
Image source: NAPA


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U.S. Department of Transportation
Federal Highway Administration

TOPS

Targeted Overlay Pavement Solutions

A solution for extending the life of an existing pavement investment.

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Every Day Counts
Innovation for a Nation on the Move

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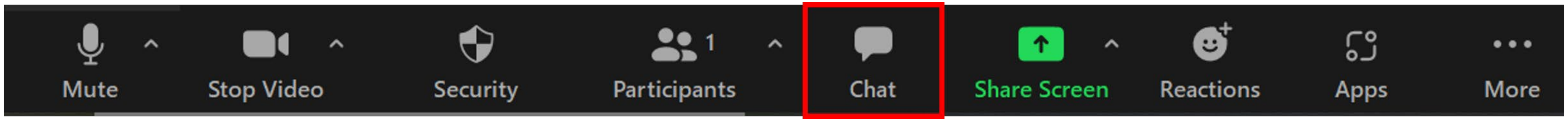
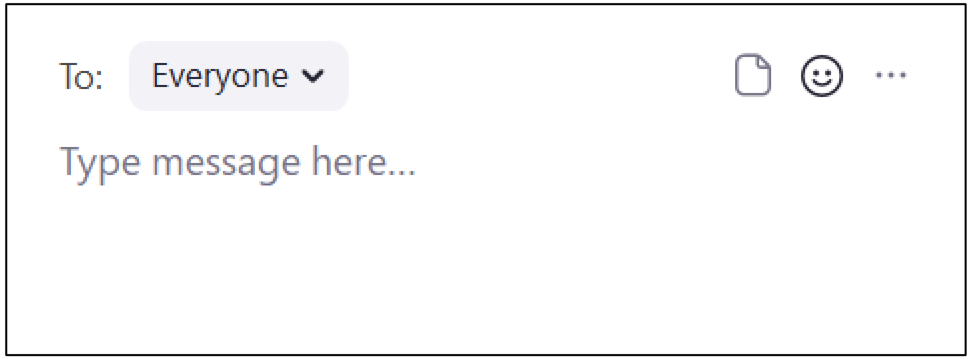
- All questions from participants will be answered during the Q&A session at the end of the webinar.





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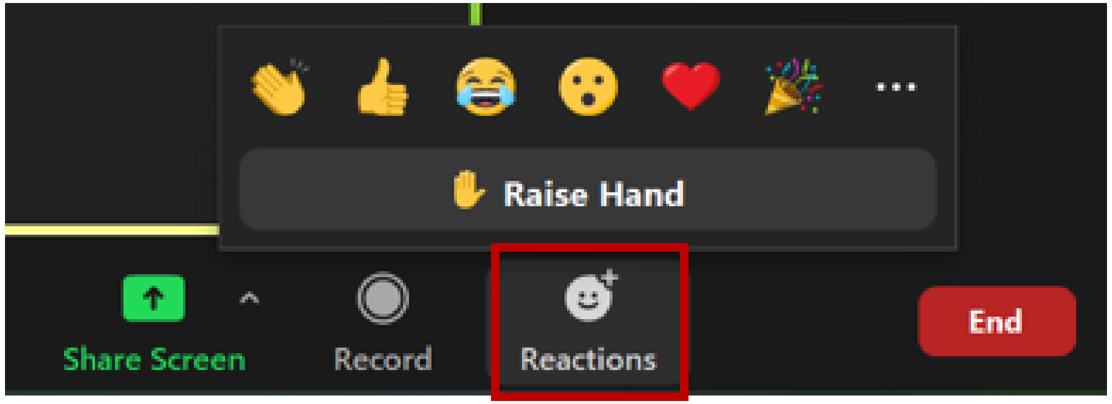

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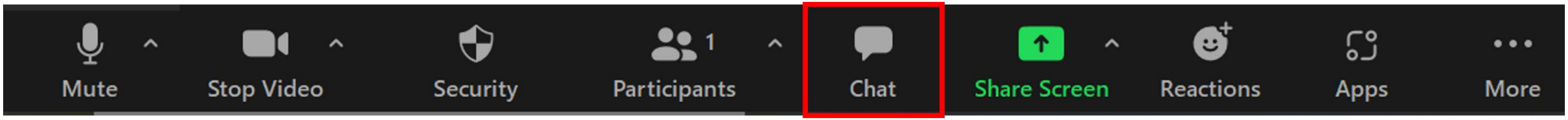

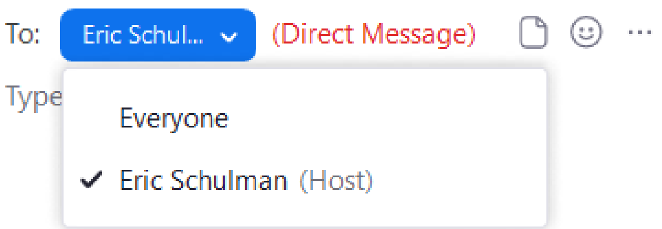

- Email eric.schulman@weris-inc.com and johan.vanrensburg@weris-inc.com

Webinar Overview

- Introduction to EDC-6 TOPS: Bob Conway, FHWA
- Concrete over Asphalt – Bonded (COA-B) Overview: Jerry Voigt, Consultant
- COA-B Agency Experience: Eric Prieve, Colorado DOT
- Q & A

FHWA TOPS EDC-6 Team

Tim Aschenbrener
FHWA Headquarters

Derek Nener-Plante
FHWA Resource Center

Bob Conway
FHWA Resource Center

Background

- Over 25% of all State DOT infrastructure funds go to pavements overlays.
- State DOT manage 2.8 million miles of pavements.

