Concrete Overlays

The Latest Strategies for Successful Projects on Highways, Streets, and Parking Lots

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Institute for Transportation

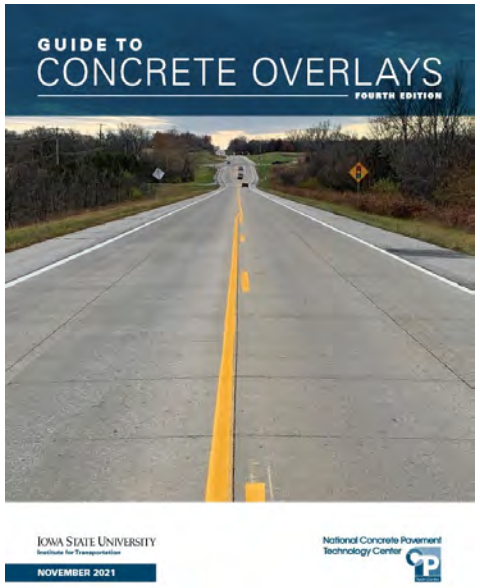
National Concrete Pavement Technology Center
Tech Center

Outline

- Introduction
- Concrete Overlay Basics
  - Project Evaluation
  - Design
  - Construction
- Special Considerations & Lessons Learned

Acknowledgments & Further Information

- Thanks to Iowa DOT & ICPA for their support of this program
- Much more information is available in these documents:
  - https://cptechcenter.org/concrete-overlays/



Introduction

What is a Concrete Overlay?

- Extending the life of an existing pavement with an overlay of a new concrete surface

Mitchell County, Iowa

Image: Rich Brumm, Mitchell County

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Mitchell County, Iowa

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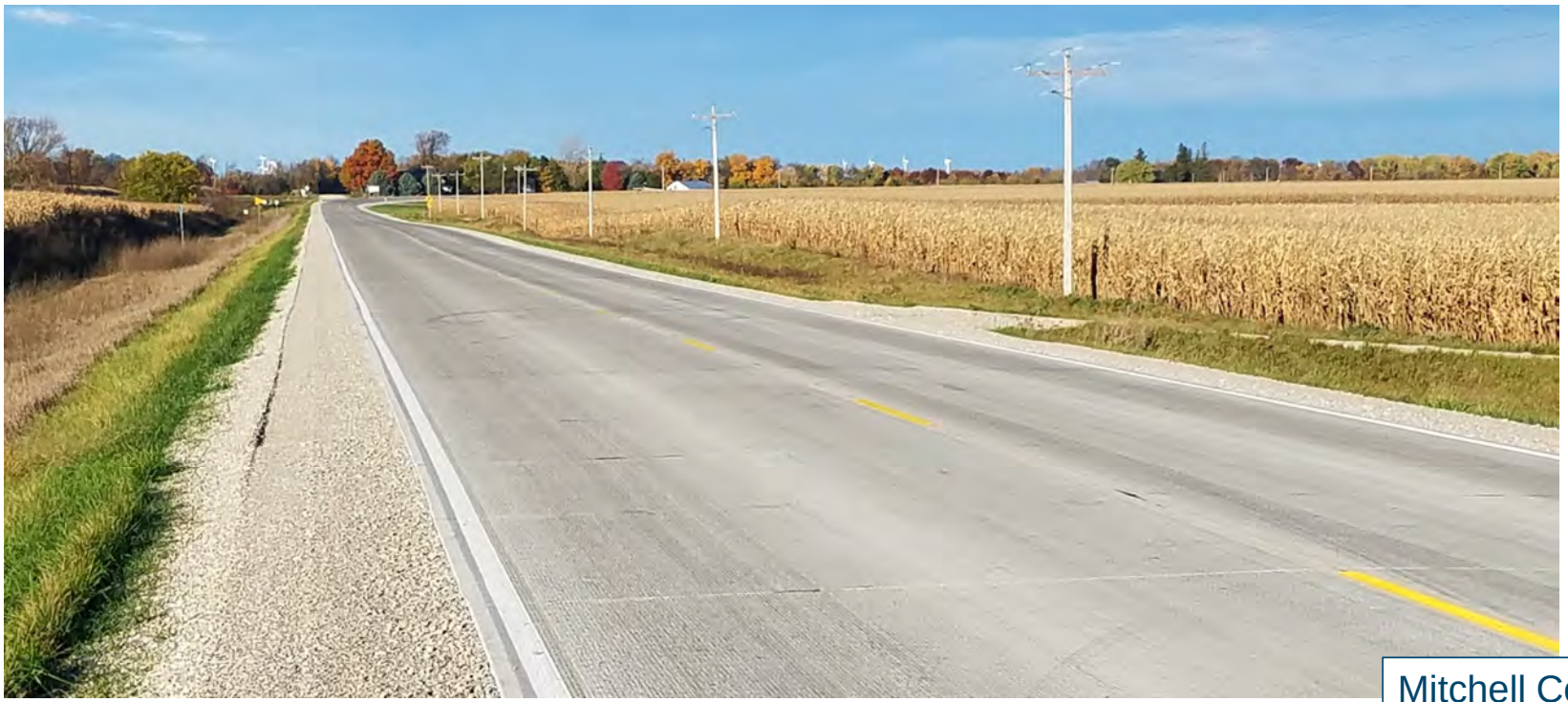
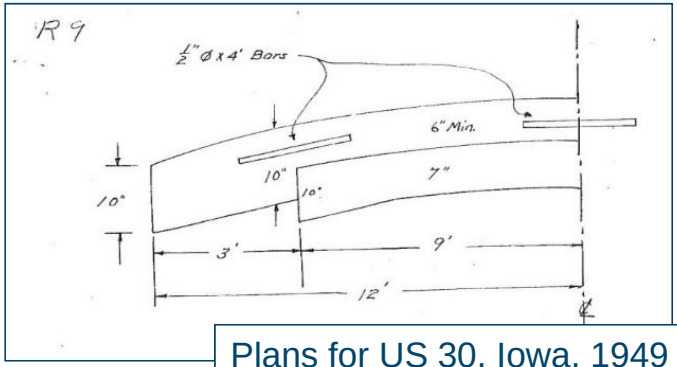
- Extending the life of an existing pavement with an overlay of a new concrete surface



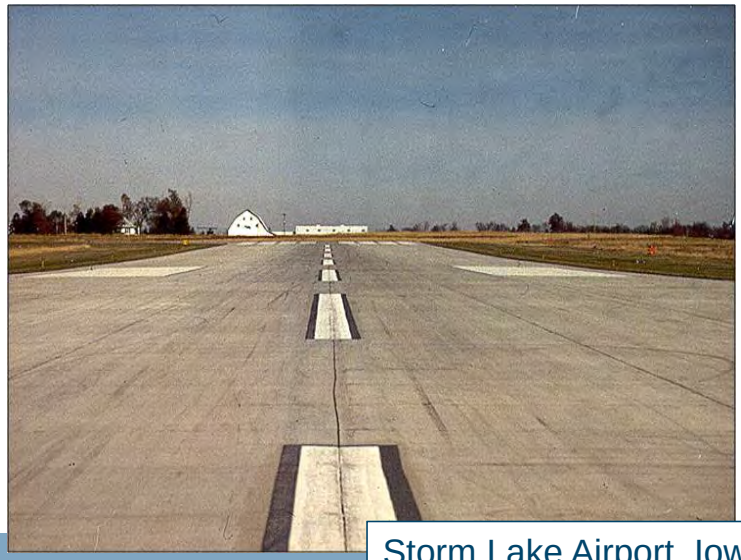
Mitchell County, Iowa

Background & History

- Experimental projects built during the mid-20th century
- 1970s to 1980s: early projects help establish concrete overlays in some U.S. states
- 1990s to present: further innovations in design, rate of adoption increases



