting.
5. Place new concrete mixture and apply curing compound right after the bleed water vanishes.
6. Saw joints to match the adjacent joints. Joints are usually sawed to one-third of the UTW thickness and are 1/8-inch wide.

3.2 PERFORMANCE AND REPAIR OF UTW PAVEMENTS, PROCEEDINGS FROM 7TH INTERNATIONAL CONFERENCE ON CONCRETE PAVEMENTS, JANUARY 2001

New Jersey DOT (NJDOT) constructed a UTW (defined in the conference paper as 2-inches to 4-inches thick BCOA) test section in 1994 with an average concrete overlay thickness of 3.8 inches over an existing asphalt of 6.6 inches average thickness. Visual survey was conducted in 1997 and most of the distresses were observed to be along the longitudinal construction joints. The following year, NJDOT conducted repairs, which most of the areas needed full-depth removal and replacement.

Iowa DOT conducted a joint project with Federal Highway Administration (FHWA) and Iowa State University in 1994 consisting of UTW (BCOA) test sections varied in slab thickness, panel size, preparation of the underlying asphalt surface, and the addition of fibers in concrete. Weigh-in-motion in

1997 recorded an average of 40 Equivalent Single Axle Loads (ESALs) per day northbound and 20 ESALs per day southbound.

Areas where either the panels had broken into four or more pieces or with potential debonding indication were removed and replaced in 1999. Techniques used for the panel removal included:

- Backhoe to remove panels if the removal areas were substantial
- Small front-end loader deemed effective to remove panels as there were de-bonding between the panels and the asphalt layers
- Backhoe to pull out the panels using chains connecting to the metal rods drilled into the panels

There were no distresses observed two years after the repairs.

Figure 3.1 Photos obtained from the report showing the repair work (Source: Sheehan, Sherwood, Tayabji, & Wu, 2001).

The American Concrete Pavement Association (ACPA) had built eight UTW test sections in McLean, Virginia, under a cooperative research agreement with FHWA in 1998. The test sections chosen for repair were along Lanes 6 and 10. Lane 6 was 2.5 inches of concrete overlay over 5.5 inches of underlying asphalt, with 4-feet joint spacing. Lane 10 was 3.5 inches of concrete overlay over 4.5 inches of underlying asphalt, with 6-feet joint spacing.

Load testing was performed utilizing FHWA's Accelerated Loading Facility (ALF) to generate distresses in the test sections in order for different repair works to be conducted and evaluated. The type of distresses observed were corner breaks, longitudinal and transverse cracking, and joint faulting. A total of eight panels were chosen to be removed and replaced (**Figure 3.1**) based on the repairs performed by New Jersey, Iowa, and other states.

ALF load testing was conducted using dual wheels with a gross load of 53.4 kN on the repaired panels eight days after the repair. The first cracks appeared after 66,700 load passes (Lane 6) and 50,000 load passes (Lane 10). The design load repetitions for the test sections were 255,000 and 441,000 for Lane 6 and Lane 10 respectively. At the end of the loading tests, Lane 6 test section was subjected to 400,000 load passes while Lane 10 test section was subjected to 427,000 load passes. Half of the repaired panels exhibited cracks and majority of the cracks were closely held together. Nonetheless, the repaired panels seemed to be performing well.

3.3 PERFORMANCE, ANALYSIS AND REPAIR OF ULTRA-THIN AND THIN WHITETOPPING AT MN/ROAD, MINNESOTA DEPARTMENT OF TRANSPORTATION (MNDOT), 2002

This paper was submitted to the Transportation Research Board for publication and presentation at the 2002 Transportation Research Board Annual Meeting. Repairs were performed on UTW test sections (defined in the report as 2-inches to 4-inches thick BCOA). Majority of the repairs were conducted on panels ranging from 3 inches to 4 inches thick overlay, with a panel size of 4 feet by 4 feet. There were also a few panels on a test section with an overlay 3-inches thick and a panel size of 5 feet long by 6 feet wide being rehabilitated.