- *Information source: FHWA at https://www.fhwa.dot.gov/innovation/everydaycounts/edc_6/targeted_overlay_pavement.cfm*

Image source: Iowa State University

TOPS

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How is this different from typical overlays?

TOPS matches treatments to high-priority, high-need locations.

Image source: Georgia DOT

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TOPS EDC Mission

Extend pavement life, increase load-carrying capacity, and improve safety, mobility, and user satisfaction in a cost-effective and sustainable manner by delivering targeted pavement overlay solutions to Federal, State, and local transportation agencies.

EDC-6 Goals

- Increase the number of participating agencies that demonstrate, assess, or institutionalize an additional TOPS technology not previously institutionalized.
- Build awareness and expand TOPS usage
  - Identify a champion at each State agency
  - Share information at conferences/workshops
  - Train people (webinars/peer exchanges)

What's in the TOPS toolbox? (1 of 2)

Asphalt overlay products:

- High-Performance Thin Overlay (HPTO)
- Crack Attenuating Mixture (CAM)
- Highly Modified Asphalt (HiMA)
- Enhanced friction overlay
- Stone matrix asphalt (SMA)
- Asphalt Rubber Gap-Graded (ARGG)
- Open-Graded Friction Course (OGFC)
- Ultra-thin bonded wearing course (UTBWC)

What’s in the TOPS toolbox? (2 of 2)

Concrete overlay products:

- Concrete on Asphalt – Bonded (COA-B)
- Concrete on Asphalt – Unbonded (COA-U)
- Concrete on Concrete – Bonded (COC-B)
- Concrete on Concrete – Unbonded (COC-U)

TOPS Potential Benefits

- Improved Safety
- Improved Performance
- Retained Investments
- Cost Savings
- Environmentally Sound

Image source: The Transtec Group, Inc.

Concrete Overlay on Asphalt - Bonded

Acronyms

- AASHTO – American Association of State Highway and Transportation Officials
- ASTM – American Society for Testing and Materials
- FWD – Falling Weight Deflectometer
- GPR – Ground Penetrating Radar
- LiDAR – Light Detection and Ranging
- NDT – Non-Destructive Testing

Overview

- What is a COA-B and How Do They Work
- The Information You Need to Develop a Project
- Basics for a Set of Plans
- Important Material & Construction Factors
- How You Can Get Started & Resources