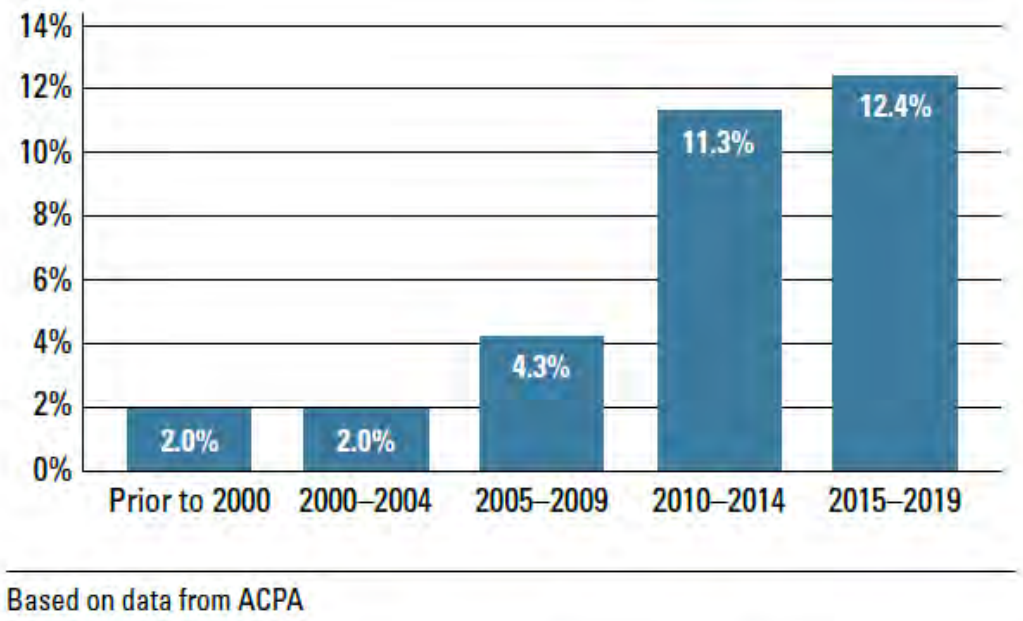
Plans for US 30, Iowa, 1949



Storm Lake Airport, Iowa, 1971

Background & History

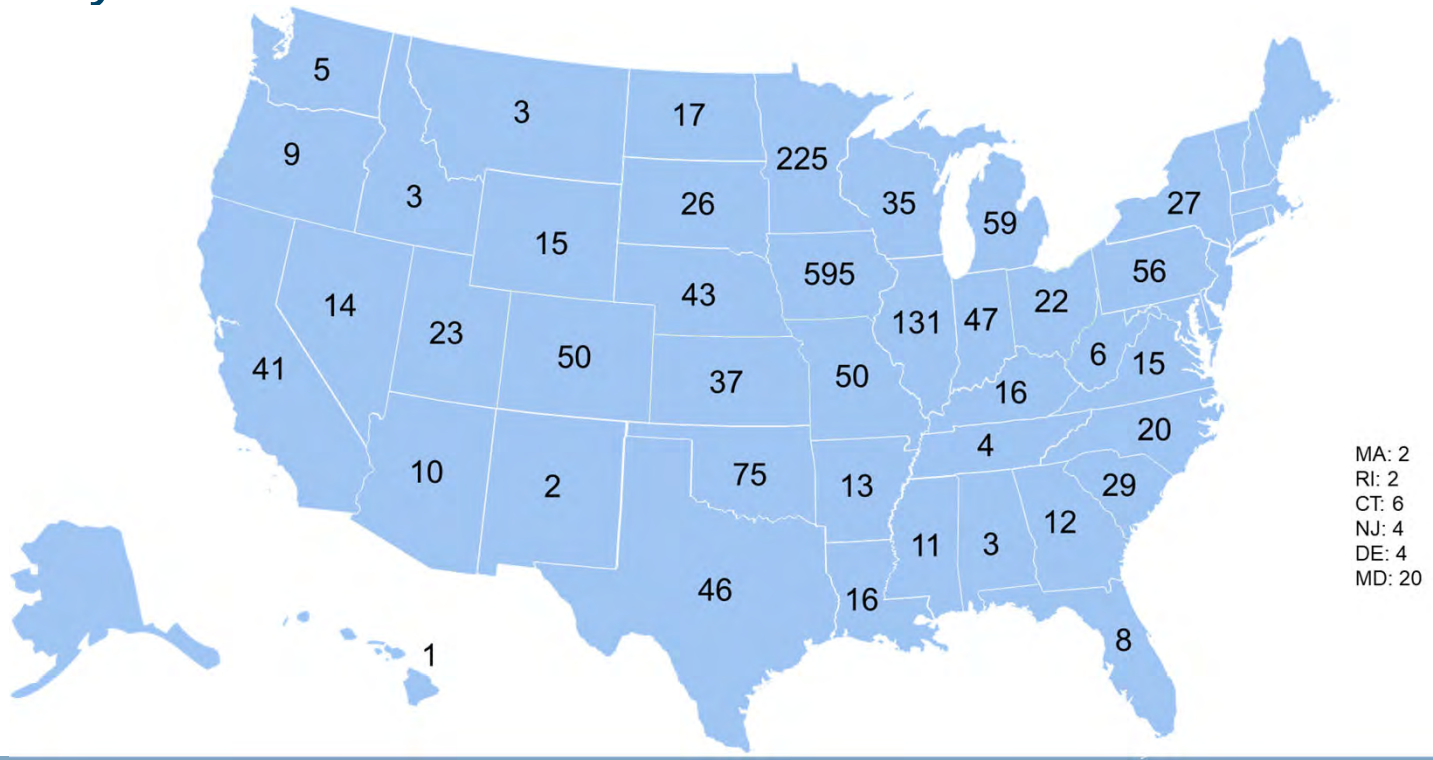
- Substantial increase in concrete overlay construction in the U.S. since 2000:



Based on data from ACPA

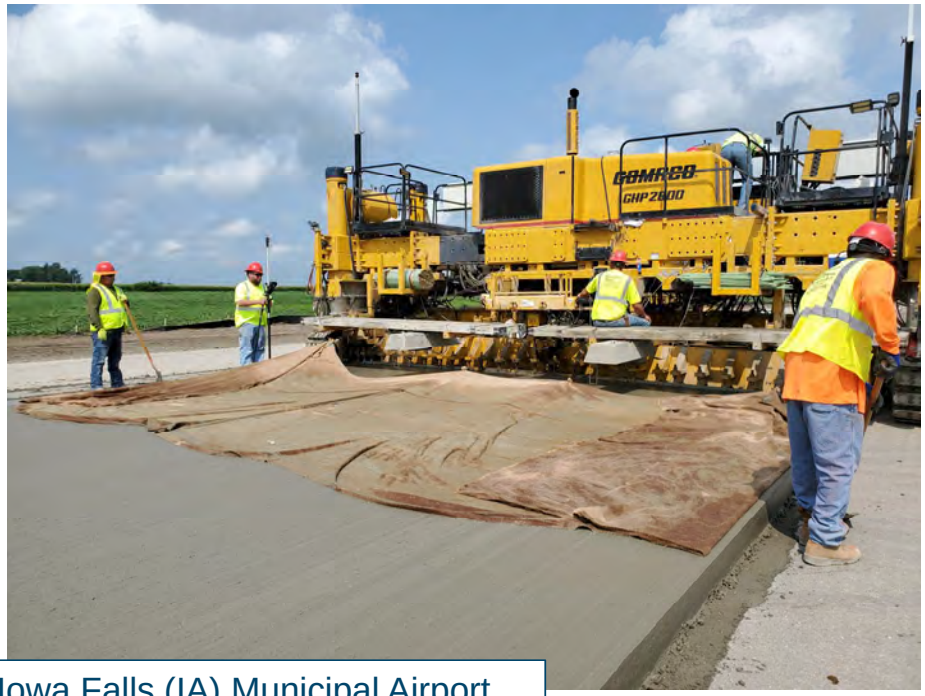
Background & History

- As of 2022, over 1,700 projects have been built on public roadways in 46 U.S. states:



Background & History

- Many successful concrete overlay projects have also been built at airfields, parking lots, and industrial and intermodal facilities



Iowa Falls (IA) Municipal Airport

Jamestown (TN) Municipal Airport

R Image: Greg Dean, ACPA – SE Chapter

Background & History

- Many successful concrete overlay projects have also been built at airfields, parking lots, and industrial and intermodal facilities

Manitowoc, Wisconsin

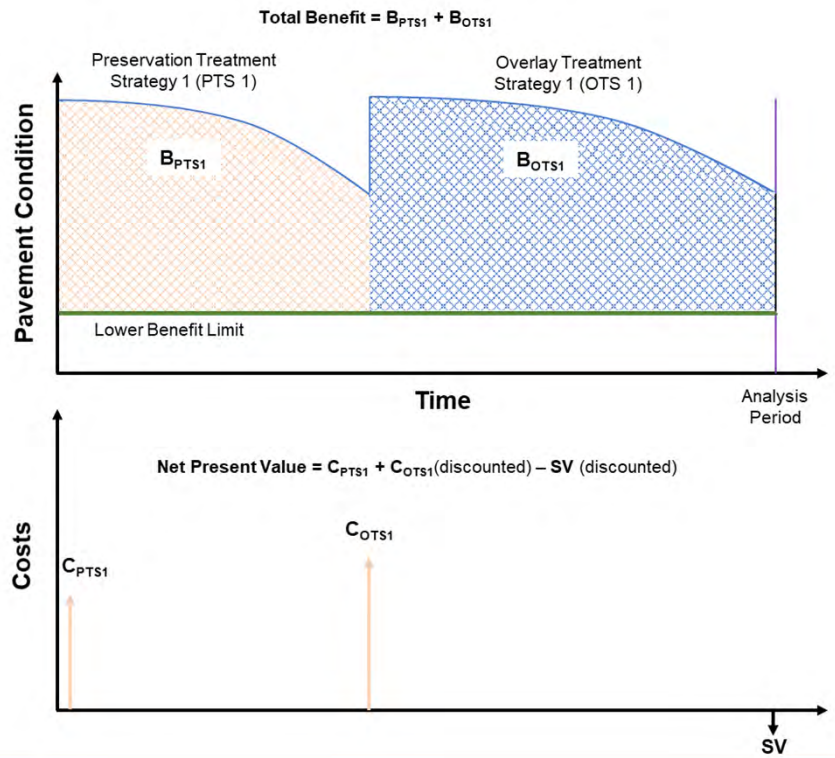
Background & History

- Concrete overlays are still new to some areas, but for many agencies they have become a regular part of the pavement network
  - “Another tool in the toolbox”

Zumbro Falls, Minnesota

Why Concrete Overlays?