Milling of the overlay could be carried out within 6 inches from the edge of the panel to be removed, and this would not disturb the adjacent panels. This technique proved that saw cuts were unnecessary, which saw cuts were initially conducted due to the concerns that the milling machine would disrupt the surrounding panels thus damaging the interlayer bond between the concrete panel and underlying asphalt. Using a milling machine with tungsten carbide teeth could shorten the time of repair in addition to creating a ridged surface that enhances the interlayer bonding between the new concrete panel and the underlying asphalt. Milling was performed beyond one inch of the overlay into the underlying asphalt. If the asphalt at the interface raveled, additional milling should be conducted to provide a sound surface for bonding.

Distressed panels exhibiting corner breaks and transverse cracking could be repaired by removing the panels using a milling machine and chisel-hammers. Reflective cracking could be mitigated by installing a bond-breaker such as duct tape and roofing paper directly over the cracks in HMA and sawing the new joint in the repair panel over the reflective crack.

High-early-strength concrete mixtures were used to fill the repair areas, with one including polyolefin fibers. Sawing of joints to a depth of 1.5 inches to 2 inches was performed using a walk-behind saw. The newly sawcut transverse joints, which were placed to match existing cracks, were not aligned with the adjacent panels in some cases. Thus, longitudinal joints were sawed full depth of the panel and on both sides of the misaligned transverse joints. This would prevent the bonding of the newly replaced panel with its adjacent panels, which bonding may cause the development of cracks from the misaligned transverse joints into the adjacent panels. Low-modulus asphalt sealant was used to seal all the joints. The repair had successfully restored the Present Serviceability Index (PSI) to an acceptable level (PSI=3.1), which the terminal PSI is 2.5.

3.4 THIN AND ULTRA-THIN WHITETOPPING, NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM (NCHRP) SYNTHESIS 338, 2004

Full panel replacement is the repair recommended for UTW (defined in the NCHRP report as 2-inches to 4-inches thick BCOA), and this has been reported as the most common method used for repair from the survey. Fast-setting concrete should be used if early opening to traffic is required so that the impact to traffic could be minimized. Another alternative to repair UTW is epoxy injecting to stabilize loose panels, however, it is expensive and should only be considered if full panel replacement is not an option.

According to the survey in that study, full panel replacement is the most common method used for repairing TWT (defined in the NCHRP report as greater than 4-inches and less than 8-inches thick BCOA), followed by partial slab replacement, joint resealing, and crack sealing. If a panel has failed, a full panel replacement should be performed instead of repairing individual distresses. **Table 3.1** was obtained from the NCHRP report, which summarizes the recommended rehabilitation alternatives for TWT based on the localized distresses; these methods are usually not applicable to UTW.

Table 3.1 Repair alternatives for TWT pavements (Source: National Academics of Sciences, Engineering, and Medicine, 2004).

Distress	Repair Alternatives
Corner cracking	Crack sealing
	Epoxy injection
	Cross stitching
Mid-panel cracking	Crack sealing
Shattered slab	Slab replacement
Joint spalling	Partial-depth repair
Joint or crack faulting	Slab stabilization
	Load transfer retrofit
	Surface grinding

Table 3.1 (continued). Repair alternatives for TWT pavements (Source: National Academics of Sciences, Engineering, and Medicine, 2004).

Distress	Repair Alternatives
Surface wear (poor skid resistance)	Surface grinding
Permanent deformation of support layers	Full-depth repair
Corner debonding	Epoxy injection
Panel debonding	Full-depth repair
	Slab replacement

3.5 REHABILITATION STRATEGIES FOR BONDED CONCRETE OVERLAYS OF ASPHALT PAVEMENTS, UNIVERSITY OF PITTSBURGH, AUGUST 2013

Full-depth patching should be performed only on isolated panels where distresses are encountered. Panels should not be replaced with asphalt materials since there will be bonding issues between asphalt patching and surrounding concrete panels due to the movements of concrete panels. Extra care needs to be taken to repair concrete panels. If removed, a debonding material should be placed over the crack (**Figure 3.2(b)**) in the asphalt surface to break the bond in the immediate area surrounding the crack. **Figure 3.2 (c)** shows that the transverse joint in the repair was sawed directly above the crack. In this case, the longitudinal joints should be sawed full depth to prevent the cracks from developing due to the misaligned transverse joints of the repaired panels and the adjacent existing panels.