Concrete on Asphalt Bonded

Counts on Bond Between the Layers

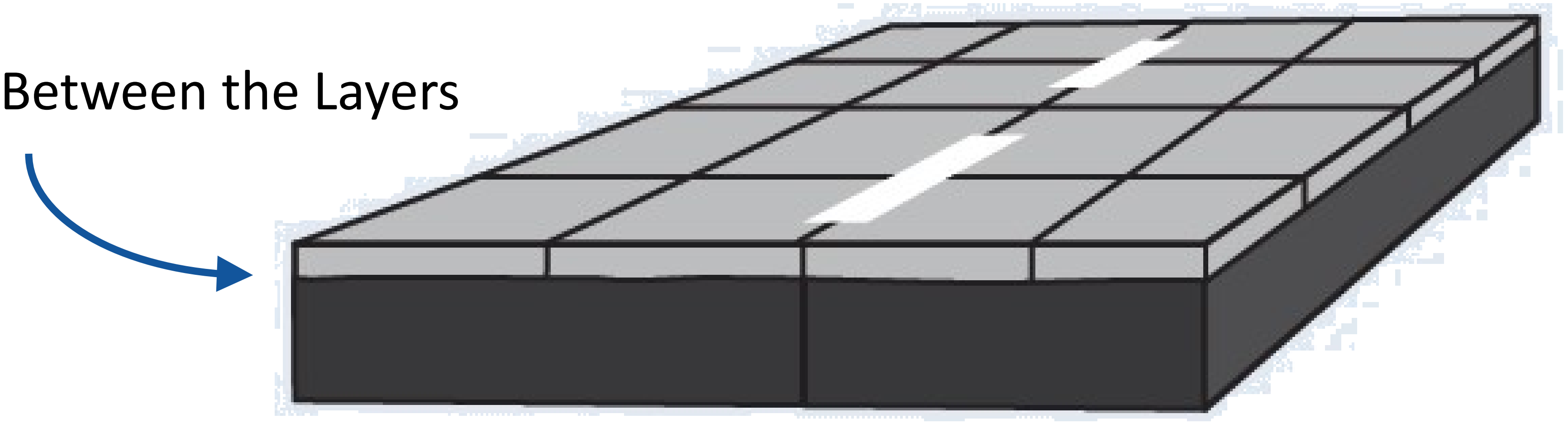


Image source: Iowa State University

Concrete on Asphalt Bonded, Continued

Overlay and existing pavement act together as a monolithic pavement section

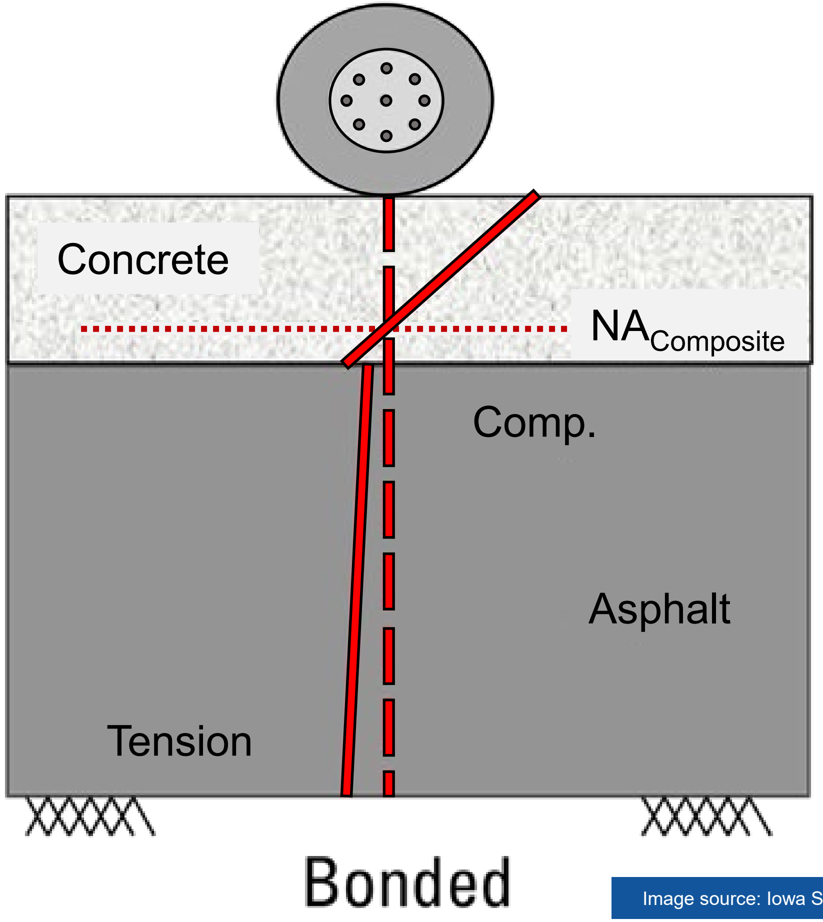


Image source: Iowa State University

Candidate Projects

HMA or WMA Pavement

Image source: David Hein

Composite Pavement

Image source: FHWA

Information Needed for Identifying Candidate

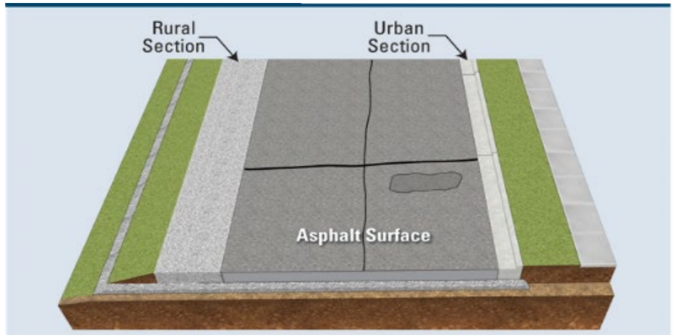
1. Existing pavement type and condition
2. Preliminary determination of typical section layers and thicknesses
3. An on-site review and evaluation
4. Assessment of need for milling and accommodating adjustments of the profile grade
5. Validation of the existing pavement condition by coring and material testing
6. Determination on feasibility of the COA-B overlay option

1. Existing Pavement Type and Condition

Starts as simple as assessing pavement condition rating by engineering judgement

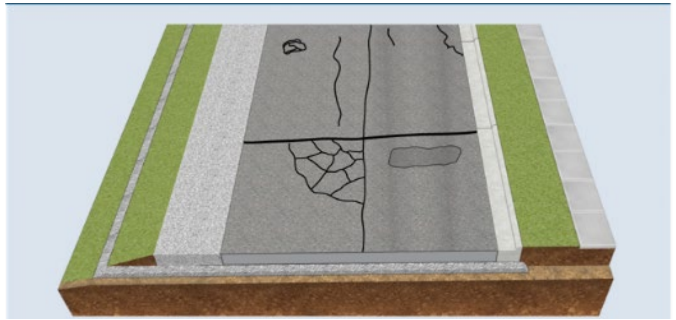
Then...