- Concrete overlays offer value to agencies and the traveling public in many ways
- Cost & Effectiveness
  - Lower up-front cost than reconstruction, but still capable of achieving a long design life
  - Preserves the equity invested in the original pavement structure



Why Concrete Overlays?

- Concrete overlays can also help agencies meet emerging needs for more sustainable & resilient pavements
  - Using fewer raw materials and a lower-impact construction process helps reduce the amount of embodied carbon
  - Hardening pavement surface layers increases resilience to the impacts of flooding and saturation of the foundation

I-29, Iowa

Image: Lincoln Journal Star

Concrete Overlay Basics

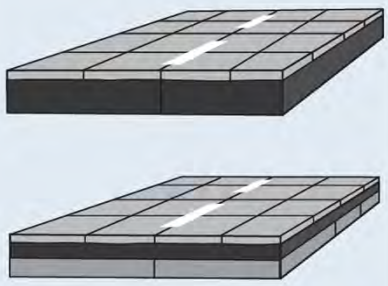
Getting Started

- Concrete overlays are primarily classified based on the existing pavement type and the bonding condition

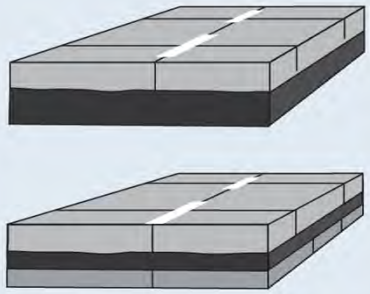
Concrete on Asphalt

Concrete on asphalt (COA) overlays can be designed to address a broad range of existing pavement conditions on both composite and full-depth asphalt pavements. Both bonded (COA–B) and unbonded (COA–U) options enable designs to cost-effectively match the condition of the existing asphalt—from deteriorated to good—as well as geometric parameters.

COA–B (Full Depth and Composite)



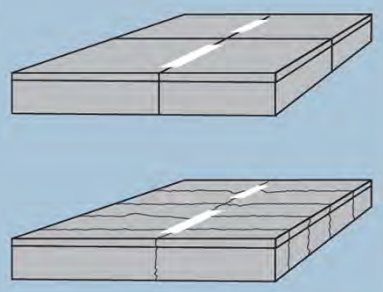
COA–U (Full Depth and Composite)



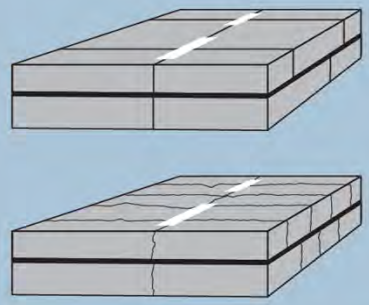
Concrete on Concrete

Concrete on concrete (COC) overlays can be designed for applications on both existing jointed plain concrete pavement (JPCP) and continuously reinforced concrete pavement (CRCP). The predominance of COC overlay designs are unbonded (COC–U) systems; however, bonded (COC–B) applications can be successful, provided the existing pavement is in good condition.

COC–B (JPCP and CRCP)



COC–U (JPCP and CRCP)



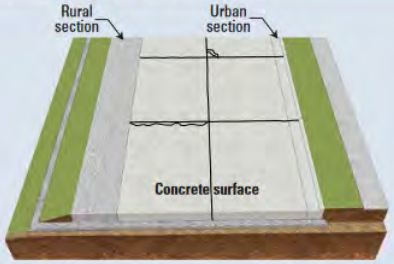
Getting Started

- That said, don’t worry about being too specific about what type of overlay you’re going to build before you get started
- Concrete overlays are adaptable to:
  - Nearly all types of existing pavements
  - All but the worst existing pavement conditions
  - Both short- and long-term design life goals

Evaluating the Existing Pavement

- Determine the existing pavement type and condition

Existing Concrete



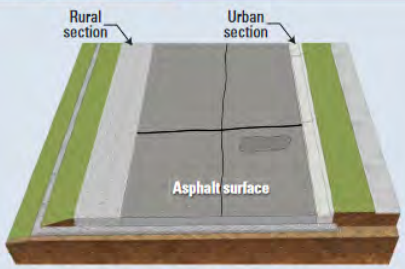
Good—Structurally sound with little to no cracking

Fair—Structurally sound with minor surface distresses such as random cracking, periodic partial-depth joint spalling, and shadowing

Poor—Full-depth joint deterioration, working cracks, spot structural failures, faulting, and/or material-related distress

Deteriorated—Significant surface deterioration and structural distresses, including joint deterioration from freeze-thaw damage or material-related distress at 50% or more of the joints

Existing Asphalt



Good—Structurally sound with minor surface defects and minor cracking

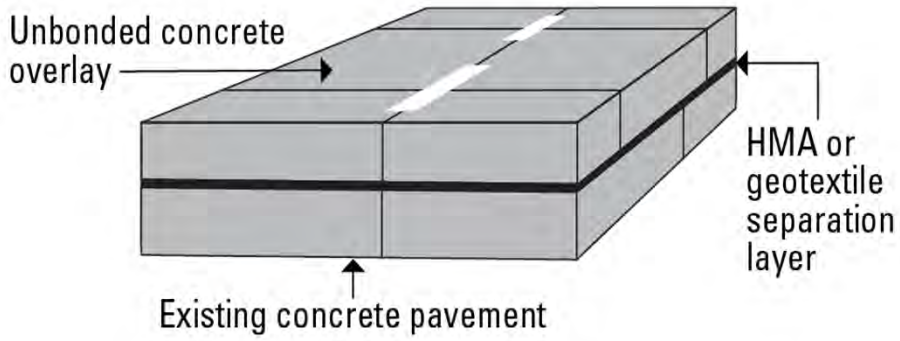
Fair—Structurally sound with minor surface distresses such as potholes, block cracking, or thermal cracking

Poor—Frequent surface distresses such as potholes, block cracking, or thermal cracking plus alligator cracking, rutting, shoving, slippage, stripping, and raveling

Deteriorated—Significant surface and structural distresses, including potholes, block cracking, or thermal cracking plus alligator cracking, rutting, shoving, slippage, stripping, and raveling

Evaluating the Existing Pavement

- Existing concrete pavements: in the vast majority of cases, you will design an unbonded overlay (COC–U)
- COC–U overlays have a separation layer, which provides isolation from the underlying pavement, bedding, and drainage
  - Either 1 to 2 inches of HMA or a geotextile

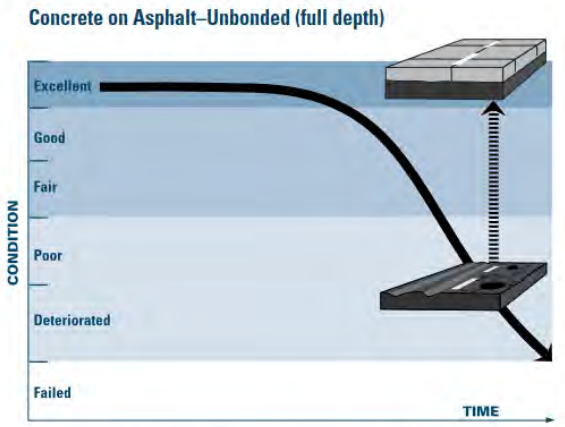


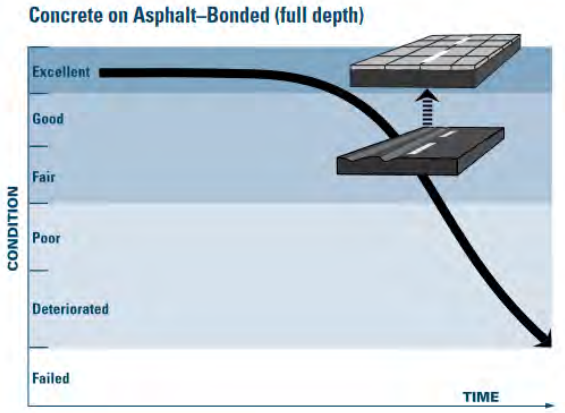
Evaluating the Existing Pavement

- Existing asphalt or composite pavements:
  - If the existing asphalt is still in relatively good condition, you may choose to design a bonded overlay (COA–B)
  - If the asphalt is in poor condition and/or needs significant repairs, you should choose an unbonded overlay (COA–U)
  - In either case, the concrete is placed directly on the existing asphalt surface and both types of COA overlays are similar

