TECHNICAL SUMMARY

CONCRETE OVERLAYS
A PROVEN TECHNOLOGY

IOWA STATE UNIVERSITY
Institute for Transportation

DECEMBER 2021

National Concrete Pavement Technology Center
CP Tech Center

About the CP Tech Center

The mission of the National Concrete Pavement Technology Center (CP Tech Center) at Iowa State University is to unite key transportation stakeholders around the central goal of advancing concrete pavement technology through research, technology transfer, and technology implementation.

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Reference Information for this Document

Cackler, T., T. Van Dam, G. Fick, J. Gross, and D. Harrington. 2021. *Concrete Overlays—A Proven Technology*. National Concrete Pavement Technology Center, Iowa State University, Ames, IA.

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle Concrete Overlays—A Proven Technology		**5. Report Date** December 2021	
		6. Performing Organization Code	
7. Author(s) Tom Cackler, Tom Van Dam, Gary Fick, Jerod Gross, and Dale Harrington		**8. Performing Organization Report No.**	
9. Performing Organization Name and Address National Concrete Pavement Technology Center Iowa State University 2711 South Loop Drive, Suite 4700 Ames, IA 50010-8664		**10. Work Unit No.**	
		11. Contract or Grant No. Part of Cooperative Agreement 693JJ31950004, Advancing Concrete Pavement Technology Solutions	
12. Sponsoring Organization Name and Address Federal Highway Administration 1200 New Jersey Avenue, SE Washington, DC 20590		**13. Type of Report and Period Covered** Technical Summary	
		14. Sponsoring Agency Code	
15. Supplementary Notes Visit https://cptechcenter.org for color pdfs of this and other research publications.			
16. Abstract While concrete overlays are used routinely and successfully in many states, a greater number of states currently have limited or no experience with the technology. The purpose of this document is to introduce concrete overlay selection, design, and construction practices to those who may not be familiar with this rehabilitation option. This document is not intended to be a detailed design guide but rather a resource that familiarizes the reader with concrete overlay technology. The material includes a technical overview of concrete overlays, guidance on effective deployment, lessons learned from decades of projects, an annotated list of additional resources, and 11 case histories demonstrating the versatility of concrete overlays. A companion document, *Concrete Overlays—The Value Proposition*, provides an overview of the value that concrete overlays offer in terms of cost, performance, safety, sustainability, and customer satisfaction.			
17. Key Words case studies—concrete overlays—pavements—pavement preservation—pavement rehabilitation—resurfacing		**18. Distribution Statement** No restrictions.	
19. Security Classification (of this report) Unclassified.	**20. Security Classification (of this page)** Unclassified.	**21. No. of Pages** 53	**22. Price** NA

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

Concrete Overlays—A Proven Technology

December 2021

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Concrete Overlays—A Proven Technology

Concrete overlays have been used successfully to address pavement condition needs in the US for over 100 years and are, as the title of this document states, a proven technology. According to the American Concrete Pavement Association (ACPA), concrete overlays currently represent approximately 12% of all concrete pavements built each year. This number has been steadily growing and is expected to increase as agencies look to address their pavement condition needs through cost-effective approaches that provide good long-term performance.

While concrete overlays are used routinely and successfully in many states, a greater number of states currently have limited or no experience with the technology. According to the ACPA, although 5 to 8 million square yards of overlays were built in each of the past 10 years, new overlay construction has been concentrated in about 12 states.

The purpose of this document is to introduce concrete overlay selection, design, and construction practices to those who may not be familiar with this rehabilitation option. This document is not intended to be a detailed design guide but rather a resource that familiarizes the reader with concrete overlay technology.

A companion document, *Concrete Overlays—The Value Proposition*, provides an overview of the value that concrete overlays offer in terms of cost, performance, safety, sustainability, and customer satisfaction. Its purpose is to convey the benefits that agencies can enjoy by routinely incorporating concrete overlays into their "mix of fixes."

Detailed engineering guidance on how to design and construct concrete overlays to address specific project conditions is presented the fourth edition of the *Guide to Concrete Overlays* (Fick et al. 2021). That document and other useful resources are available for free download from the National Concrete Pavement Technology Center (CP Tech Center) at https://cptechcenter.org/.

Concrete Overlays—A Proven Technology has been organized to provide an overview of concrete overlay technology, guidance on effectively deploying concrete overlays, lessons learned from decades of concrete overlay projects, and technical resources available on various aspects of concrete overlay selection, design, and construction. In addition, 11 case histories are presented to demonstrate the breadth of pavement conditions for which concrete overlays are suitable.

Technical Overview of Concrete Pavement Technology

Concrete overlays are adaptable to a broad range of pavement conditions and project needs, and their excellent historical performance makes them an attractive option for addressing even the most challenging pavement preservation and rehabilitation scenarios.

Concrete overlays include bonded (B) and unbonded (U) concrete on asphalt (COA) and concrete on concrete (COC) systems, as shown in Figure 1. Figure 2 shows a breakdown of the types of concrete overlays constructed in the US since 2000.

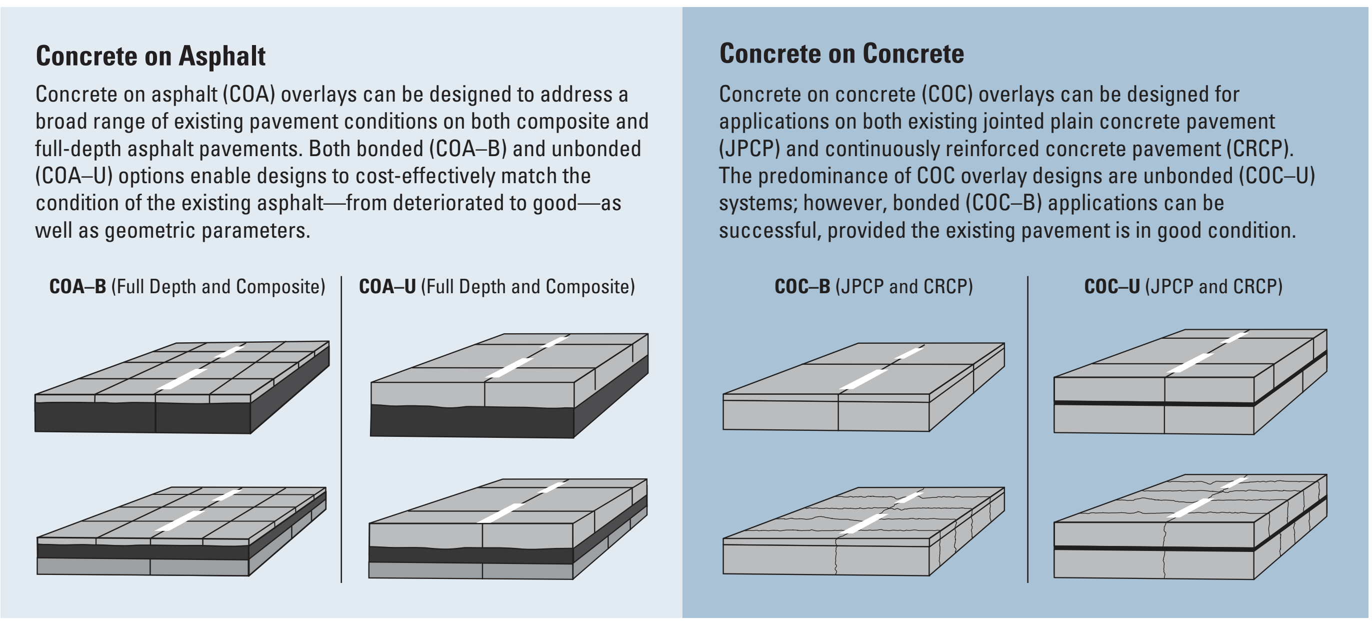

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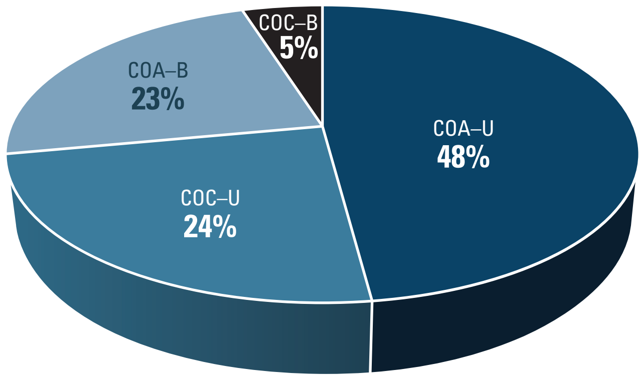
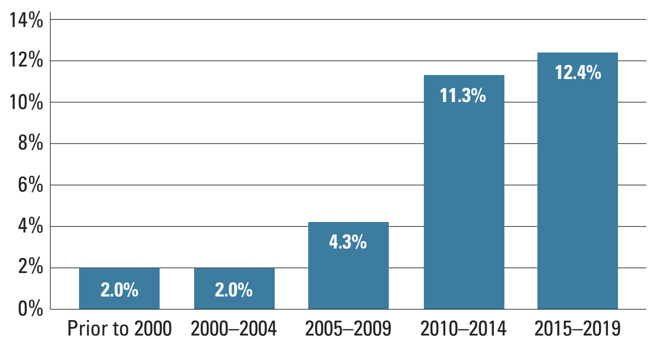
Figure 1. Summary of concrete overlay types on existing asphalt-surfaced and concrete pavements



Based on data from ACPA

Figure 2. Types of concrete overlays built in the US between 2000 and 2017



Based on data from ACPA

Figure 3. Concrete overlays as a percentage of total concrete paving in the United States

Figure 3 shows that the percentage of concrete overlays relative to the total amount of concrete paving has continued to increase over the last 10 years. This increasing popularity is due to the ability of concrete overlays to successfully address agency preservation and rehabilitation needs at a reasonably low initial cost while significantly extending the life of existing concrete and asphalt pavements.

Selecting an Appropriate Concrete Overlay Type for a Given Project

When selecting the type of concrete overlay solution for a given project, the condition of the existing pavement is a key factor. Generally, an existing pavement that is in or can be cost-effectively restored to good condition is a good candidate for a bonded concrete overlay. In this regard, an asphalt-surfaced pavement in fair to poor condition primarily due to rutting and shoving is a good candidate for a bonded concrete overlay if the existing pavement can be restored to good condition with spot repairs and milling. An existing pavement in fair to poor condition is otherwise a good candidate for an unbonded concrete overlay, provided the existing pavement offers stable and uniform support.

The appropriate overlay option can be selected and designed using a decision tree approach, such as that shown in Figure 4. Figure 5 illustrates how the condition of the existing pavement can be visually assessed to select the appropriate overlay option. Pavements in poor or deteriorated condition may require more extensive investigation to determine the underlying support conditions, drainage effectiveness, and potential material-related deterioration. In all cases, it is important to keep in mind that most pavement conditions can be addressed with a properly designed and constructed concrete overlay.

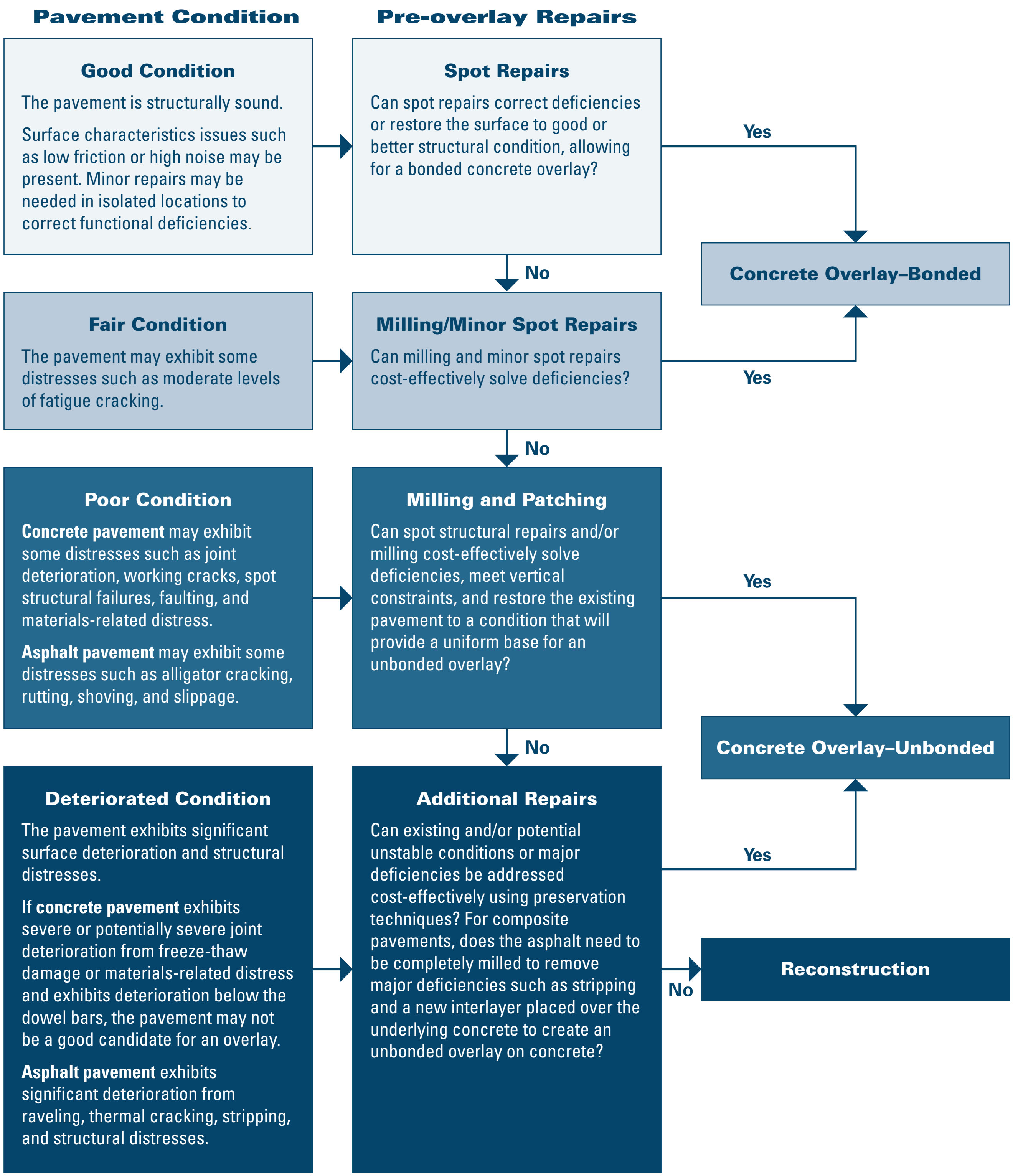


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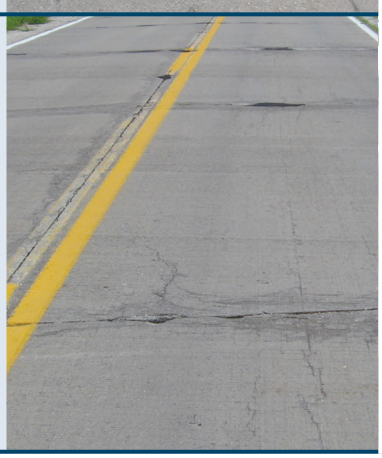
Figure 4. Decision tree for selecting the appropriate concrete overlay solution for a given project

Concrete			Asphalt/Composite
Good Condition Excellent candidate for bonded overlay. May have surface defects, which will not affect the bond.			**Good Condition** Excellent candidate for bonded overlay. May have some surface defects, which will not affect the bond.
Fair Condition Excellent candidate for unbonded overlay. Pavement is structurally sound but may have some random cracking and joint distress. If drainage or foundation issues exist, pavement should be considered in poor condition requiring repair.			**Fair Condition** May be a candidate for bonded overlay if surface distresses, such as block cracking and thermal cracking, will not affect the bond.
Poor Condition Candidate for unbonded overlay. May have some full-depth joint deterioration, working cracks, spot structural failures, and faulting. Spot structural failures must be repaired so there is uniform support throughout the slab.			**Poor Condition** Good candidate for unbonded overlay. Pavement has measurable distresses, including alligator cracking, delamination, rutting, shoving, slippage, and raveling..
Deteriorated Condition Possible candidate for unbonded overlay as long as support is uniform. Large structural problems may require reconstruction.			**Deteriorated Condition** Possible candidate for an unbonded overlay as long as support is uniform. Large structural problems may require reconstruction.