Enhanced with data

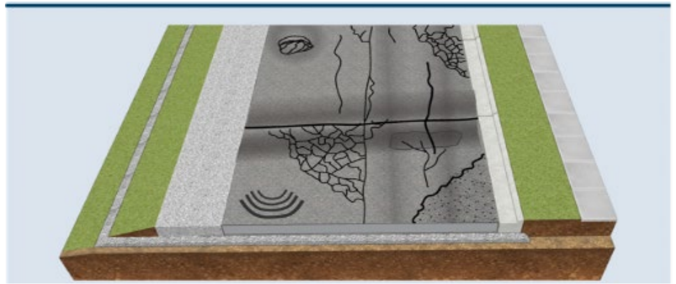


Good - Structurally sound with minor surface defects and minor cracking.

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



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



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

Images source: Iowa State University

2. Existing Pavement Typical Section

- Review historical documents, as-built plans, construction data.
- Check for:
  - Surface pavement layers and thicknesses

    Example: 5” Type D asphalt (2015) (5.5% binder, 6.5% average in-place air voids)

    IMPORTANT!... COA-B will need at least 3 to 4 in. asphalt layer remaining after milling to serve as structural support
  - Base and subbase layers and thicknesses

    Example: 6” dense-graded crushed aggregate (1991)
  - Subgrade soil

    Example: Type A-4 soil, compacted to 95% standard Proctor (1991)

3. On-Site Review and Evaluation

Qualify the Pavement Distresses

- Identify type and quantity of distresses
- Refine the pavement condition assessment initiated in Steps 1 and 2
- Identify locations for pavement coring for further investigation of distresses
- Estimate the extent of any needed pre-overlay repairs.

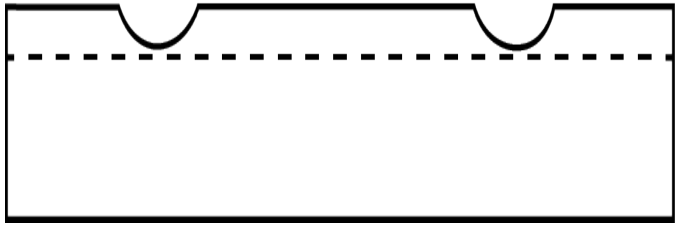
No surface repair needed

Pre-overlay repair needed

Image source: Iowa State University

4. Milling & Profile Grade Adjustments, Part 1

- Plan ahead that milling may be an iterative process
- Goal is to:
  1. Remove nonstructural surface distresses such as potholes, block cracking, partial-depth top-down cracking, random cracking, and thermal cracking
  2. Remove ±2-in. rutting/shoving to control the overly thickness and volume of concrete required for the overlay



  3. Correct profile and cross-slope variability (often referred to as profile milling). 3D machine control very helpful!

4. Milling & Profile Grade Adjustments, Part 2

- Goal is to:
    4. Remove a stripped asphalt surface and/or intermediate layer to expose structurally sound asphalt

Image source: FHWA

Asphalt core that shows the pavement can be milled to remove unsound material

4. Milling & Profile Grade Adjustments, Part 3

Image source: Iowa State University

IF:

Milling exposes the underlying base course or subgrade

THEN:

Mill around the exposure an additional 2 to 3 in.