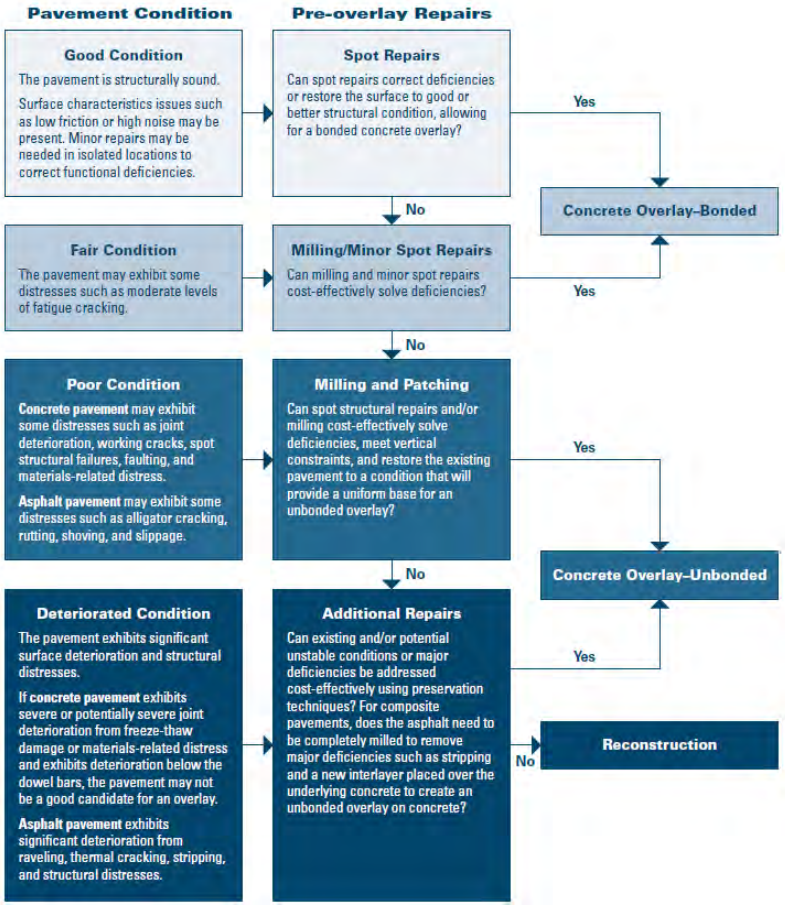
Evaluating the Existing Pavement

- What should I look for in an existing asphalt pavement when evaluating its condition?
  - Deterioration of the asphalt and/or stripping within asphalt layers
  - Loss of base or subbase support
  - Required repairs
  - Thickness of the existing asphalt
    - Is there room to mill off rutting and minor surface distresses?



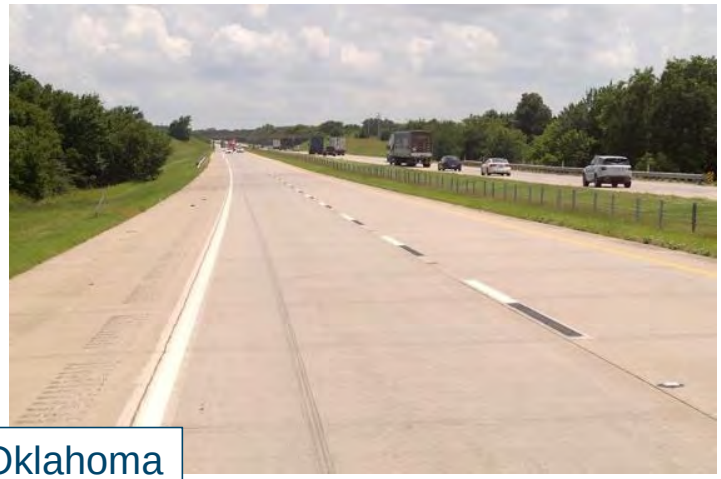


Evaluating the Existing Pavement



Concrete Overlay Design

- Once you've determined overlay type, you can design concrete overlay thickness
  - Use standard pavement design inputs
  - Both bonded and unbonded overlays can be designed for varying traffic levels as well as short- or long-term design life

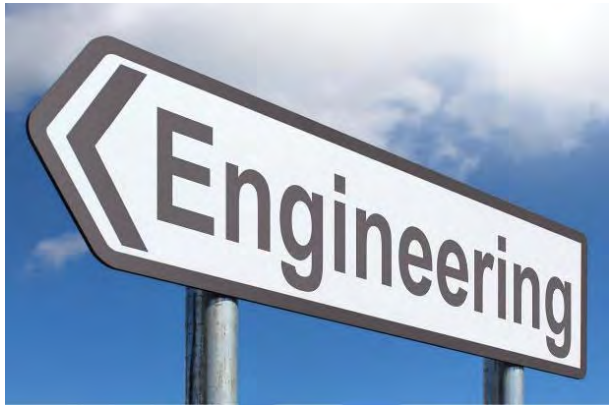


I-35, Oklahoma

Cass County, Missouri

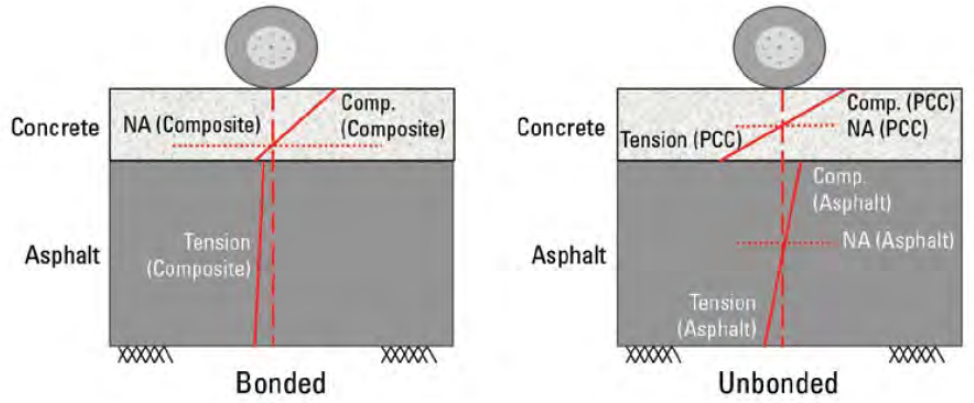
Concrete Overlay Design

- Common thickness design procedures:
  - AASHTOWare Pavement ME Design ($)
  - ACPA Pavement Designer
  - University of Pittsburgh's BCOA-ME
  - University of Pittsburgh's UBOL Design v1.0



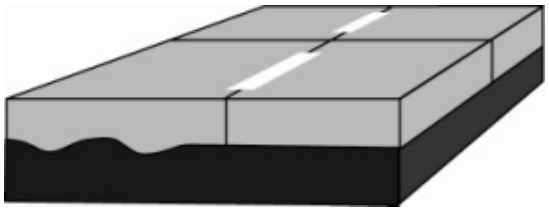
Concrete Overlay Design

- In Iowa, 6 inch COA & COC overlays are very common on county highways and well-suited to those traffic levels
- Thicker overlays may be used on higher volume roadways or to achieve a longer design life
- Thinner COA–B overlays may be designed at 4 or 5 inches
  - Relying on the bond in design makes a thinner slab feasible

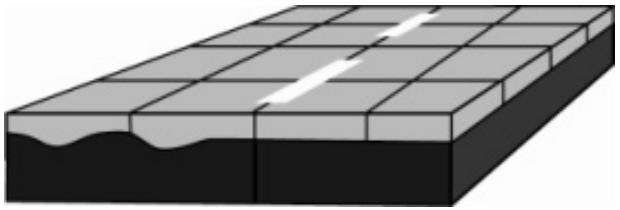


Concrete Overlay Design

- Conventional joint spacing vs. short joint spacing
  - A shorter joint spacing (e.g. 6 ft x 6 ft) may reduce stresses caused by traffic loads and curling and warping
    - Useful for thinner (4 to 6 inch) overlays on projects with higher traffic volumes
  - 6+ inch overlays on Iowa county highways are almost always designed with conventional joint spacings (e.g. 12 ft x 12 ft)
    - Rule of thumb: Joint Spacing (ft) ≤ 2 × Thickness (inches)



vs.



Concrete Overlay Design

- When using a shorter joint spacing on roadways, do not place joints in the wheel path (e.g. 4 ft x 4 ft)
  - Not an issue for parking lots

MnROAD Test Facility on I-94

Image: MnDOT

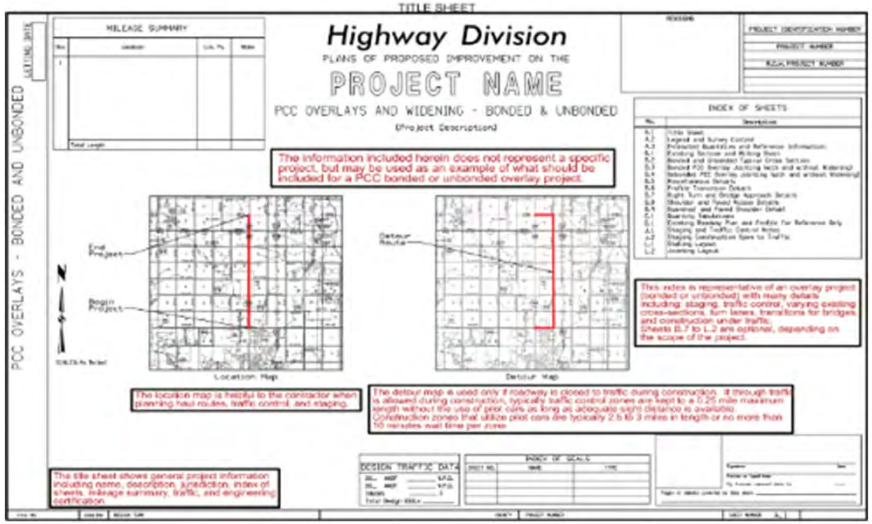
Concrete Overlay Design

- When using a shorter joint spacing on roadways, do not place joints in the wheel path (e.g. 4 ft x 4 ft)
  - Not an issue for parking lots