Photos: Snyder & Associates, Inc., used with permission

Figure 5. Use of pavement condition assessment to select an appropriate concrete overlay option

Features Common to All Concrete Overlays

All concrete overlays have the following features:

- Concrete overlays are constructed using traditional concrete paving mixes and common concrete paving construction techniques that do not require specialized equipment or skills.
- Concrete overlays can use accelerated mixtures and accelerated construction and curing methods if early time to opening is required.
- Concrete overlays are constructed with jointed plain concrete pavement (JPCP) or continuously reinforced concrete pavement (CRCP). JPCP is used far more frequently for concrete overlays, but CRCP has been used effectively for concrete overlays in Texas, California, and several other states.
- Because shrinkage in the overlay slab can result in a high level of restraint between the overlay and the existing pavement, concrete mixtures with a high paste volume (i.e., a high volume of cementitious materials and water) should be avoided. Paste volume should be targeted to around 25% or less.
- Most concrete overlays are relatively thin, resulting in a high surface-area-to-volume ratio. For this reason, curing must be given special attention to avoid excessive loss of moisture from evaporation, which can result in cracking. Synthetic macrofibers have been used to control cracking in thin bonded overlays, in some cases allowing a reduction in paving thickness to be made.
- Because the overlay slab experiences a relatively high level of restraint, special attention must be paid to timing and depth when sawing control (contraction) joints. Sawing should commence as soon as it can be done without damaging the concrete. Additional saws may be needed if short joint spacing is used.
- Properly selected, designed, and constructed overlays using durable concrete materials have design lives comparable to newly constructed pavements, from 20 to 35 or more years.

Concrete on Asphalt Overlays

COA overlays are the most common type of overlay used in the US. According to data from the ACPA's National Concrete Overlay Explorer (ACPA 2020), COA overlays represent 71% of the concrete overlays constructed nationally between 2000 and 2017. Concrete on asphalt–bonded (COA–B) overlays, which represent approximately 23% of all concrete overlays constructed nationally between 2000 and 2017, are a feasible alternative for existing asphalt and composite pavements that are in (or can be cost-effectively restored to) good to excellent condition prior to overlay placement. Concrete on asphalt–unbonded (COA–U) overlays are even more popular and widely applicable, representing 48% of all concrete overlays constructed nationally between 2000 and 2017.

Concrete on Asphalt–Bonded Overlays

COA–B overlays correct surface irregularities but also add structural capacity because the new overlay and existing pavement act monolithically. A COA–B overlay can be selected when the quality of the existing asphalt or composite pavement (or the portion of the pavement that will remain) is high and adequate thickness is available to contribute structurally to the load-carrying capacity of the combined pavement layers.

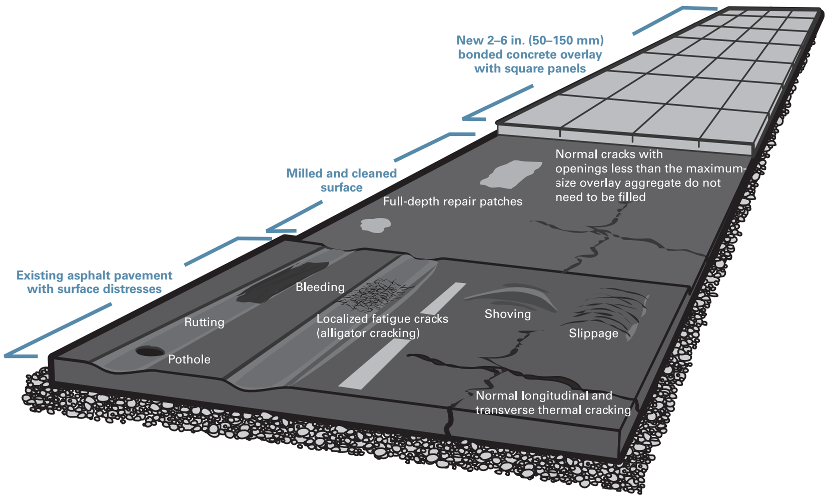
COA–B overlays can be relatively thin (3 to 6 in.), an advantage in locations where grade restrictions and other geometric constraints are a factor (e.g., intersections, underpasses, and pavements with curb and gutter sections or pedestrian ramps).

Bonding between the concrete overlay and asphalt surface is essential. Therefore, the existing pavement must be prepared in order to promote bonding and must have sufficient thickness to contribute structurally, along with the concrete overlay, to the load-carrying capacity of the single composite layer.

Loose, raveled, or stripped material or shallow areas of delamination on the existing pavement should be removed to ensure a sound asphalt surface that promotes bonding. Milling may be required to correct rutting greater than 2 in. or to maintain the profile grade. For both asphalt and composite pavements, a minimum of 3 in. of structurally sound asphalt must remain after milling prior to placement of the overlay. For composite pavements especially, the layer thickness should be studied during the evaluation phase. If, after milling, 3 in. or more of asphalt remain, the overlay can indeed be considered a COA–B overlay. If less than 3 in. of asphalt remain, it should be considered a COC–U overlay.

A COA–B overlay is normally designed as a JPCP with panel dimensions of 6 ft or less because the overlay is normally 6 in. thick or less. Because longitudinal joints should be placed outside of the wheel paths to minimize corner loading, panel widths of half the lane width are generally preferred over panel widths of 4 ft. The panel aspect ratio (length:width) should be close to 1:1 and never greater than 1.5:1.

Concrete on Asphalt–Bonded (Asphalt Pavements)
(Overlay and existing asphalt pavement act as one monolithic pavement)



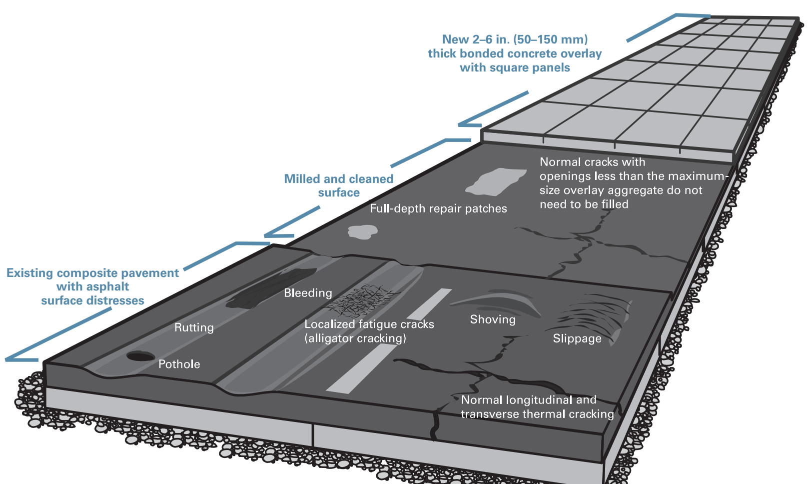
Existing pavement condition
Fair or better structural condition with surface distress

Applications
- To eliminate surface distresses such as rutting and shoving.
- To improve friction, noise, rideability, and surface albedo.
- Where traffic loads require more structural capacity, especially to resist rutting.
- Where vertical clearances must be met.

Keys to success
- Thin milling may be required to eliminate surface distortions of 2 in. (5.1 cm) or more.
- Keep joints out of wheel paths.
- Thinner pavements may accelerate sawing window.
- Saw joints in small, square panels.
- Have enough saws on site to keep up with cutting.
- Curing must be timely and thorough.

Other issues
Maintain surface temperature of asphalt below 120°F (48.9°C).

Concrete on Asphalt–Bonded (Composite Pavements)
(Overlay and existing pavement act as one monolithic pavement)



Existing pavement condition
Fair or better structural condition with severe surface distress

Applications
- To eliminate surface distresses such as rutting and shoving.
- To improve friction, noise, rideability, and surface albedo.
- Where traffic loads require more structural capacity, especially to resist rutting.
- Where vertical clearances must be met.

Keys to success
- Thin milling may be required to eliminate surface distortions of 2 in. (5.1 cm).
- Keep joints out of wheel paths.
- Thinner pavements may accelerate sawing window.
- Saw joints in small, square panels.
- Curing must be timely and thorough.
- Have enough saws on site to keep up with cutting.

Other issues
- Maintain surface temperature of asphalt below 120°F (48.9°C).
- Examine profile for vertical distortion at joints that could signal movement in the bottom layer from drainage or material-related distress of underlying pavement.

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Figure 6. Summary of COA–B overlays

Figure 6 illustrates the features of bonded concrete overlays on various types of existing asphalt pavements.

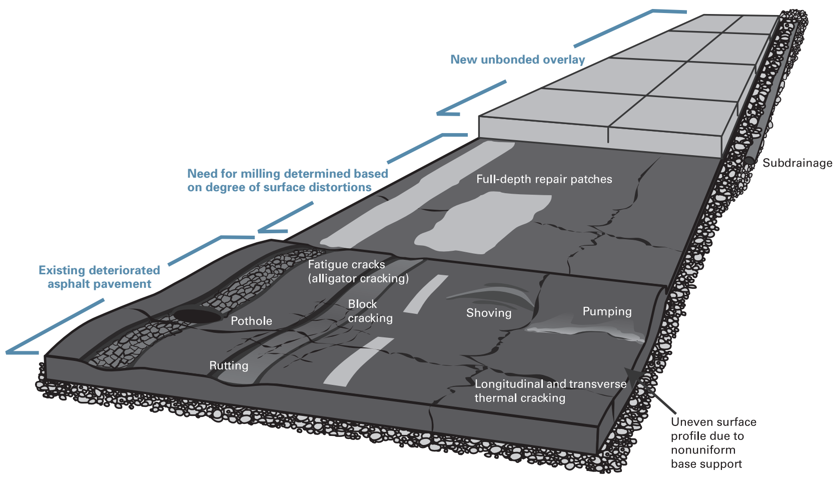
Concrete on Asphalt–Unbonded Overlays

A COA–U overlay adds significant structural capacity to an existing asphalt or composite pavement that is moderately to significantly deteriorated. The existing pavement is considered as a foundation or base and must be able to provide uniform support to the overlay. The overlay, in turn, is designed as the primary load-carrying component of the system. The system is considered unbonded because bonding between the overlay and the underlying asphalt or composite pavement is not needed to achieve the desired performance and is not considered in the design.

A COA–U overlay is an appropriate alternative for asphalt and composite pavements in fair condition. Even if the existing pavement exhibits asphalt deterioration such as rutting, fatigue cracking, or other issues, the new overlay should perform as designed if relatively stable and uniform support is provided.

Spot repairs of isolated areas may be needed to address localized failure that threatens uniform support, and loose or stripped material should be removed to ensure good, long-term uniformity of support. Milling may be required to correct rutting greater than 2 in. or to maintain the profile grade. A minimum of 3 to 4 in. of asphalt must remain after milling of an existing asphalt pavement to withstand loading from construction traffic.

Concrete on Asphalt–Unbonded (Asphalt Pavements)
(Results in a new pavement on a stable base)



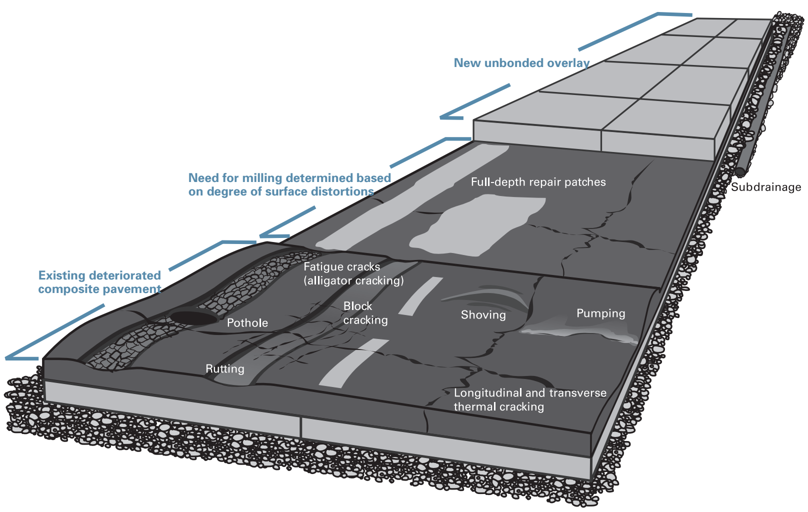
Existing pavement condition
May be deteriorated but stable and uniform

Applications
- To restore or enhance pavement's structural capacity.
- To increase pavement life equivalent to a new full-depth pavement.
- To eliminate rutting and shoving problems.
- To improve surface friction, noise, rideability, and surface albedo.

Keys to success
- Consider milling when surface distortions are 2 in. (5.1 cm) or greater.
- Repair isolated areas where structural integrity is lost.
- Timing of joint sawing.

Other issues
Maintain surface temperature of asphalt below 120°F (48.9°C).

Concrete on Asphalt–Unbonded (Composite Pavements)
(Results in a new pavement on a stable base)



Existing pavement condition
May be deteriorated but stable and uniform

Applications
- To restore or enhance pavement's structural capacity.
- To increase pavement life equivalent to new full-depth pavement.
- To eliminate rutting and shoving problems.
- To improve surface friction, noise, rideability, and surface albedo.

Keys to success
- Consider milling when surface distortions are 2 in. (5.1 cm) or greater.
- Repair isolated areas where structural integrity is lost.
- Other issues.
- Vertical distortion at joints of composite pavement must be repaired before overlay.
- Maintain surface temperature of asphalt below 120°F (48.9°C).

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Figure 7. Summary of COA–U overlays

For composite pavements, at least 1 in. of sound asphalt should remain prior to overlay placement.

COA–U overlays can be either JPCP or CRCP. Because the overlay is essentially a new pavement being constructed on a stiff base, traditional design details for both JPCP and CRCP are appropriate. For JPCP COA–U overlays, the joint spacing is typically shorter than for new construction on a granular base because the stiff support from the existing pavement will result in higher early-age stress from temperature and moisture differentials.