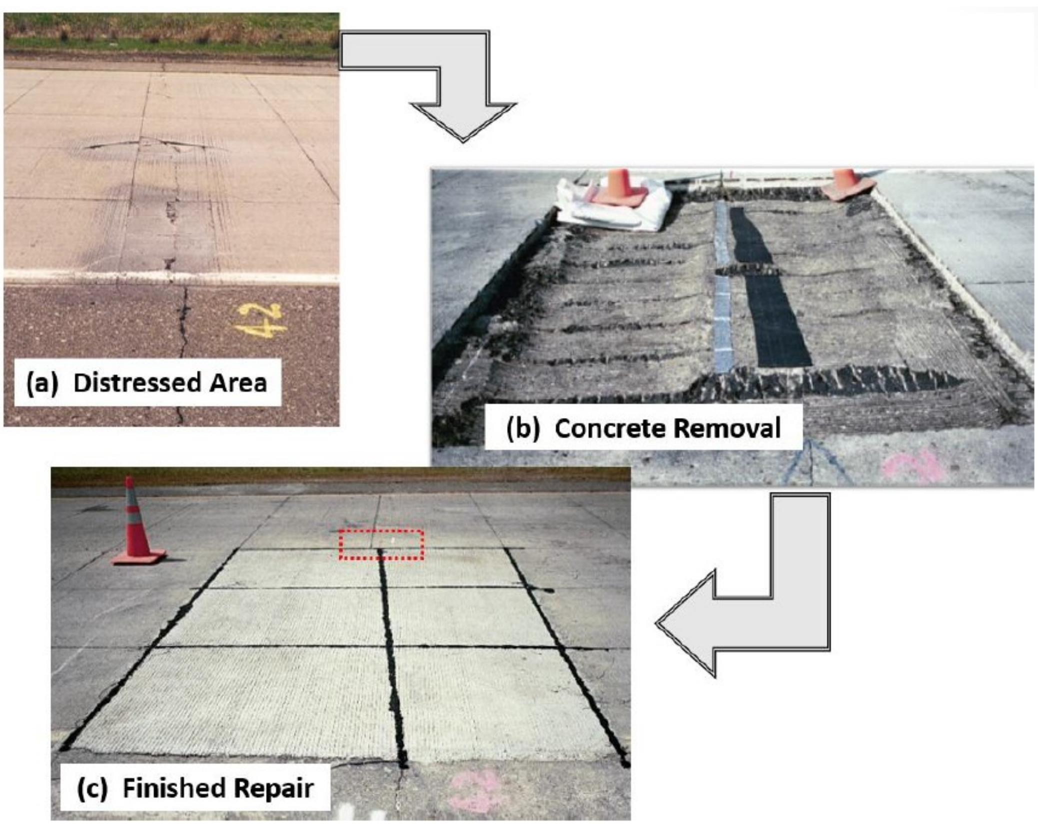

Figure 3.2 Photos obtained from the report showing the repairs done on panels with reflective cracking (Source: Sachs & Vandenbossche, 2013).

3.6 GUIDE FOR CONCRETE PAVEMENT DISTRESS ASSESSMENTS AND SOLUTIONS: IDENTIFICATION, CAUSES, PREVENTION, AND REPAIR, NATIONAL CONCRETE PAVEMENT TECHNOLOGY CENTER, OCTOBER 2018

BCOA defined in this guide as 2-inches to 6-inches concrete overlay that are bonded to at least 3 inches of underlying asphalt. Partial depth repair should be conducted only for longitudinal lane-shoulder joint spall repairs, provided the spalls are shallow and localized.