Urbana, Illinois

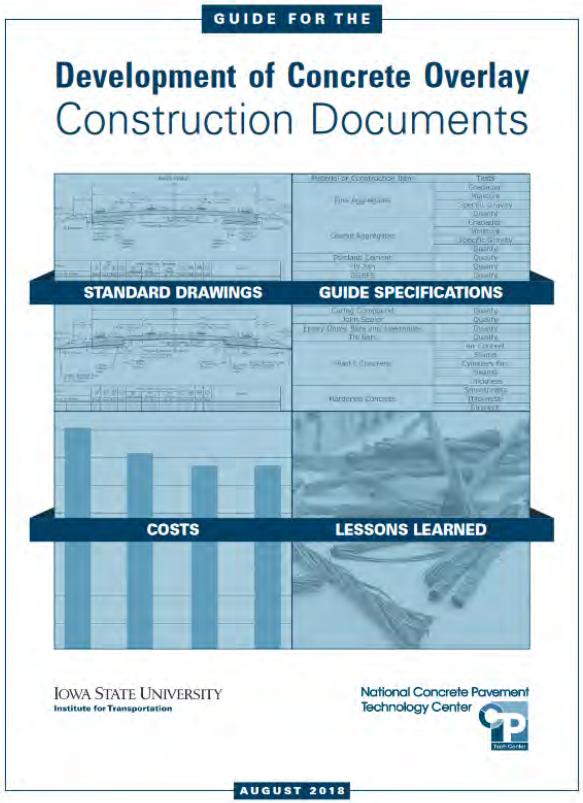
Plan Development

- Concrete overlay plans do not need to be complicated!
- Projects have been built from plan sets consisting of as few as 4 to 6 sheets on rural roadways in Iowa, Oklahoma & elsewhere



Plan Development

- Depending on location, geometric features, and maintenance of traffic requirements, some projects will obviously require a greater level of detail, but don't be intimidated!
- The Guide for the Development of Concrete Overlay Construction Documents (2018) is a very useful resource:



Concrete Overlay Construction

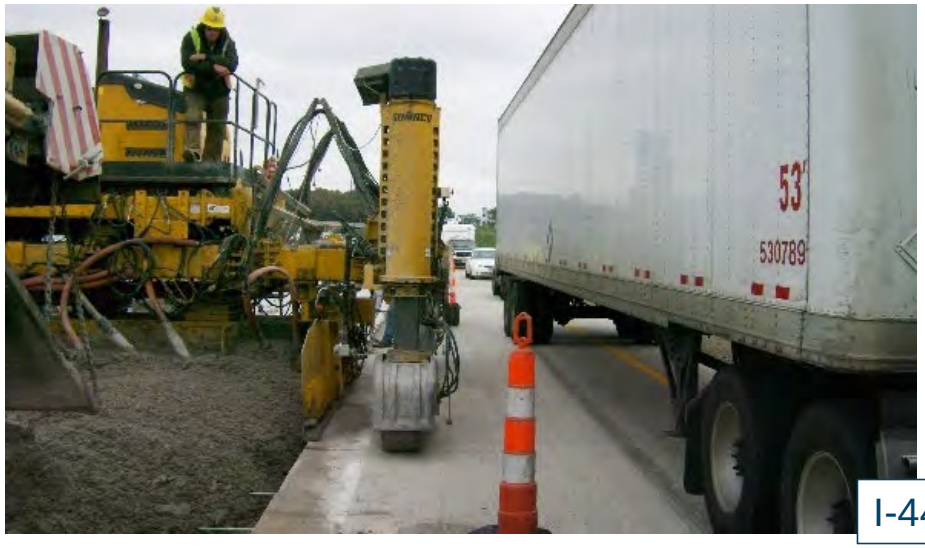
- Construction is significantly faster and less disruptive compared to full-depth concrete reconstruction
  - Limited earthwork, placement of base materials
  - Easier access for construction vehicles as well as local traffic
  - Thinner pavement → greater productivity in terms of SY/day or linear ft/day

Concrete Overlay Construction

- Concrete mixes: follow the same best practices as for conventional concrete pavements
  - Fiber-reinforced concrete (FRC) may be helpful in thin overlays
- Placement methods: follow the same best practices as for conventional concrete pavements
  - When possible, slipform paving is best for streets and roadways
- Curing is critical!
  - Depending on thickness, more surface area is exposed as a function of the concrete volume

Concrete Overlay Construction

- Construction of concrete overlays under traffic is possible
- Several ways to accommodate local traffic & homeowners:
  - Gap pours at intersections, driveways, etc.
  - Moving closures or detours along the route



I-44, Missouri

Concrete Overlay Construction

- Laser-guided screeds can allow for fast, efficient placements over large parking areas

Image: K&M Concrete Construction, Inc.

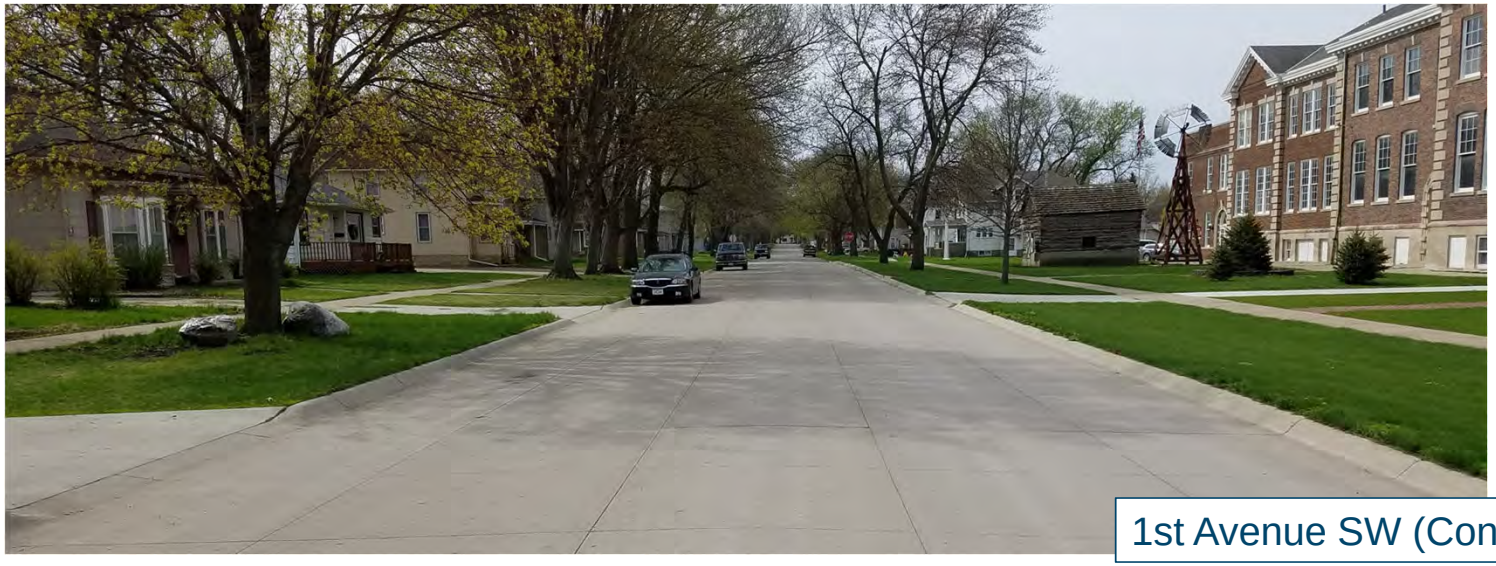
Special Considerations & Lessons Learned

Are You New to Concrete Overlays?

- If your agency, design firm, or construction company has not done a concrete overlay project before, start simple!
  - Avoid projects with complex geometry, significant staging constraints, tight closure periods, etc.
- The experience gained from designing and building a relatively straightforward concrete overlay can be useful to go on to design and build projects with more complexity

Le Mars, Iowa

- Le Mars, Iowa (population 10,571) has been built 10 concrete overlay projects on its street network since 2009
- Initially focused on improving basic residential streets with similar widths, existing cross sections, etc.



1st Avenue SW (Constructed 2011)

Le Mars, Iowa

- First 4 projects through 2016 totaled about 21,000 SY
- Allowed city staff, engineer, and contractors to gain experience and develop procedures for things like:
  - Closure strategies
  - Curb removal
  - Residential driveways
  - Fiber-reinforced concrete

3rd Avenue SE (Constructed 2010)

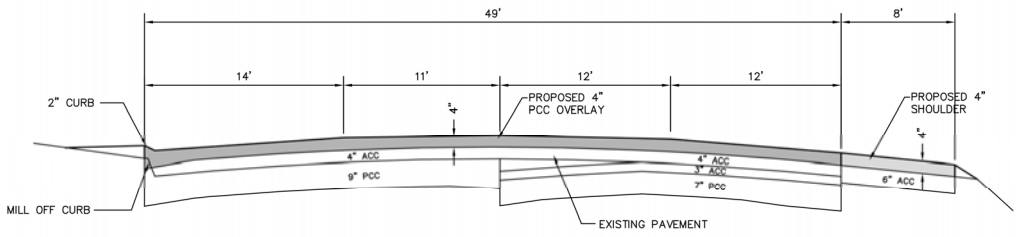
Le Mars, Iowa

- In 2017, the city undertook a concrete overlay on Business U.S. Highway 75
  - Primary north-south highway and truck route through town
  - 58,000 SY, 1.75 miles
  - Many intersections and driveways
  - Former state highway with original concrete pavement dating to 1926 and widenings constructed in the 1950s
    - Significant variation in the existing cross-section!