Figure 7 illustrates the features of unbonded concrete overlays on various types of existing asphalt pavements.

Concrete on Concrete Overlays

Though not as commonly used as COA overlays, COC overlays are a popular rehabilitation alternative, especially concrete on concrete–unbonded (COC–U) overlays. According to the ACPA's National Concrete Overlay Explorer (ACPA 2020), COC–U overlays represent 24% of all concrete overlays constructed nationally between 2000 and 2017. However, concrete on concrete–bonded (COC–B) overlays represent only approximately 5% of all concrete overlays constructed nationally in that period.

Concrete on Concrete–Bonded Overlays

COC–B overlays correct surface irregularities but also add structural capacity because the new overlay and existing concrete pavement act monolithically. For a COC–B overlay to be feasible, the existing concrete pavement must be in good to excellent condition. Generally, such pavements are rarely programmed for rehabilitation unless a significant increase in traffic is expected (e.g., a new, unanticipated industrial park is being constructed that will rely on the existing pavement).

COC–B overlays can be relatively thin (2 to 4 in.), an advantage in locations where grade restrictions and other geometric constraints are a factor (e.g., intersections, underpasses, and pavements with curb and gutter sections and pedestrian ramps).

The success of a COC–B overlay is dependent on the quality of the bond established during construction. The interface between the overlay and the existing concrete pavement must be prepared and cleaned to achieve and maintain an adhesive bond.

All spalling and working cracks in the existing pavement must be repaired prior to placement of the overlay. Tight, nonworking cracks can be left unrepaired but will likely reflect through the overlay, so joints should be placed above them. Advanced expertise should be sought if a COC–B overlay is being considered.

Figure 8 illustrates the features of COC–B overlays.

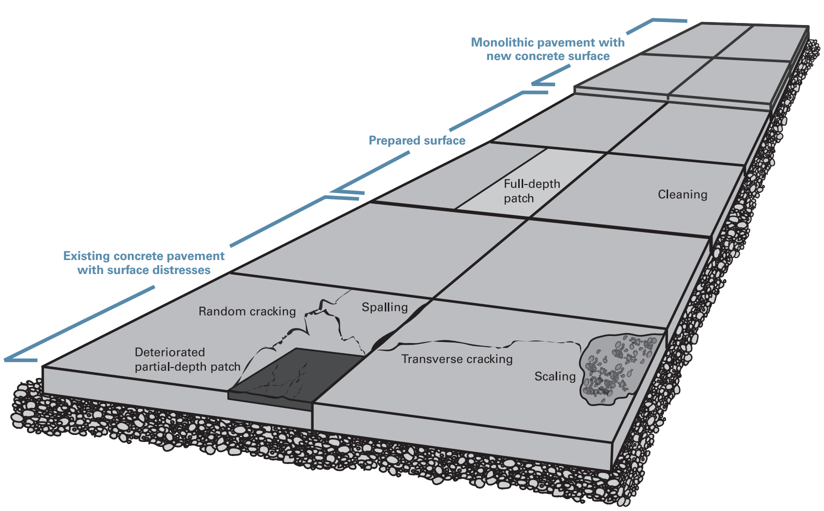
Concrete on Concrete–Unbonded Overlays

COC–U overlays have been successfully designed and constructed for over 40 years throughout the United States. This type of overlay adds significant structural capacity to an existing concrete pavement that is moderately to significantly deteriorated. Concrete pavements suffering materials-related distress that has not resulted in excessive expansion and buckling have been successfully rehabilitated with COC–U overlays. Additionally, a special case in which COC–U overlays are designed is on composite pavements where the remaining asphalt surface after milling is between 1 and 2 in.

The existing pavement is considered as a foundation or base and must be able to provide uniform support to the overlay. The overlay, in turn, is designed as the primary load-carrying component of the system. The system is considered unbonded because bonding between the overlay and the underlying pavement is not needed to achieve the desired performance.

An essential element of the design of COC–U overlays is the separation of the overlay from the underlying concrete pavement so that each act independently. It is common to use a 1 to 1.5 in. thick asphalt layer or a geotextile fabric to isolate the overlay and existing pavement and provide bedding and drainage. Additionally, for overlays placed on composite pavements where the remaining asphalt surface after milling is between 1 and 2 in., the asphalt acts as a separation layer and allows the overlay to be designed as a COC–U overlay.

Concrete on Concrete–Bonded
(Overlay and existing concrete pavement act as one monolithic pavement)



Existing pavement condition
Good structural condition; limited surface distress

Applications
- To eliminate surface distresses.
- To improve friction, noise, and rideability.
- Where increase in traffic loads requires more structural capacity.
- Where vertical clearances must be met.

Keys to success
- Existing joints must be in fair condition or repaired.
- Overlay must establish good bond with existing pavement.
- Thinner pavements may accelerate sawing window.
- Curing must be timely and thorough, especially at edges.
- Joints must align with those of existing pavement.
- Transverse joints: full depth plus 0.5 in. (1.3 cm).
- Longitudinal joints: at least T/2.

Other issues
Working cracks will reflect through unless repaired or the overlay is sawed over the crack.

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Figure 8. Summary of COC–B overlays

COC–U overlays can be either JPCP or CRCP. Because the overlay is essentially a new pavement being constructed on a stiff base, traditional design details for both JPCP and CRCP are appropriate. For JPCP COC–U overlays, the joint spacing is typically shorter than for new construction on a granular base because the stiff support from the existing pavement will result in higher early-age stress from temperature and moisture differentials.

Pre-overlay repairs to replace structurally failed sections of the existing pavement may be needed to provide stable and uniform support. Existing unstable pavement slabs should be replaced with full-depth concrete repairs, including the foundation layers, to ensure long-term stability. Working longitudinal cracks should be repaired using full-depth repairs, cross-stitching, and/or slab stabilization. Joint grinding/milling should be considered if a geotextile fabric separation layer is used and joint faulting exceeds ¼ in. or a 1 in. thick asphalt separation layer is used and joint faulting exceeds ⅜ in.

Figure 9 illustrates the features of COC–U overlays.

Concrete Overlay Thickness Design Fundamentals and Jointing Considerations

Concrete overlay design procedures generally consider user inputs such as anticipated traffic, climate, support layers, material properties, slab geometry, and performance criteria to develop a recommended overlay thickness.

Although cost is a major factor in design, additional elements are also important. The inputs required for different overlay thickness design procedures vary greatly, and designers should refer to procedure-specific user guides for details.

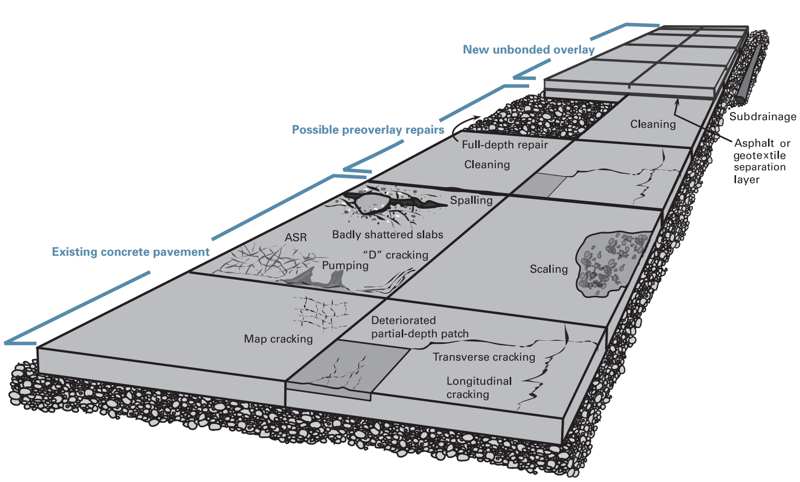
The four most commonly used software programs for concrete overlay design are summarized below.

AASHTOWare Pavement ME Design is a proprietary implementation of the current mechanistic-empirical pavement design procedures developed by the American Association of State Highway and Transportation Officials (AASHTO). The software includes design options for all types of concrete overlays. Licensing and fee structure information can be found at https://me-design.com/MEDesign.

PavementDesigner.org is a web-based procedure developed by the American Concrete Pavement Association and includes design methodologies for COC–B, COC–U, and COA–U overlays. Web access: https://www.pavementdesigner.org/.

University of Pittsburgh's BCOA-ME was developed specifically to focus on the design of COA–B overlays on conventional asphalt pavement and is applicable for composite pavements when the remaining asphalt surface exceeds 3 in. BCOA-ME can be accessed at https://www.engineering.pitt.edu/Vandenbossche/BCOA-ME/.

Concrete on Concrete–Unbonded
(Results in a new pavement on a stable base)



Existing pavement condition
Poor condition but stable and uniform

Applications
- To restore or enhance pavement's structural capacity.
- To increase pavement life equivalent to new full-depth pavement.
- To improve surface friction, noise, and rideability.
- To reduce underlying pavement temperatures, decreasing the potential for existing pavement expansion and buckling.

Keys to success
- Full-depth repairs to restore uniformity of support in isolated spots may be necessary.
- Use of asphalt or geotextile separation layer to minimize reflective cracking.
- Faulting less than or equal to .375 in. (0.9 cm) is generally not a concern when separation layer is 1 in. (2.5 cm) or more.
- Saw joints as soon as possible because the sawing window can be short.
- Use shorter joint spacing than normal full depth pavements to help reduce curling and warping stress.

Other issues
High truck traffic on the asphalt separation layer, in the presence of water, can strip the asphalt; provide adequate drainage or use a geotextile separation layer.

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Figure 9. Summary of COC–U overlays

University of Pittsburgh's UNOL Design v1.0 was developed to design JPCP COC–U overlays and is applicable for JPCP COC–U overlays of composite pavement if the remaining asphalt thickness is 1 to 2 in. This free, web-based design application is relatively simple and can be accessed at https://uboldesign3.azurewebsites.net/.

Table 1 summarizes the applicability and key features of each design application.

Determining panel size and jointing is a critical step when designing concrete overlays and is dependent on overlay thickness, bonding condition, and existing pavement type. Table 2 lists several considerations regarding joint spacing and joint sawing for different overlay types.

Table 1. Applicability and key features of commonly used concrete overlay design applications

Name	Notes	Link	Design procedure	Overlay type	Key features
AASHTOWare Pavement ME Design	Most broadly applicable and robust design procedure.	https://me-design.com/MEDesign	Mechanistic-empirical	All types	Performance indicators include International Roughness Index (IRI), transverse cracking, and mean joint faulting (for JPCP overlays); IRI and longitudinal cracking (for short-jointed plain concrete pavement [SJPCP] overlays on asphalt); and IRI and punchouts (for CRCP overlays).
PavementDesigner.org	Simple web-based software that offers quick design and sensitivity analysis. Recommended design procedure for facilities not covered by AASHTOWare Pavement ME Design.	https://www.pavementdesigner.org/	PCA/StreetPave method	COC–B, COC–U, and COA–U	Capabilities include consideration of macrofibers, development of a concrete overlay comparable to an asphalt overlay, updated joint spacing calculations.
BCOA-ME	Quick and simple web-based software for thin bonded concrete overlays on asphalt.	https://www.engineering.pitt.edu/Vandenbossche/BCOA-ME/	Mechanistic-empirical	COA–B	Failure modes include corner cracking, longitudinal cracking, and transverse cracking. Analyzes effects of synthetic structural, steel, low-modulus synthetic, or user-defined fibers Evaluates potential for reflective cracking.
UNOL Design v1.0	Simple web-based design software. Can predict performance and reliability.	https://uboldesign3.azurewebsites.net/	Mechanistic-empirical	COC–U	Performance criteria include faulting and panel cracking.

Table 2. Joint sawing and joint spacing practices for concrete overlays

Construction consideration	COC–B	COA–B	COA–U or COC–U
Joint spacing:			
Joints are to be matched with underlying concrete to prevent reflective cracking.	X		
Panel dimensions match the underlying pavement.	X		
The recommended joint pattern for COA–B overlays should not exceed 1.5 times the overlay thickness in inches.		X	
For overlays less than or equal to 6 in. thick, the panel dimensions (in feet) should not exceed 1.5 times the overlay thickness in inches (e.g., 4 in. x 1.5 ft/in. = 6 ft).			X
For overlays greater than 6 in., the panel dimensions (in feet) should not exceed 2.0 times the overlay thickness in inches, not to exceed 15 ft.			X
Because of the potential for higher curling and warping stress from a rigid underlying pavement, shorter than normal spacing is typical.			X
Joint sawing:			
The timing of sawing is critical. Sawing joints too early can cause excessive raveling. HIPERPAV (The Transtec Group 2021) may be useful in helping to predict the appropriate time window for joint sawing, based on the concrete mix design, construction times, and environmental conditions.	X	X	X
Sawing must be completed before stresses exceed the strength developed. Sawing too late can lead to uncontrolled cracking.	X	X	X
Transverse joint sawcut depth for conventional saws	Full depth + 0.50 in. (13 mm)	T/3	T/4 min.–T/3 max.
Transverse joint sawcut depth for early-entry saws	Full depth + 0.50 in. (13 mm)	Not < 1.25 in. (32 mm)	Not < 1.25 in. (32 mm)
Longitudinal joint sawcut depth	T/2 (at least)	T/4–T/3	T/4–T/3
Transverse joint width must be equal to or greater than the underlying crack width at the bottom of the existing transverse joint.	X		

How to Deploy Concrete Overlays Effectively

The critical elements for agencies to consider when preparing and developing a concrete overlay project include profile grade optimization, plan and specification development, maintenance of traffic, construction considerations, opening to traffic, and accelerated construction.

Profile Grade Optimization

With advancements in survey technologies and the trend toward three-dimensional (3D) guidance systems on the paver, it is rapidly becoming a national best practice to furnish the contractor with a profile grade of the overlay.

An existing pavement often has more profile and cross slope variation than a prepared subbase. Three primary challenges are associated with this variability: (1) ensuring that the concrete overlay is constructed to the proper thickness tolerance, (2) achieving a specified smoothness, and (3) minimizing the volume of concrete needed to construct the project. The final overlay profile must be optimized to meet all three objectives. To optimize the profile grade line for an overlay during design, a detailed survey of the existing pavement is needed that models the surface accurately.

Fast Survey Technologies

Newer surveying techniques based on scanning technologies such as light detection and ranging (LiDAR) provide a more complete data set than conventional surveys and are well suited for the task of determining an optimal profile grade line for concrete overlay construction.

Due to steady if not rapid improvements over the last decade, the latest generation of scanning technology offers a reduction in survey cost and time and less disruption for the traveling public, which in turn improves safety compared to conventional survey methods. While conventional surveys require more time and labor in the field, surveys based on scanning technologies such as LiDAR require more time and labor in the office working with the data.

Refer to *Implementation Manual—3D Engineered Models for Highway Construction: The Iowa Experience* (Reeder and Nelson 2015) for more information about new scanning technologies for surveying.