You can fill this area with concrete during overlay placement

4. Milling & Profile Grade Adjustments, Part 4

Well done milling provides increased surface area and enhanced bonding potential

Image source: FHWA

5. Validate Existing Pavement Condition

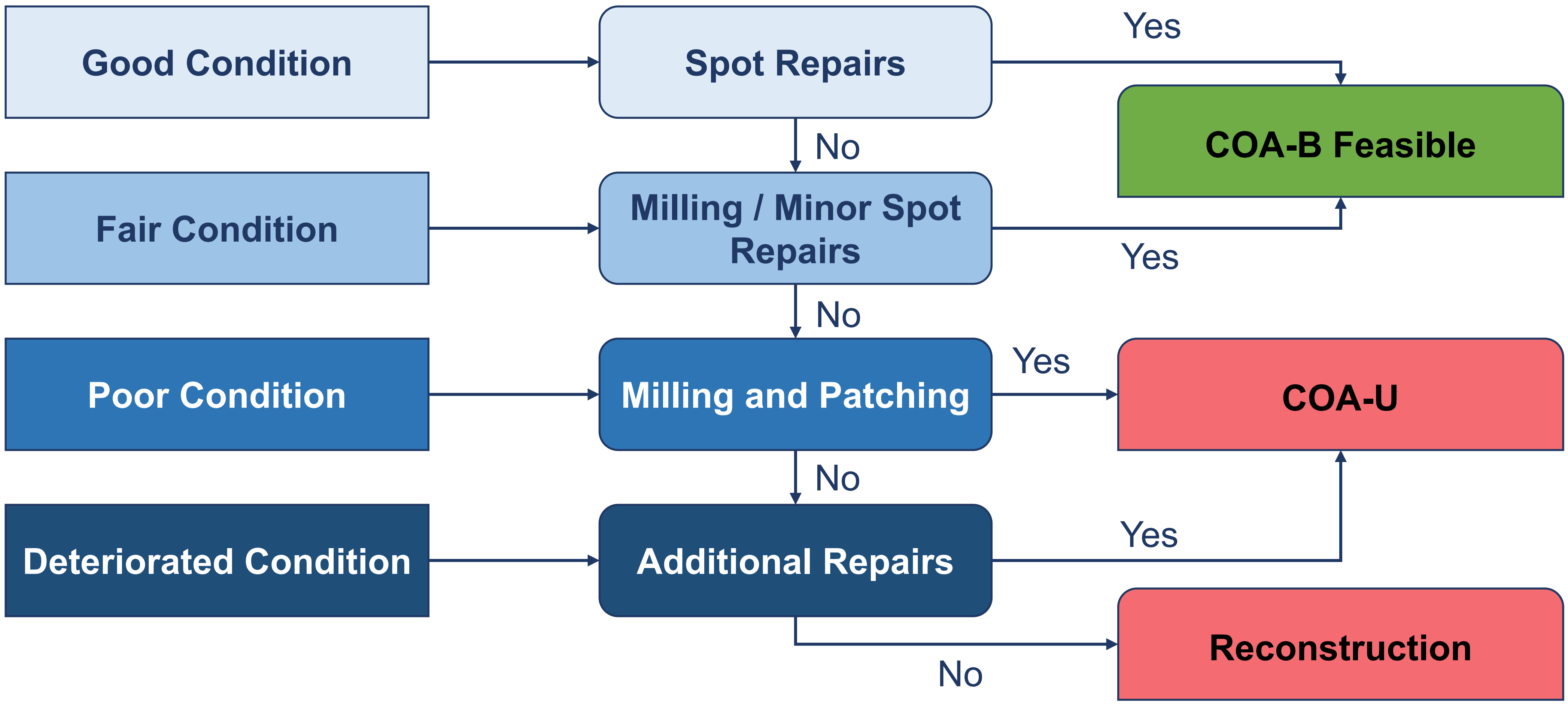
- Use Coring, NDT and Material Testing
  - Core for thickness & observe asphalt integrity
  - FWD for pavement integrity/uniformity
  - GPR for known problem areas
  - Check potential for asphalt stripping (ASTM D4867)
- Can vary level of review on roadway's functional class
  - Low-Volume Rural or Urban
  - Arterial or Urban Intersection
  - Secondary (State Route)
  - Primary (US Route/Interstate)

Image source: Voigt

More Thorough...BUT CORING IS ABSOLUTELY NECESSARY!

Use of ASTM standard is not a Federal requirement

6. Conclude Feasibility of a COA-B



Design Issues & Plans

Image source: Voigt

COA-B Jointing Considerations

Joint Spacing?

- A design variable
- Joints generally spaced closer than conventional concrete pavement.
  - Longitudinal
  - Transverse
- Squares divisible to lane geometry easiest to apply
- 6x6 ft common

Joint Sealing?

- Optional
- Multiple states do not seal or fill joints in overlays when slab sizes are 6 ft or less.
- Climate may be a factor to consider along with joint spacing.
- If applied, then usually as filler into single saw cut

Joint Spacing

6x6 ft Common

Single saw cut

COA-B Plan Development: Information Needed

- Location
- Geometrics
- Maintenance of traffic requirements
- Existing & proposed profile(s)
- Details:
  - Joint spacing
  - Transitions from the overlay to existing and/or structure elevations
  - Mitigating vertical and horizontal constraints
- Include when available: digital design data - LiDAR scans of existing pavement, existing survey data, design models, etc.

Detail for COA-B

Pavement Transition:

- At the beginning and end of concrete overlay sections
- At transitions into bridge approaches
- Under structures where vertical clearance must be maintained
  - At bridge approaches always require full-depth pavement removal and replacement
  - For speed limit of 45 mph or greater: use a 40:1 vertical taper
  - For speed limits less than 40 mph: use a 25:1 vertical taper