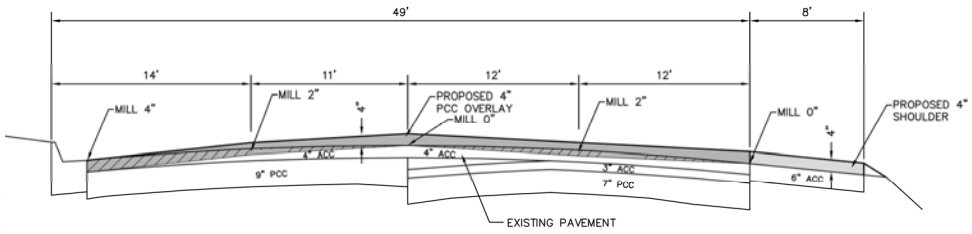
Image: Pat Bickett, Schlotfeldt Engineering

Le Mars, Iowa

- Milling depth and profile varied in different areas based on the existing cross section (no milling when not needed)
- In some areas the existing curb was left in place, while in others a new integral curb or paved shoulder was placed with the overlay
- The entire corridor was closed, but the project was separated into 4 sections which allowed for local access
- Maturity method used to determine opening strength



CROSS SECTION ⑦ – STA. 920+00 TO STA. 924+25



CROSS SECTION ⑧ – STA. 924+25 TO STA. 953+92.4

Images: Pat Bickett, Schlotfeldt Engineering

Le Mars, Iowa

Images: GCC Ready Mix

Le Mars, Iowa

L Image: GCC Ready Mix

Le Mars, Iowa

- Project outcomes:
  - Final yield of just 8% on the mainline pavement, 12% on the shoulder
  - Contractor earned all but one incentive day for completion
  - Pavement fully re-opened to the traveling public just 7 weeks after initial closure

Image: GCC Ready Mix

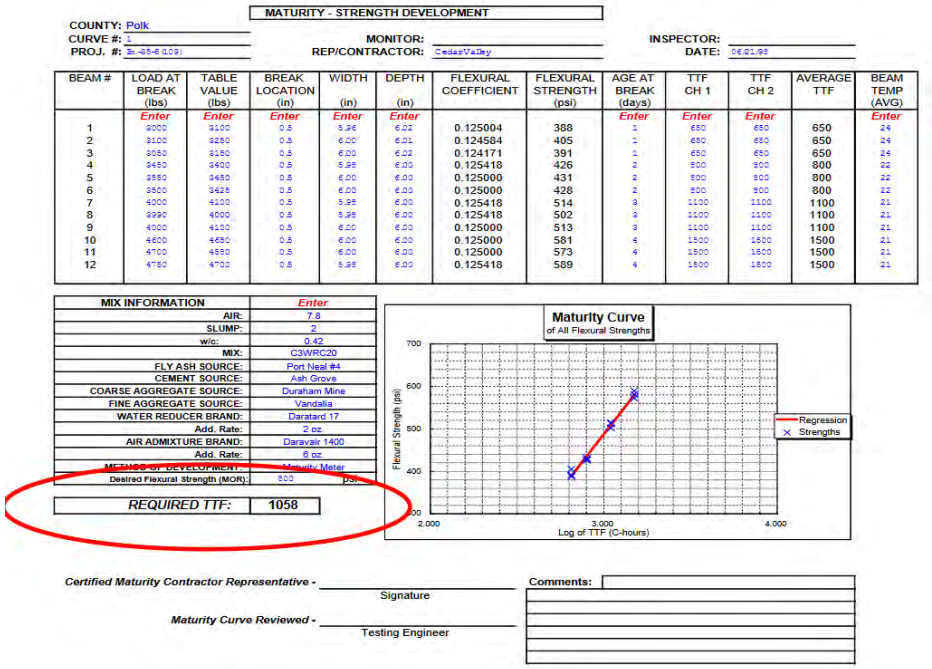
Construction Considerations

- Concrete overlays are good for early season paving
  - Existing pavement surface is stable and dries out faster – not as sensitive to weather-related disruptions

Image: GCC Ready Mix

Construction Considerations

- Opening to traffic
  - Maturity method allows for fastest opening
  - Existing opening strength specifications are conservative
    - Especially for COA overlays, it should be possible to open the pavement to traffic earlier than usually allowed



MATURITY - STRENGTH DEVELOPMENT

COUNTY: Polk
CURVE #: 1
PROJ. #: [illegible]

MONITOR:
REP/CONTRACTOR: CedarValley

INSPECTOR:
DATE: 06.01.98

BEAM #	LOAD AT BREAK (lbs)	TABLE VALUE (lbs)	BREAK LOCATION (in)	WIDTH (in)	DEPTH (in)	FLEXURAL COEFFICIENT	FLEXURAL STRENGTH (psi)	AGE AT BREAK (days)	TTF CH 1	TTF CH 2	AVERAGE TTF	BEAM TEMP (AVG)
	Enter	Enter	Enter	Enter	Enter			Enter	Enter	Enter		Enter
1	3200	3100	0.5	5.96	6.02	0.125004	388	1	650	650	650	24
2	3100	3250	0.5	6.00	6.01	0.124584	405	1	650	650	650	24
3	3050	3150	0.5	6.00	6.02	0.124171	391	1	650	650	650	24
4	3450	3400	0.5	5.98	6.00	0.125418	426	2	800	800	800	22
5	3550	3450	0.5	6.00	6.00	0.125000	431	2	800	800	800	22
6	3500	3425	0.5	6.00	6.00	0.125000	428	2	800	800	800	22
7	4000	4100	0.5	5.98	6.00	0.125418	514	3	1100	1100	1100	21
8	3990	4000	0.5	5.98	6.00	0.125418	502	3	1100	1100	1100	21
9	4000	4100	0.5	6.00	6.00	0.125000	513	3	1100	1100	1100	21
10	4600	4650	0.5	6.00	6.00	0.125000	581	4	1500	1500	1500	21
11	4700	4650	0.5	6.00	6.00	0.125000	573	4	1500	1500	1500	21
12	4750	4700	0.5	5.98	6.00	0.125418	589	4	1500	1500	1500	21

MIX INFORMATION	Enter
AIR:	7.8
SLUMP:	2
w/c:	0.42
MIX:	C3WRC20
FLY ASH SOURCE:	Port Neal #4
CEMENT SOURCE:	Ash Grove
COARSE AGGREGATE SOURCE:	Duraham Mine
FINE AGGREGATE SOURCE:	Vandalia
WATER REDUCER BRAND:	Daratard 17
Add. Rate:	2 oz.
AIR ADMIXTURE BRAND:	Daravair 1400
Add. Rate:	6 oz.
METHOD OF DEVELOPMENT:	Maturity Meter
Desired Flexural Strength (MOR):	800 psi
REQUIRED TTF:	1058

Maturity Curve
of All Flexural Strengths

Flexural Strength (psi)
700
600
500
400
300
2,000
3,000
4,000
Log of TTF (C-hours)
Regression
Strengths

Certified Maturity Contractor Representative - _____ Signature

Maturity Curve Reviewed - _____ Testing Engineer

Comments:

Construction Considerations

- Iowa Highway 3, Plymouth County (2022)
  - Opening flexural strength via maturity was reduced from 500 psi to 325 psi
    - Paving in July: open as soon as 12 hours
  - 36 ft wide, 9 mile concrete overlay was paved full width and completed in 25 calendar days
  - Rolling closures/detours maintained access for local traffic
    - Maximum 3 day total closure of any given pavement section

Image: Eric Ferrebee, ACPA

Construction Considerations

- Iowa Highway 3, Plymouth County (2022)
  - Joint sealing and shouldering operations were sped up significantly
  - While this project was not paved under traffic, the rolling closure strategy allowed for faster access to homeowners and local traffic and a much more rapid timeline to full re-opening of the roadway

Image: Greg Mulder, ICPA

Construction Considerations

- US Highway 63, Zumbro Falls, Minnesota (2018)
  - Loading with construction vehicles allowed after 24 hours

Image: Matt Zeller, CPAM

Other Design Factors

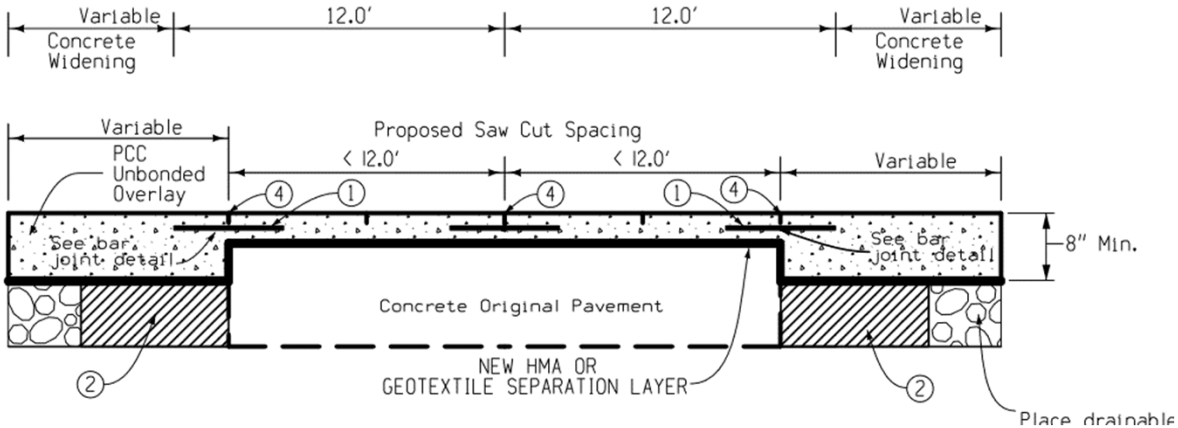
- Interlayer for COC–U overlays
  - The asphalt interlayer is the “tried and true” method
  - Geotextile interlayers were introduced around 2006 and have demonstrated good performance to date