Conventional Surveying Techniques

Conventional surveying methods using a total station can also be used as long as a sufficient number of survey lines are collected to capture all slope breaks, rutting, and other pavement conditions that will affect the optimum profile grade line for the overlay. Based on data obtained from a project constructed in 2012 on US 18 in Iowa, Cable (2012) found that performing a nine-line survey at 50 ft intervals provided the engineer with the data necessary to confidently adjust the profile of the concrete overlay.

Plan and Specification Development

Construction drawings for concrete overlays do not need to be complex; a simple approach to plan development that uses a limited number of sheets is acceptable for a concrete overlay. The location, geometric features, and maintenance of traffic requirements for a given overlay project should dictate the level of design detail that is required in the drawing set. In urban or suburban locations, for example, especially where vertical and horizontal constraints are present, the plans must include the level of detail and amount of information needed to communicate how the concrete overlay will address these constraints.

Because concrete overlay design involves an overlay of an existing pavement, a proposed profile may not need to be included in the drawing set, except when minor cross-section or design profile adjustments are needed in spot locations. However, a proposed profile is desirable prior to construction to tighten the yield on the concrete placed and thereby reduce overruns.

With the increasing use of stringless pavers, it can be beneficial to provide 3D models or electronic design files to support efficient construction methods. Whether LiDAR scanning or conventional survey methods are used, a quality review check should be performed to ensure that the correct profile and alignment are used during construction.

Guide for the Development of Concrete Overlay Construction Documents (Gross and Harrington 2018) provides example drawing sheets and construction details that can be referenced when assembling an overlay drawing set. A simplified plan set should include the following:

- Title sheet
- Typical sections
- Estimated quantities
- Survey control information
- Maintenance of traffic
- Typical construction details
- Intersection layout
- Right of way/access constraints

Guide Specifications for Concrete Overlays (Fick and Harrington 2016) can assist in the development of technical specifications for concrete overlay projects. Recognizing that standard specifications vary widely across the United States in terms of style, order of items, and other features, the guidance provided in this document is advisory in nature and is not necessarily suitable for use as specification language. Recommended modifications to the guide specifications are provided for different overlay types, and users should modify the guidance as needed for their standard specifications while preserving the intent of the suggested recommendations.

Maintenance of Traffic

One of the key factors contributing to a successful concrete overlay project is the proper maintenance of traffic during construction. Concrete overlays are constructed most quickly and economically if the project corridor can be closed to all traffic (or closed to through traffic) during construction. In urban areas where access must be provided to businesses and property owners and in areas where adjacent detour routes are inconvenient, consideration should be given to staging the construction of the overlay.

Whether the project corridor will be closed or open to traffic during construction, the plans and specifications should provide the contractor with clear criteria for scheduling and maintenance of traffic requirements. Examples of maintenance of traffic criteria include the following:

- Number of lanes open in each direction at all times
- Maximum amount of time for pilot car queues
- Critical milestone dates
- Closure limits
- Access requirements to local businesses

The contractor should be given the flexibility and responsibility to develop a staging plan that meets the maintenance of traffic criteria established by the agency. A drawing sheet should be included in the plan set that provides traffic control and staging notes outlining the maintenance of traffic criteria.

Stringless pavers and zero-offset pavers allow the contractor more flexibility in how traffic is addressed during paving operations. However, it is important that the construction documents do not dictate the types of equipment or methods needed for construction because such restrictions may unnecessarily inhibit competition and result in a more costly project. Instead, the project documents should reflect the requirements for successful construction, including the minimum clearance zone needed to accommodate traffic and traffic control devices.

Various staging sequence diagrams can be used to illustrate the traffic control needed to construct a concrete overlay without closing the road to traffic. The diagrams can show the layout of both the construction zone and the zone open to traffic at different stages of construction. The critical stages of the traffic control plan may also be explained through a description of the progression of work. Figure 10 shows an example staging sequence diagram for a two-lane road constructed under traffic.

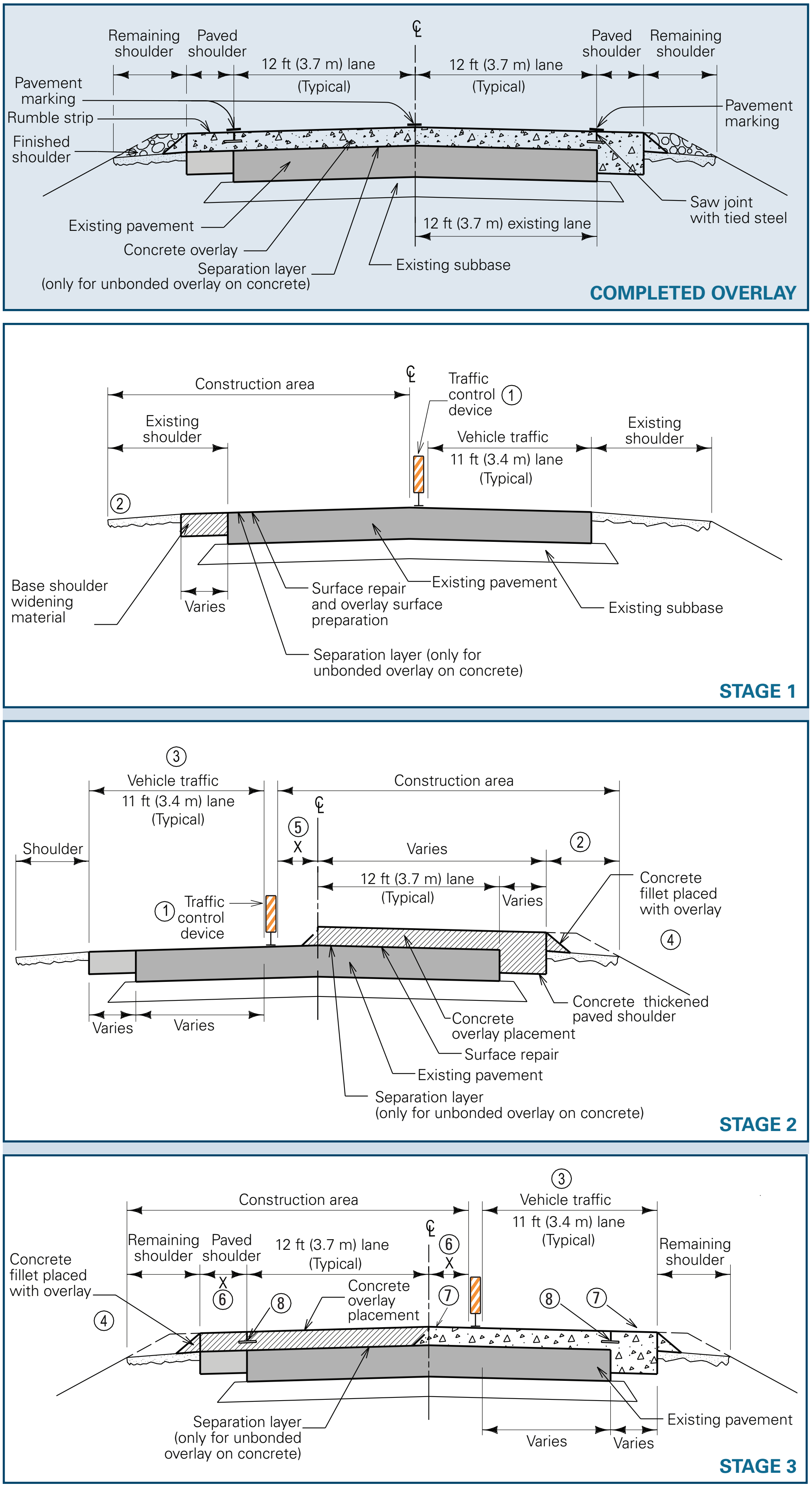
Other examples of traffic control for concrete overlay projects may include the following:

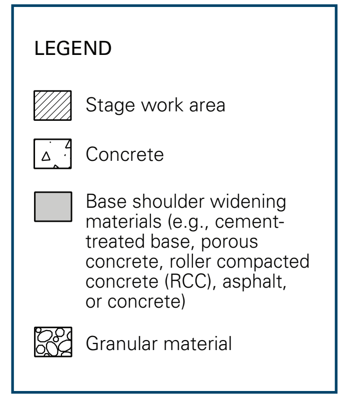
- Divided highways. Establish contraflow with crossovers.
- Two-lane roads/streets with acceptable detour routes. Close to through traffic; construct the full width of the roadway or, to maintain local access, one lane at a time.
- Two-lane roads with no acceptable detour routes. Construct one lane at a time adjacent to traffic, with a pilot car maintaining two-way traffic.
- Multilane roads/streets. Construct adjacent to traffic, allowing adequate room for construction equipment and material delivery; provide a gap where turning movements must be maintained.

Construction Considerations

Concrete overlays are constructed using conventional materials, equipment, and procedures. Total construction time for a concrete overlay is significantly shorter than for a reconstruction project because the existing pavement is left in place and earthwork is limited to minor quantities. The existing pavement provides an excellent construction platform, minimizing the impacts of weather on the construction schedule. The overlay construction process can be summarized in the following general steps, which often take place concurrently:

- Construction staking for machine control
- Pre-overlay repairs
- Provision of a separation layer for COC–U overlays
- Concrete overlay paving, including curing and jointing
- Opening to traffic





NOTES:

1. Follow jurisdictional requirements for traffic control devices.
2. Treat 3 ft (0.9 m) area outside of proposed paved shoulder with calcium chloride. If the existing shoulder outside the proposed paved shoulder is less than 3 ft (0.9 m), it may be necessary to adjust the slipform paver and/or paver control to accommodate the reduced space.
3. Minimum lane width next to the paver may be reduced for short-term, stationary work on low-volume, low-speed roadways when vehicular traffic does not include longer and wider heavy commercial vehicles.
4. If the overlay is opened to traffic in this stage, and final shoulder backfill is delayed, place fillet as shown or (if overlay creates a dropoff greater than jurisdictional allowance) place granular shoulder.
5. For "X" less than 4 ft (1.2 m), adjustments to paver may be necessary to accommodate paver control and paver track.
6. The "X" dimension can be reduced to 3 ft (0.9 m) minimum when the right lane is used as paver control.
7. Mark edgelines and centerlines per MUTCD (FHWA 2009) section 6F.77 (mark both lanes).
8. Construct longitudinal joint.

Drawings: Snyder & Associates, Inc., used with permission

Figure 10. Example staging sequence diagram for two-lane roadway maintaining traffic

Construction Staking for Machine Control

As described above, an optimized overlay profile can be developed using scanning technologies that save time in the field compared to conventional survey methods. Accurate machine controls based on the optimized profile must be used to achieve the desired smoothness (Snyder 2019). Compared to string lines, 3D controls offer the benefit of reducing the footprint of the paving operation. The lateral clearances required for stringless paving range from 2 to 3 ft compared to 6 to 10 ft for string line paving.

Pre-overlay Repairs

Because a concrete overlay will not correct existing support and drainage issues, pre-overlay repairs to the existing pavement are necessary where subgrade failures are present.

In general, an unbonded overlay requires few to no pre-overlay repairs because the existing pavement essentially serves as a base course and working platform. Therefore, an unbonded overlay can be placed on an existing pavement in a deteriorated condition with minimal costs for pre-overlay repairs. Figures 11 and 12 show a deteriorated asphalt pavement in Iowa before and after placement of a COA–U overlay, respectively.

Kevin Merryman, Iowa DOT, used with permission

Figure 11. Poor to deteriorated asphalt pavement before resurfacing with a COA–U overlay

Kevin Merryman, Iowa DOT, used with permission

Figure 12. Poor to deteriorated asphalt pavement resurfaced with a COA–U overlay

In contrast, a bonded overlay is a monolithic structure comprised of the existing pavement and the concrete overlay. The existing pavement should therefore be in (or be restored to) good condition before the concrete overlay is placed.

For concrete overlays, the cost of pre-overlay repairs for a given project should be estimated during the design stage to assess the cost-effectiveness of a concrete overlay. Common pre-overlay repairs include the following:

- Milling to remove surface deterioration and expose a sound structural section
- Subgrade and subbase repairs to remediate support issues
- Full-depth asphalt patching where subgrade and subbase repairs have been made
- Full-depth concrete patching where slabs are moving under traffic (deflecting, rocking, etc.)
- Filling of wide cracks (those wider than the nominal maximum size of the coarse aggregate in the concrete overlay mixture) in an existing asphalt pavement with crack sealer, cementitious mortar, sand, or milling fines
- Removal of loose material from deteriorated joints in an existing concrete pavement and filling with a cementitious mortar

Provision of a Separation Layer for Concrete on Concrete–Unbonded Overlays

For COC–U overlays, a separation layer is placed between the existing concrete pavement and overlay. The separation layer acts as a stress relief layer and allows the two pavement layers to move independently, preventing reflective cracking and faulting.

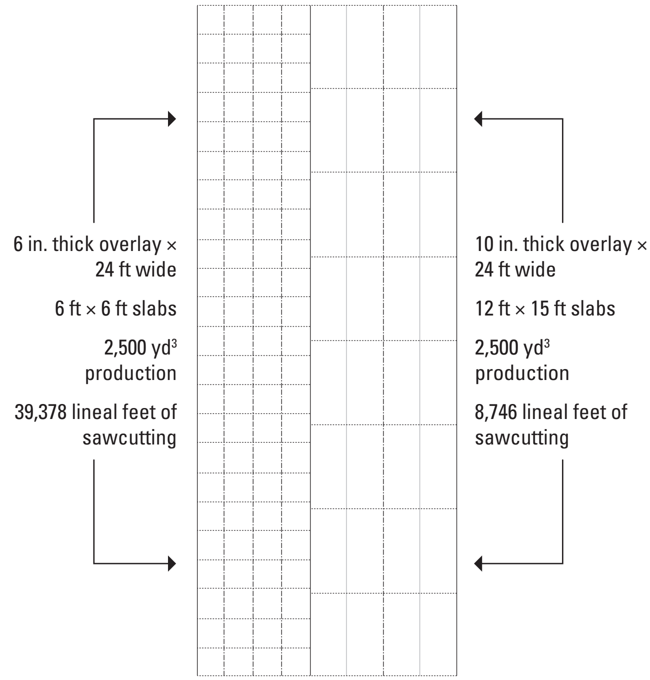
The two most common types of material used for the separation layer are asphalt and nonwoven geotextile. Asphalt separation layers typically consist of a stripping-resistant asphalt mixture with a nominal thickness of 1 in. The mixture is densely graded where drainage and stripping are not a concern and porous where drainage is a concern. Geotextile separation layers are nonwoven to promote positive drainage where needed. The geotextile fabric is 13 oz/yd^2 for overlays less than or equal to 5 in. thick or 15 oz/yd^2 for overlays greater than 5 in. thick.

Regardless of the material type, the separation layer should be constructed to allow for drainage. This is most commonly achieved by placing the separation layer to a width where it intersects with the ditch foreslope, a technique known as daylighting. Drainage of the separation layer can also be achieved through longitudinal underdrains.