COA-B Profile Transition Detail

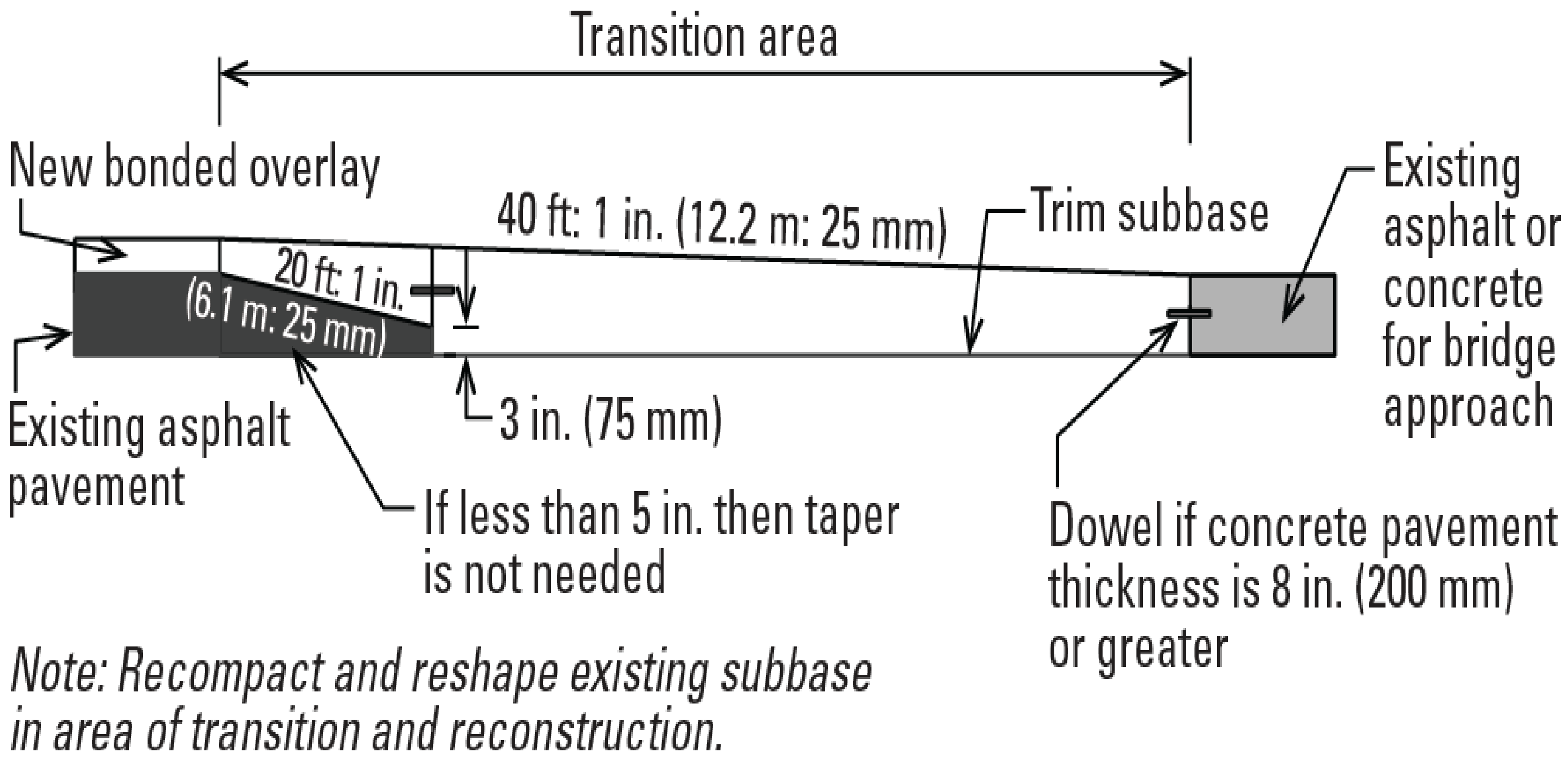


Image source: Iowa State University

Materials

Image source: Voigt

Concrete Constituents for COA-B

- Cementitious Materials
- Aggregates
- Water
- Admixtures




Image source: Iowa State University

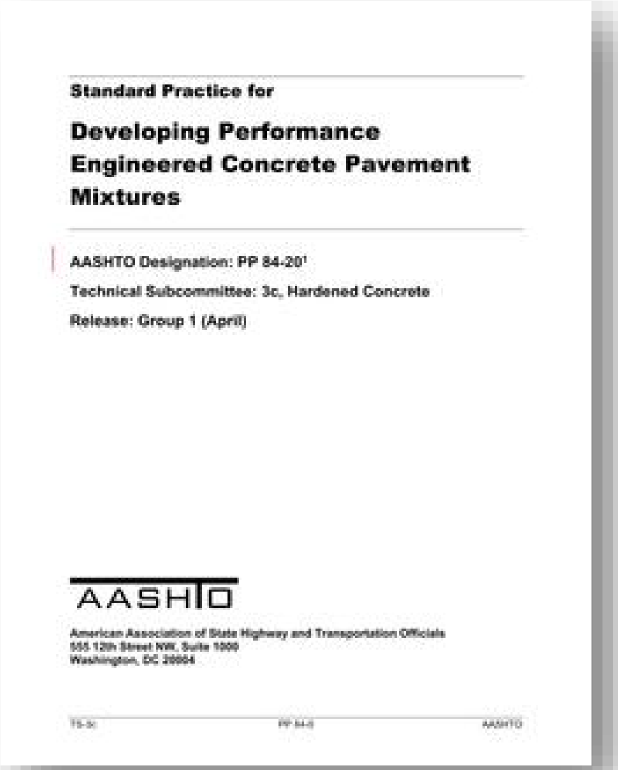
Cementitious Materials Options for COA-B

- Typically using paving cements Type I and Type II cements (ASTM C150)
- Blended cements (ASTM C595)
- Hydraulic cements (ASTM C1157)
- Commonly used SCMs are Class C or F fly ash and slag cement
- Type III cements is not typically used because of risks of increased cracking due to drying and thermal shrinkage.