Removal and replacement of individual panels are ideal for distresses exhibited on isolated panels. If there exists support issues, subbase and subgrade problems need to be addressed. Replacement of asphalt and concrete overlay with full-depth concrete panels is typical in these scenarios. If the distresses are more extensive, it is recommended to remove and replace multiple panels using the mill and inlay methods. This allows for adjustment of jointing patterns to mitigate recurrent cracking patterns.

Diamond grinding has been proven successfully to restore ride and remove joint faulting. However, faulting will resurface if the root cause of faulting is not addressed prior to the grinding operation. If grinding is scheduled more than once in the pavement life, it is a general practice to increase the initial design thickness of the concrete overlay by half an inch or more to accommodate a sacrificial layer. This provides a sacrificial layer to be ground off while maintaining the designed structural capacity of BCOA pavements.

CHAPTER 4: SPECIFICATIONS

Most of the states currently do not have specifications or standard plates written for the repair of BCOA as the agencies typically adopt the rehabilitation methods used for conventional concrete pavement. Texas Department of Transportation (DOT) has a special specification 7183, *Repair of Ultra-Thin and Thin White Topping*, which can be found in the **Appendix**.

The Texas DOT's specification outlined the repair as follows.

- Saw cut the repair area to the full depth of concrete panels. The minimum area of the repair should be 6 feet in length and a half lane in width or as directed.
- Remove the panels without disrupting the surrounding panels.
- Mill one inch into the underlying asphalt layer unless otherwise directed. Additional milling needs to be conducted if the asphalt at the interface raveled, to ensure a rigid asphalt surface for bonding. If a crack is present in the asphalt layer, a bond breaker – duct tape – should be placed over the cracks and extend two inches on each side of the crack.
- Saw and seal all construction joints.
- Unless otherwise shown on the plans, saw contraction joints to a minimum depth of one-third of the concrete overlay or to a minimum depth of one-inch for dry, early saw cuts. Do not seal the saw cuts.
- Opening to traffic may occur once the concrete overlay has been cured for 36 hours and has achieved a minimum compressive strength of 2,800 psi or as directed.

CHAPTER 5: SUMMARY & CONCLUSIONS

Based on the responses from different agencies and the literature review performed, the most common type of repair of a BCOA pavement is to conduct a full-depth removal and replacement of the concrete panels when the area of distresses is localized. The main supporting factor is that the BCOA pavement has such thin overlay (defined as between 3-inches and 7-inches in this report) that it is more cost effective to perform this type of rehabilitation technique as compared to the others. This type of repair has been cross-referenced across different reports found from the literature review.

There are a few typical techniques being followed when carrying out a panel removal and replacement:

- Removal of distressed panels should be conducted in such a way that the milling action does not cause a disruption to the surrounding panels. Saw cut or milling within six inches from the edges of the panels may be beneficial.
- Saw cut or milling of the panels should be full depth of the concrete overlay; a couple sources stated to extend the milling beyond one inch into the underlying asphalt.
- Light jackhammers (i.e., 15 lbs.) can be used to break up the concrete for removal.
- Extra care should be taken to mitigate reflective cracking by placing a bond-breaker directly on the crack and sawing the new joint over the reflective crack.
- Panels should not be replaced with asphalt materials since there will be bonding issues between asphalt patching and surrounding concrete panels due to the movements of concrete panels.
- Fast-setting concrete could be used if the traffic opening time is a constraint.
- In the event where a misaligned transverse joint is created to mitigate reflective cracking, isolation materials such as roofing materials should be placed on both sides of the misaligned joints to prevent the development of cracks from the misaligned joints into the adjacent panels.
- No load transfer device such as dowel bars should be installed during the repair; however, it may be feasible to retrofit dowel bars for repairs of overlays 6-inches thick and greater to address faulting issues. Reinforcing bars are also commonly used in the repairs.
- Contraction and construction joints should be sawed. The joints are typically sawed to a depth of one-third of the overlay thickness.