Concrete Overlay Paving

The paving process for concrete overlays uses conventional materials, equipment, and methods. However, a few construction items specific to thin concrete overlays (less than 7 in. thick) differ from what is typical for the construction of standard concrete pavements. Thin overlays require the following adjustments:

- Curing. Because the surface-area-to-volume ratio is relatively high for thin overlays, thorough curing is critical to mitigate excessive drying shrinkage. The following should be considered:
  - Curing compound should be applied before any surface evaporation occurs.
  - A good-quality curing compound is recommended. Some state departments of transportation (DOTs) have had good success with alpha-methyl-styrene curing compounds, but at additional material cost.
  - Complete coverage with curing compound (including both the surface and sides of the overlay slab) is critical. Streaking and gaps in coverage should not be visible, and the cured surface should have an appearance similar to that of a white sheet of paper. A typical coverage rate is 150 ft² per gallon, applied in two coats.
- Sawing. Overlay placement rates can easily be limited by the number of saws available for joint sawing. Therefore, proper planning is necessary to ensure that production is not hindered by the ability of saw operators to saw joints effectively before cracking can occur. For thinner concrete overlays, several factors contribute to the need for earlier sawing and an increased number of saws:
  - For concrete overlays in general, stiffer underlying layers increase internal stresses and restraint in the early-age concrete compared to JPCP placed on a granular base.
  - Thinner overlay sections have a relatively high ratio of surface area to volume. This can lead to faster strength gain, which can increase the risk of random cracking unless the joint sawing operation is timely.
  - Thinner overlays generally require smaller panel sizes and therefore many more lineal feet of sawcutting than thicker overlays (Figure 13).



CP Tech Center

Figure 13. Comparison of sawcut lengths required for thinner (left) and thicker (right) overlays

During cooler periods, such as in the spring or autumn, the existing base and pavement expand and contract with the daily change in ambient temperature, and cracking may occur in the new overlay if control joints have not been established. Various options can be used to reduce this risk:

- Construct the overlay so that sufficient strength for sawing is achieved before temperatures drop at nighttime.
- Heat the concrete to maintain a fresh concrete temperature of at least 75°F.
- Use a nonchloride accelerating admixture to accelerate strength gain.
- Cover the new overlay with insulating blankets.

Opening to Traffic

With adequate planning, expedited staging, and efficient paving operations, resurfaced streets and highways can be opened to traffic within short periods of time.

Concrete overlays are similar to conventional pavement rehabilitation strategies in that numerous activities must occur in the time between paving and opening to traffic. For example, pavement edges need to be backfilled and temporary or permanent traffic control measures (pavement markings, signing, signals, guardrails, etc.) need to be installed before the pavement can be opened to traffic. In the case of a concrete overlay, however, these activities can take place concurrently with the cure time required for the overlay to reach the specified minimum strength for opening. Project-specific guidance for minimum opening strength is provided in *Concrete Strength Required to Open to Traffic* (Freeseman et al. 2016).

Because these ancillary construction activities generally require more time than the curing period, cure time is rarely on the critical path for opening a concrete overlay to traffic. Therefore, in most cases an agency's standard specifications for opening an ordinary concrete pavement to traffic can be used for concrete overlays.

When expedited opening to traffic is desired for specific sections of a project, accelerated mixtures can be used in conjunction with monitoring the strength development of the pavement. Temporary safety edges and maturity testing can also be beneficial in achieving early opening objectives.

Accelerated Construction

By their nature, concrete overlays involve accelerated construction. The existing pavement is reused in place with minimal disturbance, and the subgrade is never exposed to weather. Overall, the total construction duration is typically one-quarter to one-third that of a reconstruction project. One of the significant benefits of concrete overlay construction is this decrease in total construction time, which reduces road user costs and increases driver safety. Road user costs should be evaluated when selecting the type of rehabilitation to be implemented.

More generally, concrete overlays reduce the indirect time-related costs of road improvements. Not only do concrete overlays reduce construction delays and road closings, which are generally not well accepted by road users (FHWA 2018), they also offer confidence to agencies that the improvements will provide a long-life pavement.

Concrete overlay construction can be further accelerated through various means. Accelerated construction techniques may be used on critical parts of a project (such as intersections and crossovers), the final segment, or the entire project. While such techniques often involve conventional concrete pavement materials and procedures, key changes such as the following can significantly expedite projects:

- Contract incentives
- Modification of pavement equipment for minimum to zero clearance
- Material proportioning modifications
- Accelerated curing methods
- Alternative construction staging
- Approved changes to pavement joint layouts to facilitate maximum use of slipform placements
- Adjustments to the criteria for opening to traffic
- Use of accelerated concrete mixtures (for certain critical projects)

Lessons Learned

The Concrete Overlay Field Application Program was conducted by the CP Tech Center under a cooperative agreement with the Federal Highway Administration (FHWA) between 2013 and 2018. Through this program, expert teams provided training to over 1,400 individuals in 32 workshops, visited 20 overlay projects, and provided technical assistance, including design, specifications, and construction assistance, to 14 states. Overall, the program supported the construction of 37 new overlay projects. Upon reviewing the completed concrete overlay projects, the expert teams compiled the list of key lessons learned presented below.

Concrete Overlay Evaluation and Selection

- Use coring, falling weight deflectometer (FWD) testing, and as-built plans to investigate conditions and thicknesses of the existing pavement layer to determine the appropriate overlay type.
- In freeze-thaw climates and/or areas with expansive soils, evaluate the existing pavement in spring and summer to identify critical pavement distresses.
- Identify all vertical constraints (bridges, utilities, loop vehicle detectors, curbs, barriers, ramps and driveways, guardrails, and other structures) that may impact construction and develop a plan to mitigate them.

Concrete Overlay Design and Construction

- Consider partial and full detour options and their impact on construction.
- When a separation layer is used in non-arid climates, provide a drainage path for moisture to exit the pavement system.
- Consider costs, construction time, and performance when comparing asphalt and geotextile separation layers.
- Determine vertical transition lengths based on design speed limit, type of traffic control, and existing profile constraints.
- Only mill when necessary to mitigate profile grade constraints, remove surface deterioration, and/or improve bonding.
- The thickness of the existing asphalt is typically variable and profile grade requirements dictate a specific milling depth, meaning that some scabbing where the milling depth is at or near a lift line is common.
- When milling asphalt for projects where the existing asphalt pavement is to be left in place for some portion of the final pavement section, ensure that an adequate (3 in. minimum) depth of structurally sound asphalt remains.
- Establish a sound strategy and token pay items for areas where milling exposes subgrade or other base materials under the pavement.
- Use two bid items to minimize the risk to the contractor: square yards to cover placement and cubic yards to cover material.
- To improve the economy of construction and the performance of overlays with asphalt separation layers, correct irregularities in the existing pavement by varying the concrete overlay depth instead of thickening the asphalt separation layer.
- To minimize concrete quantity overruns, consider the following:
    - Use scanning technologies or conduct nine-line cross sections at 50 ft intervals to map the existing surface.
    - Develop a design centerline profile and cross slope that optimizes pavement smoothness and maintains a minimum overlay depth at the centerline.
    - Limit the contractor to a percent range of additional quantity placed; some states use 6% to 8%, depending on the thickness of the overlay.
- Review the construction sequence and maintenance of traffic plan in conjunction with joint type and layout for the mainline as well as any turning lanes and shoulders.
- Ensure that the staging plan allows for paving between existing and temporary barriers and railings.
- Design transitions and bridge approaches to maximize the use of a paving machine.
- For thin concrete overlays with a joint spacing of 6 ft or less, adequate and timely sawing and curing is critical.
- For overlays on pavements that have had previous widening and for overlays with integral widening, the widening detail should be reviewed carefully for drainage and support.

- Base the surface preparation activities on a prioritization of the following items:
  - Pavement smoothness
  - Concrete quantity
  - Maintenance of minimum cross slopes
  - Removal of unstable existing pavement layers
  - Vertical clearance conditions
  - Bond improvement between the existing pavement and overlay
- Sealing the joints of thinner (4 to 6 in.) concrete overlays, especially those with small panel sizes, is encouraged in wet weather states to mitigate the occurrence of blowups. Contraction and construction joints should be filled with a hot-poured joint sealant. (The use of a backer rod is not recommended.)
- In thin (4 to 6 in.) concrete overlays, field observations have shown that some contraction joints may not initially activate and, in some cases, do not activate until many years after construction. Contraction joints that do not activate may lead to unwanted dominant joints, increased joint maintenance, and negative impacts on concrete overlay performance. This is a topic of ongoing evaluation, but early loading has been shown to assist with joint activation.

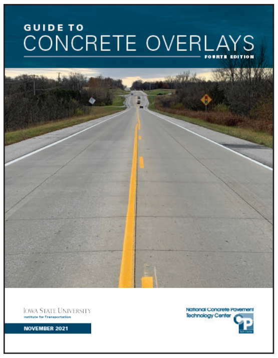
Plans and Specifications

- Reduce plan drawings to the necessary quantities, design details, plan/profile data (not sheets), and survey control information.
- Consider requiring vibrator frequency monitors on the paver.
- Utilize standard concrete mixes and the maturity method for opening critical sections of the road to traffic; minimize the use of accelerated concrete mixtures.
- For overlays with existing surface milling, clearly define vertical and cross slope limits and the required accuracy of the survey of the existing pavement.

Technical Resources

A number of technical resources are available from the National CP Tech Center and ACPA that further detail various aspects of concrete overlay selection, design, and construction.

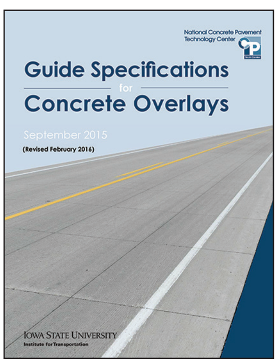
Guide to Concrete Overlays (Fourth Edition)



This guide (Fick et al. 2021) presents the basic principles that a pavement engineer needs to design and construct concrete overlays on existing asphalt, composite, and concrete pavements. Intended for both experienced engineers and less experienced users, the material in the guide is presented in the form of expert guidance meant to supplement readers' own professional experience and judgment.

https://intrans.iastate.edu/app/uploads/2021/11/guide_to_concrete_overlays_4th_Ed.pdf

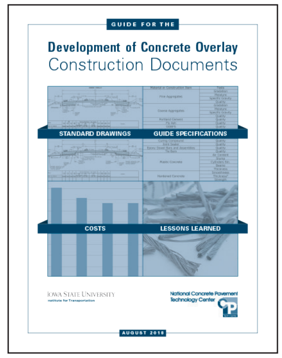
Guide Specifications for Concrete Overlays



This document (Fick and Harrington 2016) provides guidance for the development of project specifications that are tailored for concrete overlay projects. The guidance is based on a given agency's standard specifications for concrete pavements.

https://intrans.iastate.edu/app/uploads/2018/08/overlay_guide_specifications.pdf

Guide for the Development of Concrete Overlay Construction Documents

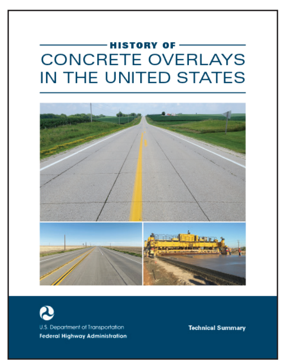


This document (Gross and Harrington 2018) provides guidance on the development of construction documents for concrete overlay projects. The guide includes a range of material essential to the design and construction of successful concrete overlay projects:

- Examples of construction drawings
- Guidance on the development of specifications
- Information on the costs involved in concrete overlay construction
- Lessons learned in concrete overlay design

https://intrans.iastate.edu/app/uploads/2018/09/overlay_construction_doc_dev_guide_w_cvr.pdf

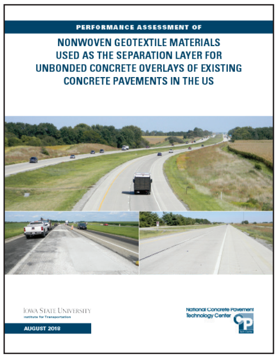
History of Concrete Overlays in the United States



The purpose of this technical brief (Gross, forthcoming) is to demonstrate the applicability of concrete overlays as an asset management solution on a wide array of existing pavement types and roadway classifications. The document provides a brief history of concrete overlay construction in the United States, summarizes performance information for 17 concrete overlay projects across the country, and includes a short list of additional resources.

https://cptechcenter.org/concrete-overlays/

Performance Assessment of Nonwoven Geotextile Materials Used as the Separation Layer for Unbonded Concrete Overlays of Existing Concrete Pavements in the US



This report (Cackler et al. 2018) summarizes the national performance experience of unbonded concrete overlays constructed since 2008 using geotextile separation layers, provides an overview of lessons learned, and highlights ongoing efforts to optimize the design and construction requirements for concrete overlay applications. The report also includes nine case studies that provide detailed performance information on overlays built with geotextile separation. Based on the performance of over 10 million square yards of concrete overlay placed using geotextile separation since 2008, the report concludes that nonwoven geotextile fabric works very well as a separation layer.

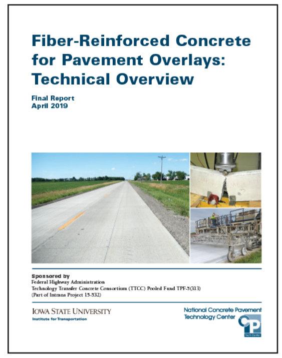
https://intrans.iastate.edu/app/uploads/2018/10/US_geotextile_performance_w_cvr.pdf

ACPA National Concrete Overlay Explorer

The ACPA's National Concrete Overlay Explorer (ACPA 2020) provides the most thorough historical database on the use of concrete overlays in the United States. The database documents the construction of 1,289 concrete overlays in the United States from 1901 through 2017 based on information from state self-reporting and past studies surveyed in National Cooperative Highway Research Program (NCHRP) Syntheses 99 (Hutchinson 1982) and 204 (McGee 1994). The website allows for project data to be filtered by overlay type, application, state, thickness, year of construction, project size, joint spacing, and reinforcing type.

http://overlays.acpa.org/webapps/overlayexplorer/index.html

Fiber-Reinforced Concrete for Pavement Overlays: Technical Overview



This report (Roesler et al. 2019) summarizes the state of the art regarding the different fiber types, test methods, structural design considerations, and construction modifications required for the use of fiber-reinforced concrete (FRC) materials in concrete overlays.

https://intrans.iastate.edu/app/uploads/2019/04/FRC_overlays_tech_ovw_w_cvr.pdf

Case Histories

Numerous case histories are available that show the performance of concrete overlay applications across the country. Additional examples are available in many of the technical resources presented above and on the CP Tech Center's website, https://cptechcenter.org.

Project highlights from 11 typical concrete overlay applications are summarized in Table 3 and described in greater detail in the following pages. Each case history includes photos of the concrete overlay under construction or in service and information on cost and smoothness.