Use of ASTM standard is not a Federal requirement

Performance Engineered Mixtures (PEM)

- Excellent technology for COA-B
- Focuses on criteria critical to COA-B:
  - strength
  - cold weather resistance
  - wet freeze-thaw
  - workability
  - shrinkage
  - aggregate stability
  - fluid transport


Standard Practice for

Developing Performance Engineered Concrete Pavement Mixtures

AASHTO Designation: PP 84-20[1]

Technical Subcommittee: 3c, Hardened Concrete

Release: Group 1 (April)

AASHTO

American Association of State Highway and Transportation Officials
555 12th Street NW, Suite 1000
Washington, DC 20004

AASHTO R101 (PP 84) specification

Use of AASHTO standard is not a Federal requirement

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PEM – Useful for Workability

- Workability important to overlays (COA-B's!)
- Workability influenced by aggregate gradation, mix proportioning, and placement sequence
- Also influenced by addition of water-reducing admixtures and macrofibers
- These PEM testing procedures helpful:
  - The vibrating Kelly ball (VKelly) test
  - The box test

Image source: FHWA

Using Macrofiber in COA-B Depends on Desired Strength

Design a fiber reinforced concrete overlay compared to plain concrete:

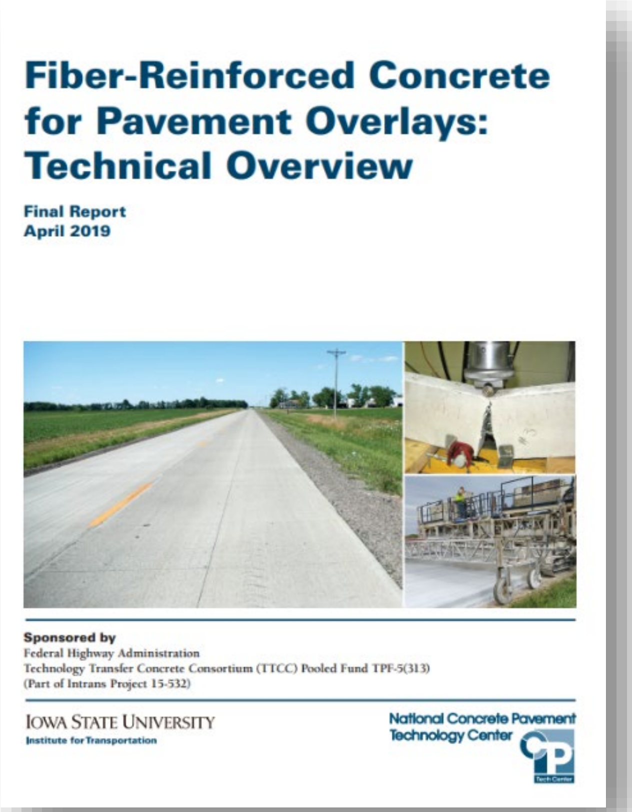
1. Run concrete overlay design software
2. Use key inputs in Residual Strength Estimator Software
3. Determine effective flexural strength for overlay design
4. Determine concrete overlay thickness with fibers

Compare plain and FRC overlay thickness

Determine fibers content to meet the design specification:

- Select fiber types to evaluate
- Create trial concrete batches with two fiber contents
- Perform ASTM C1609 on FRC beams to determine f_{150} value
- Determine required fiber content for each fiber based on specified f_{150} value

Useful Resources to Help You With Macrofibers



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Dowels & Tiebars in COA-B?

Dowels

- Not used if less than 6 in. thick
- Typically used in transitions only
- Where used:
  - Minimum diameter is usually 1-¼ in.
  - Lengths typically 18 in.
  - Spacing standard 12 in. c-c

Tiebars

- Some agencies use tie bars at longitudinal joints for overlays more than 5 in. thick

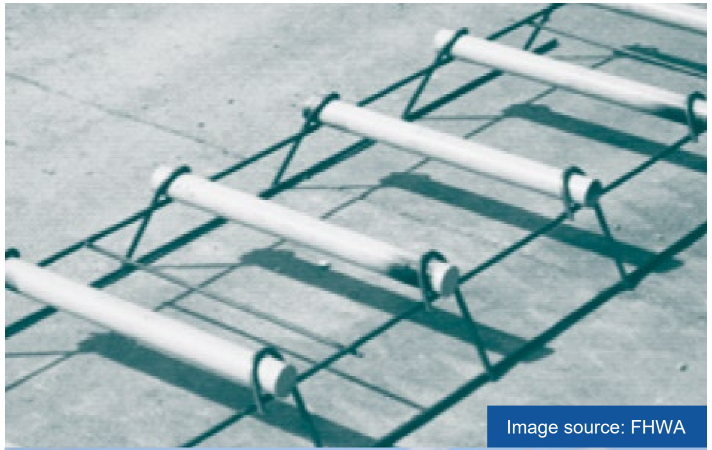


Image source: FHWA


Image source: Voigt

Construction Issues

Image source: Voigt

Pre-Overlay Repairs for COA-B

- Milling
- Subgrade/Subbase Repairs
- Repair of Thermal Cracking in Existing Asphalt Pavement

Key Considerations When Milling

- Should remove all scabs and loose asphalt.
- Depth should be controlled:
  - By stringline, ski, or 3D machine control
  - Ensure that the planned minimum thickness of asphalt remains after milling.
- If underlying layer is exposed:
  - Increase overlay thickness in that area
  - If possible, place transverse joints at thickness transitions.