Some other repair methods include cross-stitch, sealing the longitudinal cracks, and asphalt patching, the former of which is a costly fix and the latter of which is usually a temporary repair. Diamond grinding has successfully removed joint faulting, but it should be noted that faulting will resurface if the root cause of faulting has not been addressed prior to the grinding operation. Most of the state agencies, except for Texas DOT, currently do not have specifications or standard plates that explicitly focus on the repair of BCOA.

If the distresses are more widespread or/and if there are issues with the underlying base or subgrade layer, a more robust rehabilitation method would be required. If a localized repair is chosen by removing and replacing a portion of the underlying poor material with aggregate fill, geotextile fabric can be used as a separation layer to prevent the contamination of underlying material into the aggregate fill. A full-depth concrete repair (extend to the layer below asphalt) is a good alternative if all or most of the asphalt has been removed.

From the literature review, most of the information collected was on the types of repairs and the procedures of conducting a repair. However, there was not much documentation on post-repair monitoring activities of repair performance and the planned or observed life span of repairs on BCOA.

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APPENDIX A: SURVEY RESPONSES

PRELIMINARY SURVEY RESPONSES

1. Are there any Bonded Concrete Overlay of Asphalt (BCOA) constructed roadways or test sections in your state?

All the agencies surveyed have BCOA pavements in their respective state (**Table A.1**).

Table A.1. Responses from agencies on the presence of BCOA in their respective state.

Agency / Organization	Response
Caltrans	Yes
Georgia DOT	Yes
Illinois DOT	Yes
Indiana DOT	Yes
Kansas DOT	Yes
Michigan Concrete Association	Yes
Minnesota DOT	Yes
Minnesota DOT – District 7	Yes
Missouri DOT	Yes
North Dakota DOT	Yes
Pennsylvania DOT	Yes

2. If yes, have you needed to repair the BCOA?

Among all the states surveyed, Caltrans and Indiana DOT have not performed any repair on BCOA pavements (**Table A.2**). However, Indiana DOT has been looking for options as repairs are needed immediately.

Table A.2. Responses from agencies on their experience repairing BCOA.

Agency / Organization	Response
Caltrans	No
Georgia DOT	Not many
Illinois DOT	Yes
Indiana DOT	No
Kansas DOT	A few
Michigan Concrete Association	Yes
Minnesota DOT	Yes
Minnesota DOT – District 7	Yes
Missouri DOT	Yes
North Dakota DOT	Yes
Pennsylvania DOT	Yes

3. If yes, what type of repairs have been completed?

Type of repairs include panel removal and replacement, joint replacement or repair, crack sealing, micro-surfacing, spall repair, and grinding (**Table A.3**). The most common repair among the states surveyed is full depth panel removal and replacement.

Table A.3. Responses from agencies on type of repairs performed.

Agency	Response
Illinois DOT	Individual panels have been removed and replaced with either hot mix asphalt or conventional PCC
Kansas DOT	Included in Section 2.2 of this report
Michigan DOT	Included in Section 2.3 of this report
Minnesota DOT	Joint replacements, full panel replacements, crack sealing with methymethacrylate, joint filling, micro-surfacing, grinding
Minnesota DOT – District 7	Mostly full depth repair
Missouri DOT	Modified full depth concrete, asphalt patching
North Dakota DOT	Panel repair, spall repair, grinding
Pennsylvania DOT	Panel replacement, joint cleaning and sealing

4. Why were repairs needed (e.g. construction errors, fatigue, etc.)?

Multiple factors have contributed to the needs of repairs, which distresses are cracked or shattered panels stemmed from loading, shifting of slabs, construction errors, oversized panels, etc. (**Table A.4**).

Table A.4. Responses from agencies on the reasons that prompted the repairs.