Table 3. List of case histories

State/Route	Year constructed	Existing pavement and overlay type	Functional classification	Traffic volume	Maintenance of traffic strategy
California/I-8	2017	COC–U on JPCP	Interstate	19,000 annual average daily traffic (AADT) with 25% trucks	Contraflow
North Carolina/I-77	2007-2008	COC–U on CRCP	Interstate	31,500 AADT with 25% trucks	Maintain two lanes each direction
Kansas/I-70	2011-2012	COA–B on asphalt	Interstate	17,200 AADT with 25% trucks	Contraflow
South Dakota/US 12	2011	COC–U on JPCP	Primary highway	6,700 AADT with 11% trucks	Contraflow
Illinois/City of Macomb	2013	COA–B on asphalt over brick	Urban residential street	N/A	Road closed
North Dakota/US 2	2012	COA–B on asphalt	Urban (six intersections)	11,555 AADT with 5% trucks	Contraflow
Kansas/City of Salina	2012	COA–U on composite pavement	Urban intersection	32,000	Staged construction maintaining traffic
Iowa/County Route S10/S14	2009	COA–B on asphalt	County road	260-800 AADT	Closed to through traffic
West Virginia/US 30	2017	COC–U on jointed reinforced concrete pavement (JRCP)	Primary highway	8,985 AADT with 14% trucks	Mainline closed
Oklahoma/SH51	2016	COA–B on asphalt	Primary highway	2,000 AADT	Closed to through traffic
Colorado/SH13	2016	COA–B on asphalt	Primary highway	1,400 AADT with 20% trucks	24-hour pilot car

I-8 in Imperial County, California, 2017–2018

In 2017 and 2018, a CRCP COC–U overlay on JPCP was constructed between mileposts 159 and 166 on I-8 in California. This section of I-8 traverses Imperial Valley near the Arizona border and is traveled heavily by long-haul trucks as well as local transporters of agricultural products. Information about the overlay project, existing pavement, and construction is summarized in Table 4.

More detailed information about this project can be found in the plans, specifications, and bid tabulations available online:

- Plans and specifications: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/California_I-8_plans_and_specifications.pdf
- Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/California_I-8_11-418524_bid_results.pdf

Table 4. Project information for I-8 in Imperial County, California

Overlay details	
Overlay type	CRCP COC–U overlay on JPCP
Year constructed	2017
Overlay thickness (in.)	9
Project length (mi)	6.9
Current traffic	19,000 two-way AADT (2017), ≈25% trucks
Existing typical section	
Year of original construction	Circa 1970
Pavement type	JPCP
Width (ft)	24
Thickness (in.)	8.4
Joint spacing (ft)	≈20
Shoulders	5 ft wide inside and 10 ft wide outside (asphalt)
Subbase(s)	5.4 in. cement-treated base over 3 in. aggregate base over 6 in. aggregate subbase
Additional details	Longitudinal and transverse cracking, periodic crack sealing
Construction details	
Smoothness before and after construction (IRI)	≈115 in./mi before and ≈60 in./mi after; disincentive applied at 76 in./mi and corrective action required for IRI values greater than 90 in./mi
Pre-overlay repairs	Panel replacements and spall repair
Milling of existing pavement	N/A
Separation layer	2.4 in. asphalt layer
Maintenance of traffic strategy	Contraflow, with existing outside shoulder strengthened and temporary pavement placed in the median
Longitudinal joint spacing (ft)	12 ft wide passing lane and 14 ft wide truck lane
Transverse joint spacing (ft)	N/A
Load transfer dowels	N/A
Tie bars	#5 x 30 in. spaced at 48 in. center on center (c/c)
Reinforcement	#6 longitudinal bars spaced at 8.0 in. c/c; #6 transverse bars spaced at 48 in. c/c

Project highlights are as follows:

- The overall construction duration for this 6.9 mi long project was 18 months.
- Prior to construction of the COC–U overlay, the IRI values for this segment of I-8 averaged approximately 115 in./mi. After construction of the overlay (in March 2018), the westbound IRI values averaged approximately 61 in./mi.
- Mehdi Parvini of the California Department of Transportation (Caltrans) offered the following insights:
  - Innovation, efficiency, and sustainability are part of Caltrans's values and goals. Caltrans finds concrete overlays to be sustainable and cost-effective strategies that extend pavement life and improve both the functional and structural characteristics of pavements.
  - The CRCP COC–U overlay was designed using a mechanistic-empirical approach and constructed for the first time in California to address the safety, environmental, and cost issues associated with rehabilitation or replacement of the pavement.
  - The main elements of this rather innovative approach were to utilize the support capacity of the well-aged existing JPCP, employ a state-of-the-art design method, and provide the option of using recycled concrete aggregate (RCA) in the fresh concrete mixture.
  - Based on the estimated quantities and the winning bidder's unit costs, the construction of the COC–U overlay resulted in a savings of approximately $270,000 per lane-mile for the 84 lane-miles of the project compared to pavement replacement. (Note that this project was one of five contracts that ultimately overlaid more than one million square yards of the I-8 corridor in Imperial Valley. More information on the entire corridor can be found at https://swcpa.org/caltrans-overlays-i-8-across-the-imperial-valley-with-long-life-pavement/.)
  - This pilot project provided knowledge and experience to help expedite the implementation of this concrete overlay strategy into Caltrans specifications.

Figures 14 through 17 show the condition of the existing pavement and the construction of the overlay.

Mehdi Parvini, Caltrans, used with permission

Figure 14. Existing pavement condition on I-8, showing longitudinal cracking

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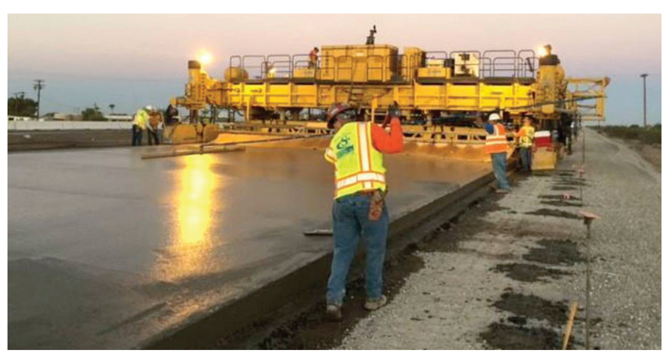
Figure 15. I-8 during CRCP COC–U overlay construction in November 2017, with existing eastbound lanes used for contraflow traffic control

Mehdi Parvini, Caltrans, used with permission

Figure 16. Slipform paving of the CRCP COC–U overlay on I-8



Mehdi Parvini, Caltrans, used with permission

Figure 17. COC–U overlay construction on I-8

I-77 in Yadkin County, North Carolina, 2007–2008

In 2007 and 2008, an JPCP COC–U overlay on CRCP was constructed between mileposts 72 and 79 on I-77 in North Carolina. This section of I-77 is located in the Greensboro, Winston-Salem, and High Point region of North Carolina where I-77 and US 421 intersect. This design-build project included some unique approaches to pavement reconstruction, maintenance of traffic, and adjustment of structures to accommodate the change in profile grade due to the COC–U overlay. Information about the overlay project, existing pavement, and construction is summarized in Table 5.

Table 5. Project information for I-77 in Yadkin County, North Carolina

Overlay details	
Overlay type	JPCP COC–U overlay on CRCP
Year constructed	2007 and 2008
Overlay thickness (in.)	11
Project length (mi)	6.5
Current traffic	31,500 two-way AADT (2019), ≈25% trucks
Existing typical section	
Year of original construction	1974
Pavement type	CRCP
Width (ft)	24
Thickness (in.)	8
Joint spacing (ft)	No transverse joints (CRCP); longitudinal joints at 12 ft
Shoulders	Asphalt
Subbase(s)	6 in. thick granular
Additional details	Punchouts, faulting at cracks, and mild alkali-silica reactivity (ASR)
Construction details	
Smoothness before and after construction (IRI)	Reinhart profilograph (0 blanking band) showed 32 in./mi before grinding and 12 in./mi after blanket grinding
Pre-overlay repairs	Minimal
Milling of existing pavement	None
Separation layer	1.5 in. asphalt layer
Maintenance of traffic strategy	Two-lane, two-way traffic maintained for most of the project using a temporary asphalt widening in conjunction with the inside shoulder of the unbonded overlay
Longitudinal joint spacing (ft)	12
Transverse joint spacing (ft)	15
Load transfer dowels	Yes
Tie bars	At centerline
Reinforcement	N/A

More detailed information about this project can be found in the request for proposals, typical sections, and bid tabulations available online:

- Request for proposals: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/North_Carolina_I-77_D-B_RFP_with_Addenda.pdf
- Typical sections: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/North_Carolina_I-77_D-B_Typical_Sections_HDR-Lane.pdf
- Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/North_Carolina_I-77_Lump_Sum_Bid_Tabs.pdf

Project highlights are as follows:

- Ramps and loops at the US 421 interchange were originally designed to be reconstructed with hot-mix asphalt (HMA). To meet an 11-day time restriction, the contractor instead proposed to use COC–U overlay sections, and the NCDOT agreed.
- The use of concrete maturity testing provided the contractor the means to open the pavement to construction traffic as soon as the minimum strength criteria had been met. Thus, subsequent construction activities were accelerated because all scheduled float time associated with curing time was eliminated.
- A single temporary widening in the median addressed the objectives of minimizing impacts on seasonal traffic and avoiding single-lane traffic patterns. The contract required two-lane, two-way traffic to be maintained during holidays, summer weekends, and NASCAR events. The contractor's approach consisted of utilizing a 12 ft wide JPCP inside shoulder and an 11 ft wide temporary asphalt widening to allow for two-lane, two-way traffic as required by the contract.
- Existing bridges were raised 13 in. to match the new elevation resulting from the thickness added by the COC–U overlay and separation layer.
- The project was 100% diamond ground to provide optimized pavement smoothness, reduced noise level, and desired texture.

Figures 18 through 21 show the condition of the existing pavement and the construction of the overlay.

Robert Heibel, Jr., The Lane Construction Company, used with permission

Figure 18. Existing pavement condition on I-77, with punchouts, ruptured steel, and faulting at cracks

ACPA, used with permission (The Lane Construction Corporation)

Figure 19. COC–U overlay construction on I-77 with two-lane crossover

ACPA, used with permission (The Lane Construction Corporation)

Figure 20. Bridge jacking to match the new COC–U overlay elevation on I-77

ACPA, used with permission (The Lane Construction Corporation)

Figure 21. Southbound lanes of I-77 opened to traffic, showing a median detour that had been carrying southbound traffic during COC–U overlay construction

I-70 in Ellsworth and Lincoln Counties, Kansas, 2011–2012

In 2011 and 2012, a JPCP COA–B overlay on asphalt pavement was constructed between mileposts 205 and 235.5 on I-70 in Kansas. This section of I-70 is located west of Salina, Kansas, beginning approximately 15 mi west of the junction of I-70 and I-135. The project, which consisted of multiple contracts, was over 30 mi long and was constructed by Koss Construction Company. Information about the overlay project, existing pavement, and construction is summarized in Table 6.

More detailed information about the Ellsworth County and Lincoln County projects can be found in the proposals, plans, special provisions, and bid tabulations available online:

- Ellsworth County:
  - Proposal: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_511072272_Proposal_Ellsworth.pdf
  - Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_511072272_Plans_Ellsworth.pdf
  - Special provisions: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_511072272_Special_Provisions_Ellsworth.pdf
  - Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_bid_tabs_Ellsworth.pdf

Table 6. Project information for I-70 in Ellsworth and Lincoln Counties, Kansas

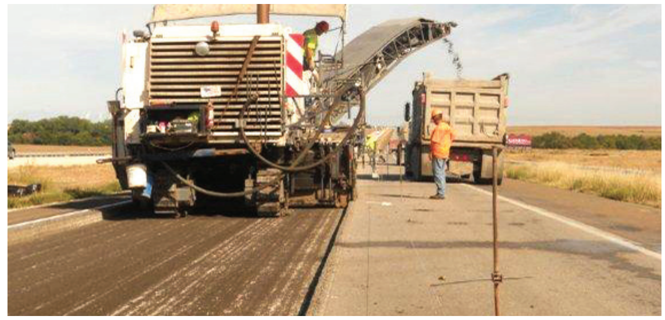
Overlay details	
Overlay type	JPCP COA–B overlay on asphalt
Year constructed	2011 and 2012
Overlay thickness (in.)	6
Project length (mi)	30+
Current traffic	17,200 two-way AADT (June 2021), >25% trucks
Existing typical section	
Year of original construction	1964
Pavement type	HMA
Width (ft)	40
Thickness (in.)	26 in. (17 in. original construction with additional 9 in. of overlays from 1974 through 2006)
Joint spacing (ft)	N/A
Shoulders	6 ft wide median and 10 ft wide outside
Subbase(s)	N/A
Additional details	Transverse and fatigue cracking
Construction details	
Smoothness before and after construction (IRI)	49 in./mi
Pre-overlay repairs	Minimal
Milling of existing pavement	Profile milled using string line machine control to a maximum depth of 6 in.
Separation layer	1.5 in. asphalt layer
Maintenance of traffic strategy	Contraflow two-way traffic was maintained on the existing I-70 pavement utilizing median crossovers at both ends of the project
Longitudinal joint spacing (ft)	6 and 5
Transverse joint spacing (ft)	6
Load transfer dowels	No
Tie bars	Yes, epoxy-coated #4 x 30 in. spaced at 36 in. c/c
Reinforcement	N/A

- Lincoln County:
  - Proposal: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_511072292_Proposal_Lincoln.pdf
  - Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_511072292_Plans_Lincoln.pdf
  - Special provisions: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_511072292_Special_Provisions_Lincoln.pdf
  - Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Kansas_I-70_bid_tabs_Lincoln.pdf

Project highlights are as follows:

- The existing asphalt pavement was profile milled to a maximum depth of 6 in. After milling, the depth of the remaining asphalt was approximately 20 in. After milling and before COA–B overlay construction, isolated locations of pavement and base failure in the shoulders were repaired by treating the in situ materials with fly ash (for smaller areas) or patching with HMA (for larger areas).
- Two-way, single-lane traffic was maintained using median crossovers and a contraflow pattern.
- A 40 ft wide (including a 6 ft median shoulder, 24 ft mainline, and 10 ft outside shoulder) by 6 in. thick COA–B overlay was placed on top of the milled surface.
- Nighttime paving was necessary during the summer months to ensure that the milled surface was less than 120°F.
- All five longitudinal joints were tied with epoxy-coated deformed bars at 36 in. c/c. The contract did not allow mechanical insertion of the tie bars. The contractor was granted permission to mechanically insert tie bars provided that the specified tolerances were achieved. With the use of ground penetrating radar mounted at the rear of the paver and handheld pachometers, the contractor was able to monitor tie bar placement in real time and adjust bars that were either at the wrong depth or too close to a planned transverse joint.
- With four longitudinal contraction joints and transverse contraction joints spaced at 6 ft c/c, high-production paving days required the sawing crew to complete approximately 54,000 lineal feet of joint sawing per day.
- Current IRI values range from 63 to 110 (average 86) in./mi according to 2020 data obtained from the Kansas Department of Transportation's (KDOT's) pavement management system.

Figures 22 through 25 show the construction of the COA–B overlay.



ACPA, used with permission (Koss Construction Co., Inc.)

Figure 22. Profile milling of the existing pavement on I-70 using string line machine control

ACPA, used with permission (Koss Construction Co., Inc.)