Washington County, Iowa (HMA)

Buchanan County, Iowa (Geotextile)

Other Design Factors

- Integral widening at the shoulder
  - Place a longitudinal joint at the widening with No. 4 tie bar
- Ensure drainage out to the edge of the pavement
  - Incorporate a drainable subbase under a widening unit
  - Daylight geotextile layer in a COC–U overlay to the edge



Other Design Factors

- Matching existing curb and gutter, intersections, etc.
  - Ensure there is enough depth in the existing pavement to mill
  - Inadequate support from a thin section in the underlying pavement may lead to cracking:

Other Design Factors

- To match existing curb, intersections, sidewalk, structures, etc., you may also consider a full-depth transition area where the existing pavement is completely removed:

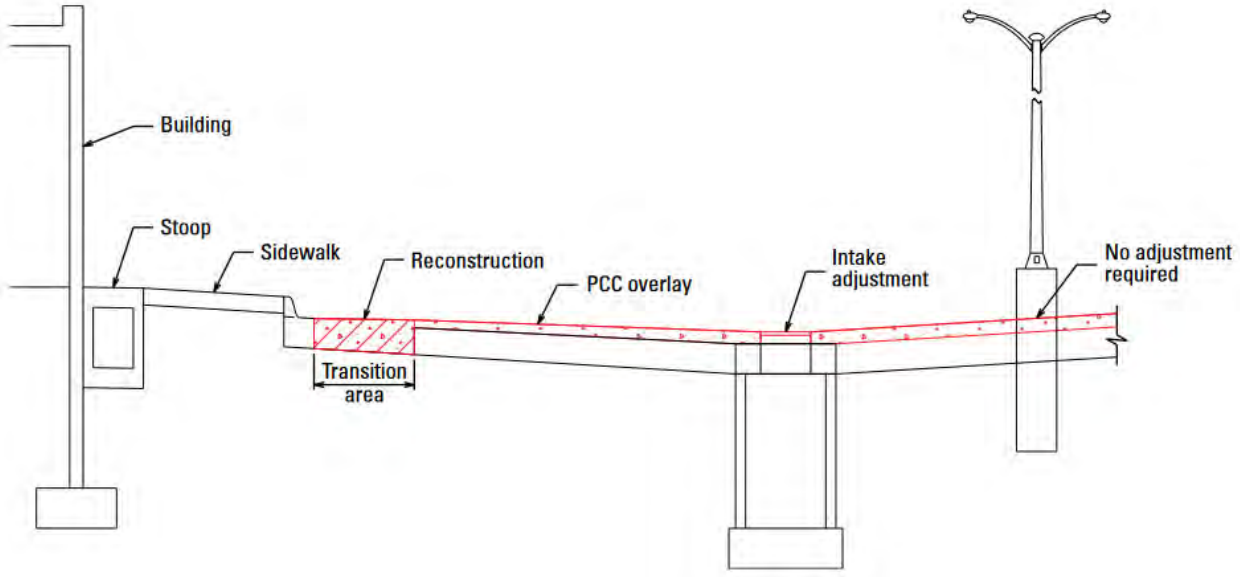


Image: Snyder and Associates

Other Design Factors

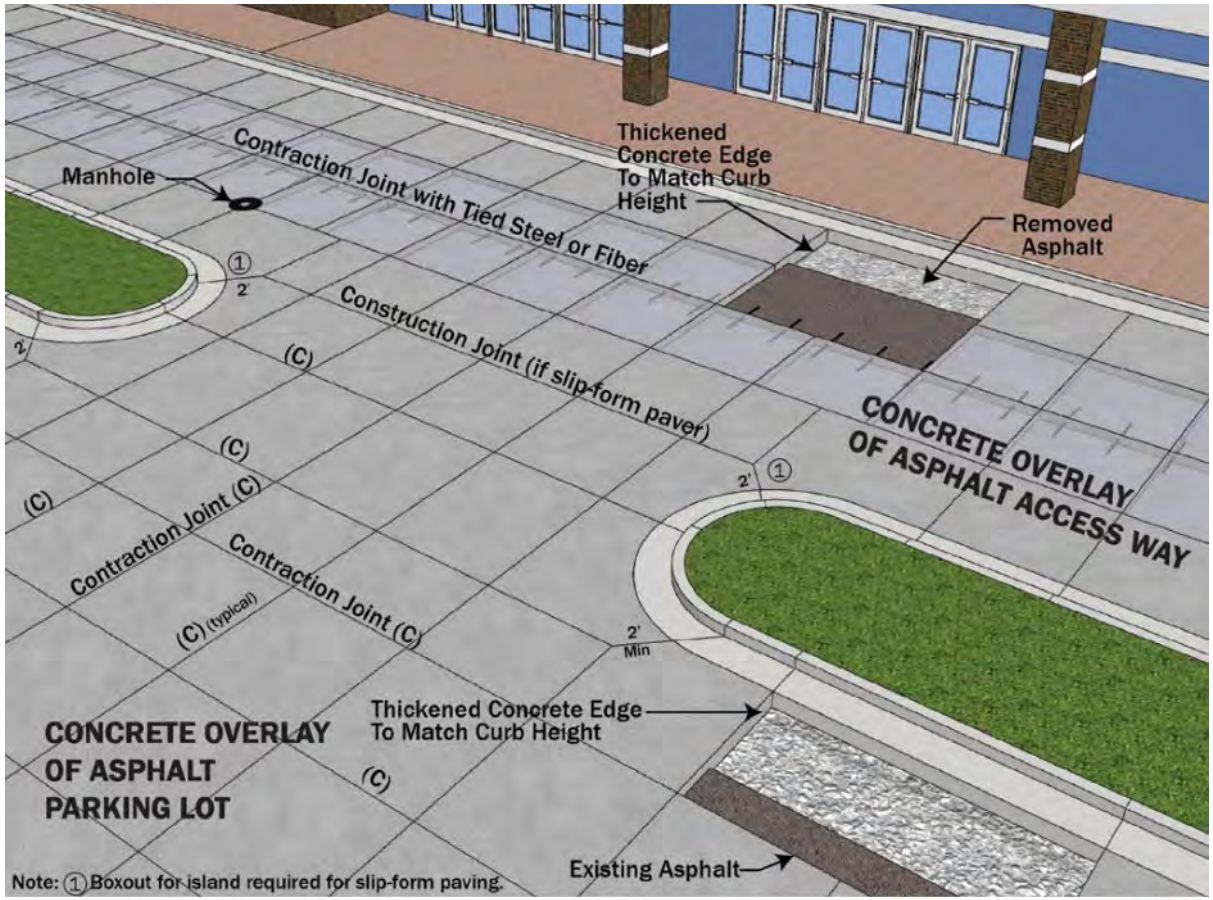
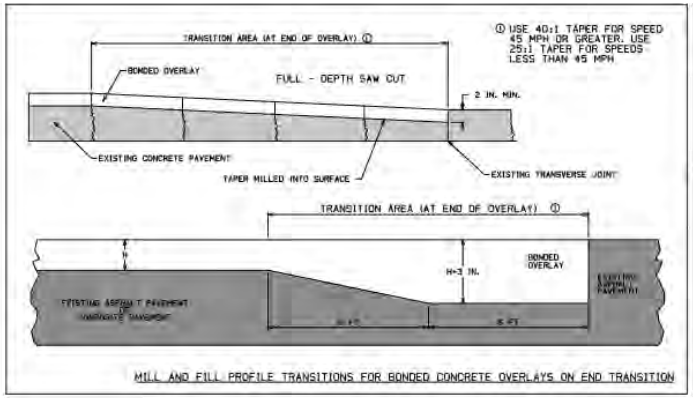
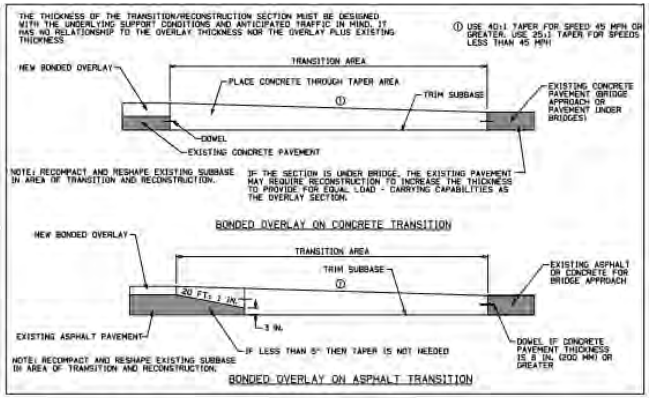