Agency / Organization	Response
Illinois DOT	Mostly shattered slabs due to loading with loose/missing pieces
Kansas DOT	Corner breaks and fractured/shattered slabs
Michigan DOT	Blowups due to shifting slabs from unsealed joints
Minnesota DOT	Construction errors e.g. dowel baskets moved during paving, materials related distress, insufficient slab thickness, slab buckling/blowups
Minnesota DOT – District 7	Multiple reasons
Missouri DOT	Cracked panels from fatigue, instigated by debonding with asphalt layer and water infiltration.
North Dakota DOT	Failing edge drain, oversized panels have cracked, faulting and ride
Pennsylvania DOT	Cracked panels, de-bonded panels, poor lateral support

5. Does your agency have any standard plates or specifications on the repair?

All states surveyed (except Texas DOT) currently do not have any standard plates or specifications specifically on the repairs for BCOA pavements.

6. Are there any performance measurements being conducted on the repair?

Minnesota has collected performance measurements on some of the repairs but not the other states. Missouri DOT has not gathered any performance data but has been monitoring the repair.

7. If yes, what type of performance measurements have been collected?

Minnesota has conducted visual distress surveys and Falling Weight Deflectometer (FWD) testing.

FOLLOW-UP SURVEY RESPONSES

California DOT

BCOA pavements were present but no repairs had been done to the pavements due to their young ages.

Illinois DOT

Individual panels have been removed and replaced with either asphalt or conventional concrete. The types of failure were mostly shattered slabs due to vehicle loadings, with loose or missing pieces.

Missouri DOT

Missouri DOT has seven to eight BCOA pavements, mostly at intersections. There was a 20-year BCOA pavement on US 60 in Neosho, which will be featured in the future NCHRP 01-61 project report. The concrete overlay was 4 inches thick, and with 4 feet by 4 feet panel size. There have been some repairs of these panels with HMA or cold mix. There was another BCOA pavement at the MO 78/291 intersection in Independence, where the DOT performed high early strength full depth repairs at some cracked panels throughout the entire thickness.

APPENDIX B: TEXAS DOT SPECIFICATION

Special Specification 7183
Repair of Ultra-Thin and Thin White Topping

1. DESCRIPTION

Repair damaged Ultra-thin and Thin White topping concrete panels in accordance with the details shown on the plans or as directed.

2. MATERIALS

2.1. **Hydraulic Cement Concrete.** Provide Class K hydraulic cement concrete in accordance with Item 421, "Hydraulic Cement Concrete." Unless otherwise shown on the plans or as directed, design the concrete mix with a maximum water cement ratio **of** *0.45,* Grade No.4 coarse aggregate, and a minimum average compressive strength of 3,000 psi at 24 hr. Test in accordance with Tex-4l8-A, "Compressive Strength of Cylindrical Concrete Specimens."

2.2. **Joint Sealants and Fillers.** Provide joint sealants and fillers in accordance with Section 360.2.7, "Joint Sealants and Fillers."

2.3. **Curing Materials.** Provide membrane curing compound conforming to Section 360.2.4, "Curing Materials."

2.4. **Reinforcing Fibers.** When shown on the plans, provide fibers as follows, unless otherwise approved:

2.4.1. **Synthetic Fibers.** ASTM C 1116-03 Type III, Polypropylene or Nylon, 3/4" to 1 1/2" in length. Mix 3 lb. synthetic fibers for each cubic yard concrete as per manufactures recommendation.

2.4.2. **Steel Fibers.** ASTM C 1116-03 Type I, and certified to meet ASIM A 820-01 Type I, cold-drawn crimped-end wire, 1½" to 2" in length, collated into bundles to facilitate handing and mixing. Mix 30 lb. steel fibers for each cubic yard concrete as per manufactures recommendation. Do not use steel fibers where deicing salts may be used.

3. EQUIPMENT

Provide tools and equipment necessary for proper execution of the work.

4. CONSTRUCTION

Submit a repair plan for approval before beginning operations. Include details of repair method and sequence, joint layout, sawing plan, curing, other details and description of all equipment.

4.1. **Outline Sawing of Repair Area.** Saw cut the perimeter of repair areas as shown on the plans or as directed. Saw cut to the depth of concrete panels. The repair area should be a minimum of 6 feet in length and a half lane in width or as directed.