Figure 23. COA–B overlay construction on I-70, with traffic using a contraflow pattern

Koss Construction Co., Inc., used with permission

Figure 24. Nighttime paving on I-70 during the summer months

ACPA, used with permission (Koss Construction Co., Inc.)

Figure 25. Longitudinal and transverse joint sawing caught up to the paving operation on I-70, with eight saws required to keep pace

US 12 Westbound Lanes in Brown County, South Dakota, 2012

In 2012, a COC–U overlay was constructed in the westbound lanes of US 12 in Brown County, South Dakota, from 0.9 mi east of the BNSF overpass to Bath Corner (395th Avenue) approximately 8.5 mi west.

Information about the overlay project, existing pavement, and construction is summarized in Table 7.

Table 7. Project information for US 12 in Brown County, South Dakota

Overlay details	
Overlay type	COC–U overlay on JPCP
Year constructed	2012
Overlay thickness (in.)	8
Project length (mi)	8.5
Current traffic	6,700 two-way AADT (2019), ≈11% trucks
Existing typical section	
Year of original construction	Before 1985 based on Google Earth images
Pavement type	JPCP
Width (ft)	24
Thickness (in.)	8
Joint spacing (ft)	Variable, 13 to 18
Shoulders	4 ft wide median and 10 ft wide outside
Subbase(s)	4 in. lime-treated gravel cushion
Additional details	Faulting
Construction details	
Smoothness before and after construction (IRI)	193 in./mi before, less than 70 in./mi after
Pre-overlay repairs	Minimal, some leveling at locations of severe faulting
Milling of existing pavement	None
Separation layer	≈15 oz/yd^2 black and gray nonwoven geotextile fabric
Maintenance of traffic strategy	Contraflow, westbound traffic shifted to the inside lane of the eastbound lanes
Longitudinal joint spacing (ft)	12 ft from median shoulder joint (mainline paved 26 ft wide, including 12 ft passing lane and 14 ft truck lane)
Transverse joint spacing (ft)	15
Load transfer dowels	Yes, within the wheel paths only, epoxy-coated 1 ¼ in. x 18 in. spaced at 12 in. c/c
Tie bars	Yes, epoxy-coated #5 x 48 in. spaced at 30 in. c/c
Reinforcement	N/A

More detailed information about this project can be found in the plans, addendum, special provisions, and bid tabulations available online:

- Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/South_Dakota_US12_023C_Plans.pdf
- Addendum: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/South_Dakota_US12_023C_Addendum_1.pdf
- Special provisions: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/South_Dakota_US12_023C_Special_Provisions.pdf
- Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/South_Dakota_US12_Bid_Tabs.pdf

Project highlights were as follows:

- This project was one of the first in the US to feature full-scale implementation of a geotextile separation layer.
- Both black and gray geotextiles were used as separation layer materials. An informal study was performed by the geotextile manufacturer to assess the impact of geotextile color on early-age temperature gradients in the unbonded overlay.
- The existing pavement had moderate to severe faulting and joint deterioration, but minimal pre-overlay repairs were performed.
- The paving train utilized an “Iowa Special” concrete spreader in front of the slipform paver.
- Prior to construction of the COC–U, the IRI values for this segment of US 12 averaged 193 in./mi (2011). Current IRI values range from 50 to 135 in./mi, with an average of 71 in./mi (2020).

Figures 26 through 29 show the construction of the COC–U overlay and a core taken.

Darin Hodges, SDDOT, used with permission

Figure 26. Gray geotextile separation layer placed on top of the existing JPCP on US 12

Darin Hodges, SDDOT, used with permission

Figure 27. Placement of dowel baskets between the “Iowa Special” concrete spreader and the slipform paving machine on US 12

Darin Hodges, SDDOT, used with permission

Figure 28. Slipform placement of the COC–U overlay on US 12

Darin Hodges, SDDOT, used with permission

Figure 29. Inverted core extracted from the concrete overlay on US 12, showing the geotextile separation layer adhering to the COC–U overlay

Carroll Street in Macomb, Illinois, 2013

In 2013, a JPCP COA–B overlay on asphalt-brick composite pavement was constructed on Carroll Street in the city of Macomb (population approximately 18,000) in McDonough County, Illinois. The project extended from US 67 east approximately 0.5 mi (8 blocks) to N. White Street. Carroll Street is a typical tree-lined, midwestern, small town, residential street. Originally constructed as a brick pavement on a sand foundation with quarried stone curbs, the street had been overlaid with asphalt numerous times before the concrete overlay was constructed in 2013. Information about the overlay project, existing pavement, and construction is summarized in Table 8.

Project highlights are as follows:

- Variable-depth milling was used to mitigate the parabolic crown of the existing pavement. Existing bricks were exposed in some areas where the asphalt overlay thickness was not uniform.
- The existing stone curb was replaced with a concrete curb and gutter section placed outside the limits of the existing pavement, providing a wider street to accommodate on-street parking and a dedicated bicycle lane.
- A 4 in. thick COA–B reinforced with synthetic structural fibers was constructed on the milled surface. Joint spacing is ±4 ft in each direction.

Table 8. Project information for Carroll Street in Macomb, Illinois

Overlay details	
Overlay type	JPCP COA–B overlay on asphalt-brick composite pavement
Year constructed	2013
Overlay thickness (in.)	4
Project length (mi)	0.5
Current traffic	N/A: pavement design based on typical residential street loading (garbage trucks, school buses, delivery trucks, etc.)
Existing typical section	
Year of original construction	Unknown, but likely before 1950
Pavement type	Brick pavers on a natural sand foundation with numerous asphalt overlays
Width (ft)	±18
Thickness (in.)	Variable-thickness asphalt overlay on original brick pavers
Joint spacing (ft)	N/A
Shoulders	N/A
Subbase(s)	Sand foundation underneath brick pavers
Additional details	N/A
Construction details	
Smoothness before and after construction (IRI)	Unknown before construction; overall average of 105 in./mi after construction according to inertial profiler
Pre-overlay repairs	Minimal
Milling of existing pavement	Variable depth to mitigate the existing parabolic crown. After milling, the concrete overlay was nominally 4 in. thick at the crown point and up to 7 in. thick at the curb and gutter sections.
Separation layer	N/A
Maintenance of traffic strategy	Road closed to through traffic during construction of each four-block-long segment, crossing streets kept open
Longitudinal joint spacing (ft)	±4
Transverse joint spacing (ft)	±4
Load transfer dowels	No
Tie bars	No
Reinforcement	Concrete overlay mixture dosed with 4 lb/yd^3 of synthetic structural fibers

- The project was completed in four months, with construction accomplished in two phases of four blocks each. Each four-block segment was closed to traffic while under construction. Prior to starting the project, an informational letter was hand-delivered to every resident and business owner along the length of the project. This letter gave a brief overview of the project, outlined the anticipated schedule, provided closure information, and included contact information for key personnel. Additional letters were provided throughout the project to keep all parties informed of project changes and progress.
- Over 40 mature trees were adjacent to the street. Despite the widening of the roadway, only one tree was lost during construction.

Figures 30 through 35 show the construction and current condition of the overlay.

Mike Ayers, ACPA, IL Chapter, used with permission

Figure 30. Carroll Street just east of the project limits, depicting the pre-overlay condition of the existing pavement (2021)

Randy Riley, ACPA, IL Chapter, used with permission

Figure 31. Carroll Street with the new concrete curb and gutter sections installed before overlay paving, showing the nonuniformity of the milled surface

Randy Riley, ACPA, IL Chapter, used with permission

Figure 32. COA–B overlay placement on Carroll Street using a bridge deck paver riding on the new curb and gutter sections

Randy Riley, ACPA, IL Chapter, used with permission

Figure 33. Carroll Street after construction of the COA–B overlay, showing square panels with joints at ±4 ft in each direction

Mike Ayers, ACPA, IL Chapter, used with permission

Figure 34. Closeup of the surface of the COA–B overlay on Carroll Street, with structural fibers visible at the pavement's surface (2021)

Mike Ayers, ACPA, IL Chapter, used with permission

Figure 35. Minor cracking on Carroll Street after nearly eight years, with the structural fibers holding the crack tight (2021)

West Dakota Parkway (US 2) in Williston, North Dakota, 2012

In 2012, six JPCP COA–B overlays on asphalt pavement were constructed at six urban intersections within the city limits of Williston in Williams County, North Dakota. Due to an oil boom that began in 2010, the city's population grew from 14,000 to an estimated total of over 60,000 by 2014. Roads that were designed to carry agricultural trucks with seasonal peaks had seen a dramatic increase in heavy truck traffic. The existing asphalt pavement on the primary arterial route through Williston, the West Dakota Parkway (US 2), had become severely rutted. North Dakota Department of Transportation (NDDOT) engineers seized an opportunity to repair the rutted intersections with COA–B overlays. Information about the overlay project, existing pavement, and construction is summarized in Table 9.

Table 9. Project information for West Dakota Parkway (US 2) in Williston, North Dakota

Overlay details	
Overlay type	JPCP COA–B overlay on asphalt
Year constructed	2012
Overlay thickness (in.)	6 and 7
Project length (mi)	Six intersections of varying lengths to accommodate braking, acceleration, and turning movements for all intersection quadrants
Current traffic	11,555 two-way AADT, 5% trucks
Existing typical section	
Year of original construction	Before 1985 based on Google Earth images
Pavement type	Asphalt of various ages and mix types
Width (ft)	Variable
Thickness (in.)	Variable
Joint spacing (ft)	N/A
Shoulders	N/A
Subbase(s)	Sand foundation underneath brick pavers
Additional details	N/A
Construction details	
Smoothness before and after construction (IRI)	N/A: straightedge requirement only due to the short paving runs
Pre-overlay repairs	Minimal
Milling of existing pavement	Profile milled using the same string line as paving, with 4 to 6 in. of asphalt remaining after milling
Separation layer	N/A
Maintenance of traffic strategy	Contraflow, placing both directions of traffic in adjacent lanes
Longitudinal joint spacing (ft)	6
Transverse joint spacing (ft)	6
Load transfer dowels	No
Tie bars	At longitudinal joints between lanes only, #4 x 30 in. spaced at 30 in. c/c
Reinforcement	N/A

More detailed information about this project can be found in the plans, special provisions, change orders, and cost estimates available online:

- Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/North_Dakota_US2_SOI-7-002123014_Final-Plans_1.pdf, https://intrans.iastate.edu/app/uploads/sites/7/2021/09/North_Dakota_US2_SOI-7-002123014_Final-Plans_2.pdf
- Special provisions: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/North_Dakota_US2_86608_Special_Provisions_19801.pdf
- Change orders: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/North_Dakota_US2_SOI-7-002123014_Change_Order_1_and_2.pdf
- Cost estimates: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/North_Dakota_US2_SOI-7-002123014_Cost_Estimate_and_Update.pdf

Project highlights are as follows:

- Deemed an emergency, the COA–B overlays at six intersections, totaling over 85,000 yd², were added to a previously planned NDDOT project.
- The contractor suggested a construction sequence that would place traffic in a contraflow pattern, which allowed full-width paving and reduced the construction duration by two weeks. More than 20 phases were required to complete the six intersections.
- Heavy traffic made preconstruction surveys impractical, and therefore each intersection was designed in the field. Beginning with the change in the traffic pattern, the construction sequence of each intersection consisted of an initial survey, field design, milling, paving, joint sawing, and the restoration of permanent traffic control measures. Each intersection was completed within one week.
- The 6 and 7 in. thick COA–B overlays utilized a slightly modified mixture (564 lb/yd³ of Type I/II cement with 20% Class F fly ash replacement and admixtures) and routinely reached the required 550 psi opening strength in 36 hours, as determined by maturity testing.

Figures 36 through 39 show the construction and completed condition of the overlay.

ACPA, used with permission (Acme Concrete Paving Inc.)

Figure 36. Milling of the West Dakota Parkway

ACPA, used with permission (Acme Concrete Paving Inc.)

Figure 37. Nighttime paving on the West Dakota Parkway to avoid heavy traffic and allow for consistent delivery of mixture to the paver

ACPA, used with permission (Acme Concrete Paving Inc.)

Figure 38. Concrete mixture being placed on the milled surface of the West Dakota Parkway, with tie bars between lanes on P-stakes

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Figure 39. COA–B overlay placed in the left lane of the West Dakota Parkway just west of a major left-turn movement, with the existing inside shoulder and less traveled right lane and shoulder undisturbed during overlay construction

Intersection of E. Crawford Street and S. Ohio Street in Salina, Kansas, 2012

In 2012, a JPCP COA–U overlay on composite pavement was constructed at the intersection of E. Crawford Street and S. Ohio Street in the city of Salina in Saline County, Kansas. This intersection, the busiest in Salina, carries over 32,000 vehicles per day. A planned project on another route in Salina would utilize this already busy intersection as a detour. To avoid any delays to that project, the city opted to construct an 8 in. thick unbonded concrete overlay over the existing composite pavement, which consisted of an original concrete pavement that had been overlaid with variable-thickness asphalt. Information about the overlay project, existing pavement, and construction is summarized in Table 10.

Table 10. Project information for intersection of E. Crawford Street and S. Ohio Street in Salina, Kansas

Overlay details	
Overlay type	COA–U overlay on composite pavement
Year constructed	2012
Overlay thickness (in.)	8
Project length (mi)	Five lanes extending ≈150 ft in each direction from the center of the intersection
Current traffic	> 30,000 AADT
Existing typical section	
Year of original construction	Circa 1950
Pavement type	Composite: concrete with asphalt overlay
Width (ft)	Five lanes, ≈60 total
Thickness (in.)	Variable
Joint spacing (ft)	N/A
Shoulders	N/A
Subbase(s)	Granular
Additional details	N/A
Construction details	
Smoothness before and after construction (IRI)	N/A: urban section, straightedge requirement
Pre-overlay repairs	Areas of failed pavement exposed during the milling operation excavated and brought to grade with compacted granular base
Milling of existing pavement	Yes, variable depth
Separation layer	N/A
Maintenance of traffic strategy	Constructed in quadrants, traffic carried on adjacent lanes
Longitudinal joint spacing (ft)	12
Transverse joint spacing (ft)	12
Load transfer dowels	Yes
Tie bars	#5 x 30 in. spaced at 30 in. c/c
Reinforcement	N/A

Project highlights are as follows:

- A letter to the editor published in the *Salina Journal* stated the following: “The city staff and the contractor should be commended for the street improvements at the intersection of Ohio and Crawford Streets.”
- Though the project was scheduled for completion in 60 days, the contractor completed the project in 45 days, earning the maximum early completion incentive of $18,000.
- Unit price pay items established in the contract were used whenever changes were necessary due to the variable thickness of the existing pavement section.
- The total project cost was just over $425,000, with the concrete overlay costs representing approximately 30% of the contract amount.
- Approximately 20% of the project area involved full reconstruction to provide transitions into the existing profile grade and to correct areas where the underlying pavement had failed.

Figures 40 through 43 show the condition of the existing pavement and the construction and completed condition of the COA–U overlay.

ACPA, used with permission (Pavers Inc.)

Figure 41. Milling of the existing asphalt overlay(s) at the intersection of E. Crawford Street and S. Ohio Street

ACPA, used with permission (Pavers Inc.)