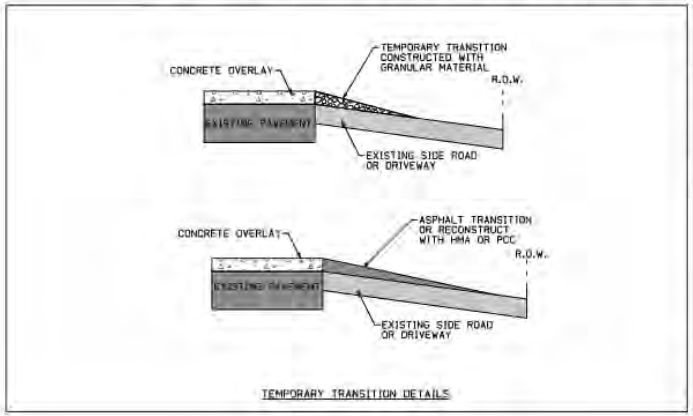
Image: Snyder and Associates

Other Design Factors

- Transitions to full depth pavement
  - End of overlay section
  - Side roads and driveways
  - Temporary transitions during construction







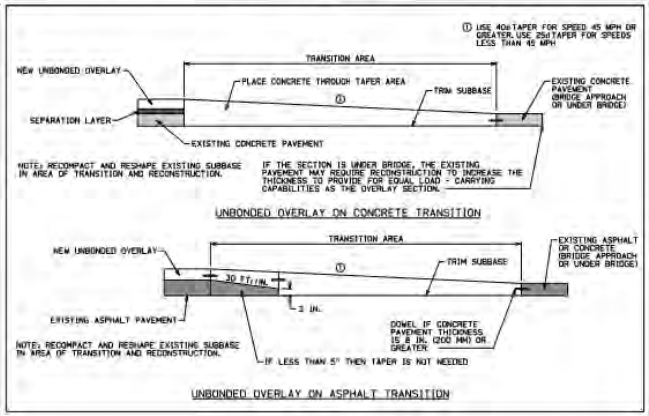


Image: Snyder and Associates

Other Design Factors

- Joint reinforcement
  - Many concrete overlays are too thin (< 7 in.) for dowel bars
  - Most overlays ≥ 5 in. thick are constructed with tie bars
  - Fiber-reinforced concrete isn't a one-for-one replacement for steel, but can be helpful when steel can't be used in thin overlays
- Recommended to fill/seal all joints, even with short joint spacing

Plymouth County, Iowa

Fiber-Reinforced Concrete Overlays

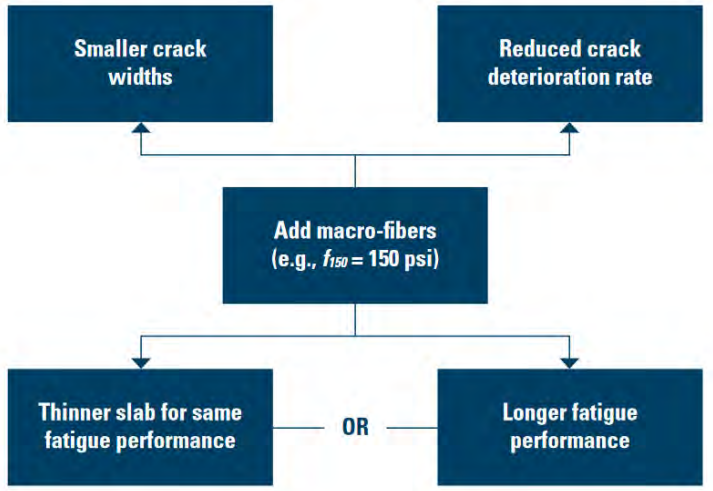
- What is fiber-reinforced concrete?
  - Concrete reinforced with discrete, distributed fibers
  - Macro-fibers and micro-fibers
  - Steel, glass, synthetic, natural

- 1-2 in. length
- 0.01 to 0.04 in. diameter

Images: Sika

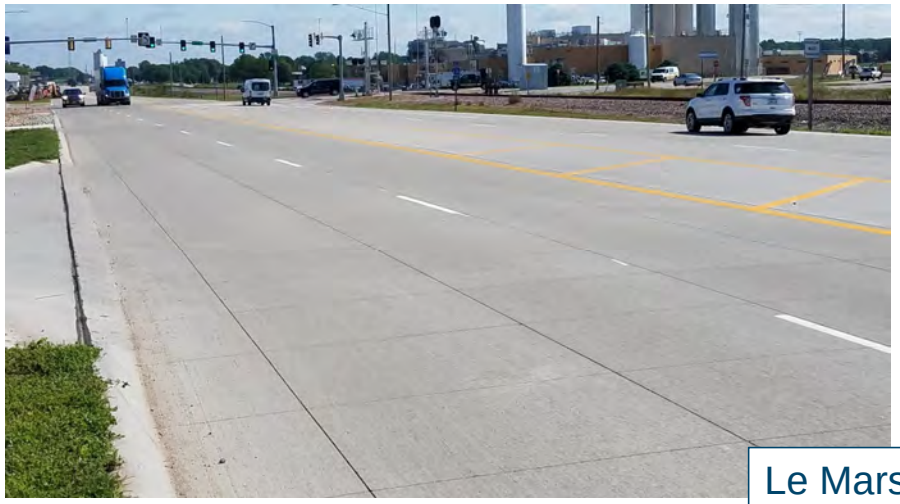
Fiber-Reinforced Concrete Overlays

- Typical dosage rate for pavements: 4 lb/cy (about 0.25% by vol.)
- How the properties of FRC translate to pavement performance:
  - Improves long-term fatigue performance
  - Keeps joints and cracks tight
  - Enhances aggregate interlock
  - Prevents panel movement/sliding
- Design implications:
  - Improves design life/reduces thickness
  - Improves joint load transfer
  - Allows for longer joint spacings?



Fiber-Reinforced Concrete Overlays

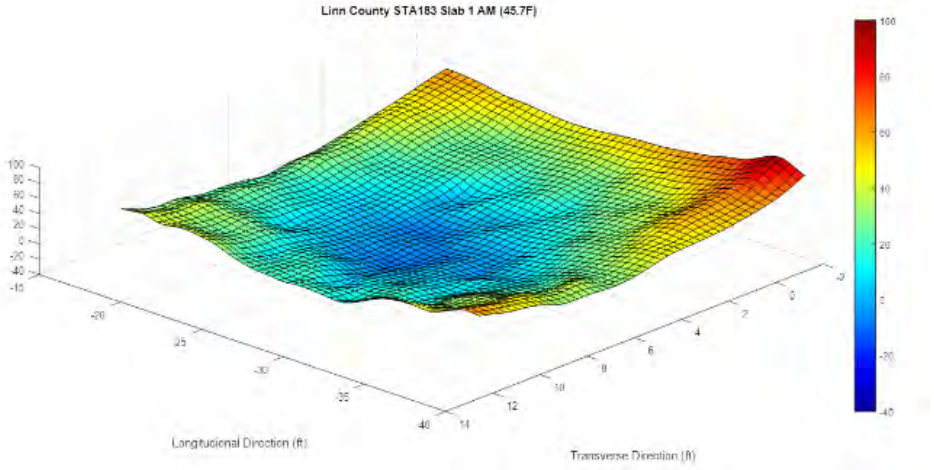
- Useful for projects where you might be constrained in terms of how much you are able to raise the pavement
  - Largely COA–B overlays, but also thinner (6 inch) COC–U
  - Helps enhance aggregate interlock when slab is too thin for dowel bars and/or tie bars



Le Mars, Iowa

Fiber-Reinforced Concrete Overlays

- New IHRB research project to better characterize the impact of fiber-reinforcement on ride quality, load transfer, curling, optimum joint spacing design, and other factors



Rehabilitation and Repair

- Most repairs of concrete overlays are relatively straightforward
  - Most distress types and typical rehabilitation methods are similar to those for full-depth concrete pavements

Rehabilitation and Repair

- Full-depth patching
  - Saw cut around edges of repair, then remove panels with jackhammer or backhoe
  - Alternative for thinner overlays: mill the concrete pavement
  - May place patch to a greater depth than the overlay

Rehabilitation and Repair

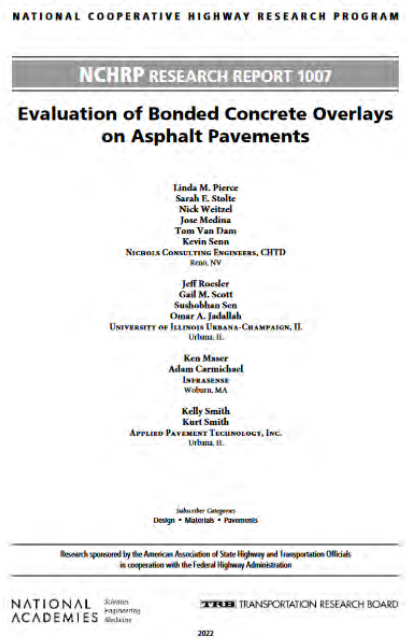
- Even though concrete overlays can be much thinner than conventional concrete pavements, diamond grinding and dowel bar retrofit are also viable rehabilitation methods

Rochester, Minnesota

Image: IGGA

Performance of Concrete Overlays

- A number of studies have been done at state & national levels to measure concrete overlay performance
  - https://cptechcenter.org/webinars-and-videos/

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