4.2. **Removing Damaged Panels.** After outline sawing, remove the damaged panels from the center of repair area without disturbing surrounding panels. Additional saw cuts may be required within the repair area to facilitate removal of the concrete.

4.3. **Prepare Asphalt Support Layer.** Unless otherwise directed, mill 1 in into the asphalt layer. If the asphalt at the interface raveled, perform additional milling to expose a solid asphalt surface for bonding to the repair.

Use hammers to remove the ridges which may cause stress concentrations in the concrete overlay. Remove any debris and use compressed air to thoroughly clean the surface.

4.4. When repairing panels with reflective cracks and if after milling, a crack still propagates down into the asphalt layer, place duct tape over the cracks and 2 in beyond each side of the crack to act as bond breaker.

4.5. **Concrete Placement.** Immediately prior to concrete placement, prepare the pavement surface such that the surface is free of all contaminants and material detrimental to achieving an adequate bond between the asphaltic surface and the concrete overlay.

4.6. When needed, place and remove forms in accordance with Section 360.4.5, "Placing and Removing Forms." Deliver concrete in accordance with Section 360.4.6, "Concrete Delivery." Place concrete at temperatures in accordance with Section 360.4.7.3, "Temperature Restrictions." Spread and finish concrete in accordance with Section 360.4.8, "Spreading and Finishing."

4.7. **Construction Joints.** Saw and seal all construction joints using a Class *5* joint seal, in accordance with Section 360.4.4, "Joints." When placing of concrete is stopped, install a bulkhead of sufficient cross sectional area at a planned transverse contraction joint location and remove the excess of concrete. Place the bulkhead at right angles to the centerline of the pavement, perpendicular to the surface and at the required elevation. Saw and seal this joint.

4.8. **Curing.** Cure concrete in accordance with Section 360.4.9, "Curing," except apply curing compound at a rate of not more than 120 sq. ft. per gallon.

4.9. **Saw Cutting Contraction Joints.** Unless otherwise shown on the plans, saw joints to a minimum depth of one-third the concrete thickness or for dry, early saw cuts, saw to a minimum depth of 1 in. Saw cuts in lines that are perpendicular and parallel to the centerline of the travel lanes. Saw cuts perpendicular to the surface of the overlay. Saw joints for radii as detailed in the plans. Use a chalk line, offset string line, sawing template or other approved methods to provide a true joint alignment. Do not seal the saw cuts; remove all debris after sawing. The Contractor is fully responsible for the timing and order of the saw cutting to prevent uncontrolled cracking, spalling, or raveling. If excess spalling or raveling occurs at the top of the saw cuts or the intersection of saw cuts, or if uncontrolled cracking occurs before opening to traffic, remove and replace all damaged concrete panels without any additional compensation.

4.10. **Deficient Thickness.** The Engineer will determine the overlay thickness in accordance with Test Method Tex-423-A, "Determining Pavement Thickness by Direct Measurement," at selected locations. If the thickness of the overlay measured is deficient by more than 0.40 in. of the plan thickness, the Contractor may verify the thickness by cores taken in accordance with Test Method Tex-424-A, "Obtaining and Testing Drilled Cores of Concrete," at the locations selected by the Engineer. Remove and replace any concrete panel deficient by more than 0.40 in. of plan thickness without any additional compensation.

4.11. **Opening to Traffic.** The completed overlay may be opened to traffic after the concrete has been cured for 36 hr and has obtained a minimum compressive strength of 2,800 psi or as directed. Determine the compressive strength in accordance with Tex-4l 8-A, "Compressive Strength of Cylindrical Concrete Specimens" using concrete cylinders cured at the job site under the same conditions as the pavement, or in accordance with Tex-426-A, "Estimating Concrete Strength by the "Maturity Method".

4.12. **Ride Quality.** When shown on the plans, achieve ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces, Type A."

5. MEASUREMENT

This Item will be measured by the square yard of surface area in place.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Repair of Ultra-Thin and Thin Whitetopping" of the thickness specified. This price is full compensation for materials, equipment, labor, tools, and incidentals.