Figure 42. Fixed-form construction of the COA–U overlay at the intersection of E. Crawford Street and S. Ohio Street

ACPA, used with permission (Pavers Inc.)

Figure 40. Pavement condition at the intersection of E. Crawford Street and S. Ohio Street prior to the overlay

ACPA, used with permission (Pavers Inc.)

Figure 43. Finished project at the intersection of E. Crawford Street and S. Ohio Street, including new curb and gutter sections, inlets, and sidewalks

County Highway S10/S14 in Worth County, Iowa, 2009

In 2009, a JPCP COA–B overlay on asphalt pavement was constructed on County Highway S10/S14 in Worth County, Iowa. With one wind turbine for every 35 people, the roadways in Worth County had experienced increased heavy loading associated with the construction of wind farms. To make needed repairs to County Highway S10/S14, the county engineer developed a 23 mi long concrete overlay project that extended from the border with Cerro Gordo County in the south to the border with Minnesota in the north. Information about the overlay project, existing pavement, and construction is summarized in Table 11.

Table 11. Project information for County Highway S10/S14 in Worth County, Iowa

Overlay details	
Overlay type	COA–B overlay on asphalt
Year constructed	2009
Overlay thickness (in.)	4
Project length (mi)	+23
Current traffic	260 to 800 AADT (2017)
Existing typical section	
Year of original construction	Circa 1970
Pavement type	HMA
Width (ft)	22
Thickness (in.)	Variable
Joint spacing (ft)	N/A
Shoulders	N/A
Subbase(s)	Granular
Additional details	N/A
Construction details	
Smoothness before and after construction (IRI)	Not required by contract due to the limited pad line; post-construction smoothness averaged under 3 in./mi (California profilograph with 0.2 in. blanking band)
Pre-overlay repairs	None
Milling of existing pavement	No
Separation layer	N/A
Maintenance of traffic strategy	Roadway closed to traffic, property owners granted access through ditches and shoulders
Longitudinal joint spacing (ft)	±6
Transverse joint spacing (ft)	6
Load transfer dowels	No
Tie bars	N/A
Reinforcement	N/A

More detailed information about this project can be found in the plans and contract documents available online:

- Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Iowa_S10-S14_Plans.pdf
- Contract documents: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Iowa_S10-S14_Contracts.pdf

Project highlights are as follows:

- After construction of the COA–B overlay, the county engineer wrote the following as an endorsement of this project for an industry award:

  > Because of economics, money to budget for road improvements is very tight, and the County sought to get the best value for its money when designing the overlay project. Through the use of Tax Increment Financing (TIF), the County was able to overlay a remarkable 34 mi of pavement, 24 mi of which was placed as a 4 in. unbonded portland cement concrete (PCC) overlay on existing hot-mix asphalt (HMA). The County bid a 3 in. HMA overlay versus a 4 in. PCC overlay and determined that if PCC bids came in that were within 10% of the HMA bids, the County would choose PCC. This determination was based on the longevity of PCC versus HMA. As it turned out, the lowest PCC bid came in roughly 9% higher than the lowest HMA bid.

- The entire plan set for this 23 mi project consisted of 10 sheets.
- No pre-overlay repairs were performed, and surface preparation prior to the overlay consisted only of power sweeping.
- Six curves were upgraded from crowned sections to superelevated cross slopes by placing a variable-thickness concrete overlay.
- The road was closed to through traffic in sections as the paving progressed across the county. The contractor's project manager provided daily updates to every property owner that would be affected by that day's paving operations.
- Paving production was limited by the small panel sizes (approximately 6 ft x 6 ft) and the associated effort required to saw joints. The project's highest production day required over 54,000 lineal feet of joint sawing.
- The entire project was opened to unrestricted traffic in 110 calendar days.

Figures 44 through 47 show the construction of the COA–B overlay and its condition after one year in service.

ACPA, used with permission (Cedar Valley Corp.)

Figure 44. Paving of the COA–B overlay on County Highway S10/S14, with no milling of the existing roadway surface prior to overlay placement

ACPA, used with permission (Cedar Valley Corp.)

Figure 45. Variable-depth concrete used to upgrade a curve on County Highway S10/S14 to a superelevated cross slope

ACPA, used with permission (Cedar Valley Corp.)

Figure 46. Sawing of longitudinal joints on County Highway S10/S14, with saws in the distance cutting transverse contraction joints

ACPA, used with permission (Cedar Valley Corp.)

Figure 47. Finished COA–B overlay on County Highway S10/S14 after approximately one year

US 30 in Hancock County, West Virginia, 2017

In 2017, a JPCP COC–U overlay on JRCP was constructed on US 30 in Hancock County, West Virginia. The project extended from the east approach to the Ohio River Bridge in Chester, West Virginia, for 0.7 mi to the east and included ramps. The existing 9 in. thick JPCP on this section of US 30 had deteriorated to a level that required rehabilitation, and the West Virginia Department of Transportation (WVDOT) designed a 7 in. thick COC–U overlay for the project. Information about the overlay project, existing pavement, and construction is summarized in Table 12.

Table 12. Project information for US 30 in Hancock County, West Virginia

Overlay details	
Overlay type	COC–U overlay on JRCP
Year constructed	2017
Overlay thickness (in.)	7
Project length (mi)	0.7 mi plus ramps
Current traffic	8,985 AADT (2020), 14.4% trucks
Existing typical section	
Year of original construction	Circa 1965
Pavement type	JPCP
Width (ft)	Variable (≈16 to 33)
Thickness (in.)	9
Joint spacing (ft)	≈60
Shoulders	HMA
Subbase(s)	Granular slag
Additional details	Mid-panel cracking and joint deterioration with periodic maintenance patching
Construction details	
Smoothness before and after construction (IRI)	Less than 65 in./mi
Pre-overlay repairs	Isolated full-depth patching and partial-depth filling of deteriorated joints
Milling of existing pavement	No
Separation layer	HMA (nominally 1 in. thick)
Maintenance of traffic strategy	Mainline closed to traffic, ramp movements maintained and construction adjacent to traffic where necessary
Longitudinal joint spacing (ft)	±6
Transverse joint spacing (ft)	6
Load transfer dowels	No
Tie bars	Yes, #5 x 30 in. spaced at 30 in. c/c
Reinforcement	N/A

More detailed information about this project can be found in the plans, special provisions, bid items, and standards available online:

- Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/West_Virginia_US30_1516124_Plan_Set.pdf
- Special provisions: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/West_Virginia_US30_Special_Provisions.pdf
- Bid items: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/West_Virginia_US30_Bid_Items.pdf
- Standards: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/West_Virginia_US30_2015_Standard_Details_Vol1.pdf

Project highlights are as follows:

- This 2017 project was the first concrete overlay to be constructed in West Virginia.
- The contract called for a nine-day roadway closure that utilized a 20 mi long detour during construction. The contractor proposed an alternate maintenance of traffic plan that eliminated the lengthy detour and kept ramp movements open during construction. This plan also provided uninterrupted access to local businesses. This alternate plan was accepted by WVDOT.
- Pre-overlay repairs consisted of minor quantities of full-depth patching where the existing pavement had failed and partial-depth filling of deteriorated joints.
- A 1 in. thick asphalt separation layer was used to isolate the unbonded concrete overlay from the existing deteriorated JPCP.
- The average IRI value after construction was less than 65 in./mi.

Figures 48 through 51 show the condition of the existing pavement and the construction and completed condition of the COC–U overlay.

Figure 48. Existing pavement condition on US 30 prior to overlay placement (September 2016)

ACPA, used with permission (Golden Triangle Construction)

Figure 49. Paving of the COC–U overlay on US 30 over an asphalt separation layer

ACPA, used with permission (Golden Triangle Construction)

Figure 50. COC–U overlay placement on US 30

ACPA, used with permission (Golden Triangle Construction)

Figure 51. Completed COC–U overlay on US 30, with ramp movements maintained during construction

SH51 in Blaine County, Oklahoma, 2016

In 2016, a JPCP COA–B overlay on an asphalt pavement was constructed on SH51 in Blaine County, Oklahoma. The project extended from the intersection with SH58 to the intersection with SH51A 5.5 mi east. The Oklahoma Department of Transportation (ODOT) had initially designed a 3 in. thick asphalt overlay to repair this section of SH51. The project was bid twice, with ODOT receiving only one bid each time and each bid exceeding the allocated funds. The ODOT Assistant Division Engineer then opted to design a 5 in. thick concrete overlay and rebid the project for a third time. The concrete overlay project received four competitive bids on June 16, 2016, and the 5.5 mi long concrete overlay was completed on September 7, 2016, less than 90 days after the bids were opened. Information about the COA–B overlay project, existing pavement, and construction is summarized in Table 13.

Table 13. Project information for SH51 in Blaine County, Oklahoma

Overlay details	
Overlay type	JPCP COA–B overlay on asphalt
Year constructed	2016
Overlay thickness (in.)	5
Project length (mi)	5.5
Current traffic	2,000 AADT (2018)
Existing typical section	
Year of original construction	Circa 1960
Pavement type	Asphalt
Width (ft)	Variable (≈28)
Thickness (in.)	> 6 in.
Joint spacing (ft)	N/A
Shoulders	HMA
Subbase(s)	Granular
Additional details	N/A
Construction details	
Smoothness before and after construction (IRI)	Less than 30 in./mi (zero blanking band)
Pre-overlay repairs	None
Milling of existing pavement	Yes
Separation layer	N/A
Maintenance of traffic strategy	Roadway closed to traffic, local access maintained through the construction area
Longitudinal joint spacing (ft)	±7.5
Transverse joint spacing (ft)	6
Load transfer dowels	No
Tie bars	No
Reinforcement	Fiber reinforcement

More detailed information about this project can be found in the plans, sample proposal, and bid tabulations available online:

- Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Oklahoma_SH51_SSR-106C122SR_Plans.pdf
- Sample proposal: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Oklahoma_SH51_CO015_160616_JP2813904_Sample_Proposal.pdf
- Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Oklahoma_SH51_Bid_Tab.pdf

Project highlights are as follows:

- Fiber reinforcement at 3 lb/yd³ was specified as a factor of safety to mitigate any cracks that might occur over the life of the concrete overlay.
- The width of the existing asphalt pavement varied throughout the length of the project. Excess asphalt millings were used to provide an adequate subbase where the concrete overlay was wider than the existing pavement. Drainage structures were extended to accommodate the widened roadway.
- The roadway was closed to through traffic and constructed in sections to allow access for adjacent property owners.
- The contractor's project manager provided face-to-face daily briefings with the affected property owners to keep them apprised of progress and to explain how to safely navigate the area under construction. After the overlay was paved but miscellaneous construction activities continued, trained flaggers were used to direct local traffic through the construction zone.
- The average profile index value after construction and corrective actions was less than 30 in./mi (zero blanking band).

Figures 52 through 55 show the construction and completed condition of the COA–B overlay.

ACPA, used with permission (Duit Construction Company, Inc.)

Figure 52. Full-width paving of the COA–B overlay on SH51, with the milled surface of the existing pavement visible

ACPA, used with permission (Duit Construction Company, Inc.)

Figure 53. COA–B overlay placement on SH51, with the texture and curing operations following closely behind the paving

ACPA, used with permission (Duit Construction Company, Inc.)

Figure 54. Sawing operations on SH51 timed to prevent random cracking

ACPA, used with permission (Duit Construction Company, Inc.)

Figure 55. Completed COA–B overlay on SH51, with drainage structures extended to accommodate widening of the existing roadway

SH13 in Moffat County, Colorado, 2016

In 2016, a JPCP COA–B overlay on an asphalt pavement was constructed on SH13 in Moffat County, Colorado, from milepost 98 extending north 6 mi to milepost 104. This section of SH13 in western Colorado connects I-70 to the south with I-80 to the north in Wyoming and has an AADT of 1,400 with 20% trucks. Being in a remote area, SH13 does not have feasible detour routes. Therefore, a 24-hour pilot car operation was used to maintain two-way traffic on the existing two-lane roadway through the 6 mi long construction zone. Information about the COA–B overlay project, existing pavement, and construction is summarized in Table 14.

Table 14. Project information for SH13 in Moffat County, Colorado

Overlay details	
Overlay type	JPCP COA–B on asphalt
Year constructed	2016
Overlay thickness (in.)	6
Project length (mi)	6
Current traffic	1,400 AADT, 20% trucks
Existing typical section	
Year of original construction	Circa 1970
Pavement type	Asphalt
Width (ft)	40
Thickness (in.)	8 to 15
Joint spacing (ft)	N/A
Shoulders	HMA
Subbase(s)	Granular
Additional details	N/A
Construction details	
Smoothness before and after construction (IRI)	Less than 45 in./mi
Pre-overlay repairs	None
Milling of existing pavement	Yes, variable-depth profile milling optimized for smoothness, cross slopes, thickness, and concrete yield
Separation layer	N/A
Maintenance of traffic strategy	24-hour pilot car, one lane, two-way traffic
Longitudinal joint spacing (ft)	6 for the mainline and 8 for the shoulders
Transverse joint spacing (ft)	6
Load transfer dowels	No
Tie bars	Yes, at longitudinal construction joints, #4 x 30 in. spaced at 36 in. c/c
Reinforcement	N/A

More detailed information about this project can be found in the plans, specifications, and bid tabulations available online:

- Plans: https://intrans.iastate.edu/app/uploads/sites/7/2021/08/Colorado_SH13_STA-0132-019_Plan_Sheets.pdf
- Specifications: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Colorado_SH13_STA-0132-019_Specs.pdf
- Bid tabulations: https://intrans.iastate.edu/app/uploads/sites/7/2021/09/Colorado_SH13_STA-0132-019_Alt_Bid_Tabs.pdf

Project highlights are as follows:

- An initial survey of the existing pavement led to the development of an optimized profile for the COA–B overlay.
- The contractor performed profile milling to establish a new profile and cross slopes and to control concrete yield.
- The edges of the existing pavement were excavated prior to milling and then backfilled with compacted millings to provide a stable track line for the paver.
- Milling in one lane was performed concurrently with concrete overlay paving in the opposing lane. This was facilitated by having the pilot car alternate lanes through the construction zone.
- The contractor's paving operation utilized real-time smoothness measurements and a specially fabricated V-float attached to the paver, which eliminated the need for hand finishing.
- The average IRI value after construction and corrective actions was less than 45 in./mi.

Figures 56 through 59 show the construction and completed condition of the COA–B overlay.

ACPA, used with permission (Castle Rock Construction Company)

Figure 56. Paving of the first pass of the COA–B overlay on SH13, showing the milled surface ahead of the paver and the condition of the existing pavement

ACPA, used with permission (Castle Rock Construction Company)

Figure 57. Paving of the second pass of the COA–B overlay on SH13, with the match side of the paver not using a string line to control the paver

ACPA, used with permission (Castle Rock Construction Company)

Figure 58. Overlay placement on SH13, with one-way traffic adjacent to paving and the texture and curing operations following closely behind the paving

ACPA, used with permission (Castle Rock Construction Company)

Figure 59. Completed COA–B overlay on SH13

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