Image source: Voigt

Suggested Strategies If Failed Areas Encountered

- Repair the Subgrade/Subbase
- If failed area smaller than 6x6 ft
  - Scarify new asphalt with milling machine to enhance bonding to concrete overlay
- If failed area greater than 6x6 ft
  - Place a two-layer patch
  - Use concrete for bottom layer
  - Use asphalt for top layer and scarify with milling to enhance bonding

To Address Asphalt Thermal Cracking

- Narrow cracks – Do nothing
- Address cracks that are wider than the maximum coarse aggregate size in concrete overlay mixture.
- Fill wide cracks with one of these options:
  - Joint filler material
  - Flowable mortar mixture
  - Sand or fines produced by the milling operation

Concrete Overlay Placement

- Placing a COA-B is typical of other concrete paving
- Steps are similar
- Key Considerations
  - Construction staking and machine control
  - Sawing joints
  - Curing the concrete
  - Opening to traffic

Concrete Overlay Placement –
Construction Staking and Machine Control, Part 1

- An optimized overlay profile should meet three objectives:
  1. ensuring that the concrete overlay is constructed to the proper thickness tolerance
  2. achieving a specified smoothness
  3. minimizing yield loss on the volume of concrete needed

- To meet all three, prepare a survey of the existing pavement that accurately models the surface

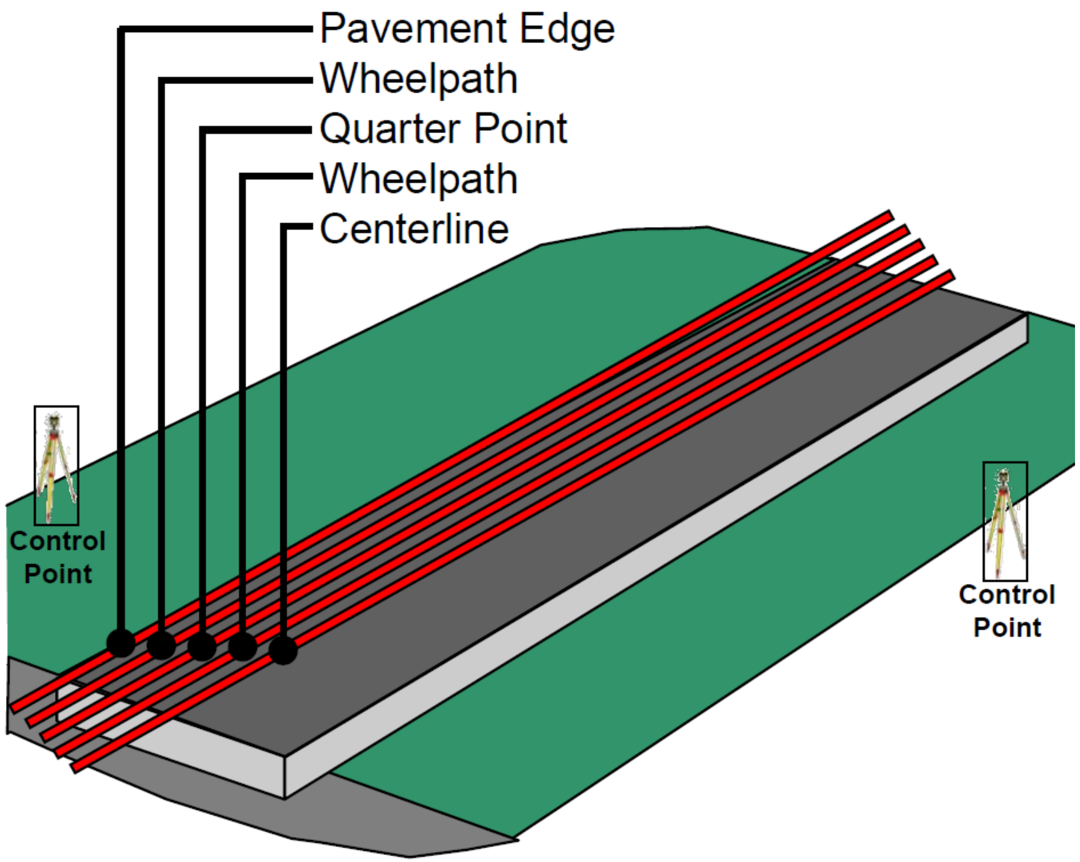


Image source: Iowa State University

Concrete Overlay Placement –
Construction Staking and Machine Control, Part 2

- To achieve optimum profile collect enough survey lines to capture all:
  - slope breaks
  - areas of rutting
  - any pavement characteristics affecting the optimum overlay profile grade line.
- Automated conventional surveying
- Newer surveying techniques such as LiDAR scanning and aerial drone surveying are well suited for this application.

Concrete Overlay Placement –
Construction Staking and Machine Control, Part 3

- Accurate machine controls must be used to achieve smooth overlay:
  - Stringline
  - Stringless (3D) controls
- Among the many benefits of 3D controls is:
  - Reduction of the paving operation footprint compared to stringline controls
  - 2-3 ft lateral clearance needed for 3D paving compared to 6-10 ft clearance for stringline paving.

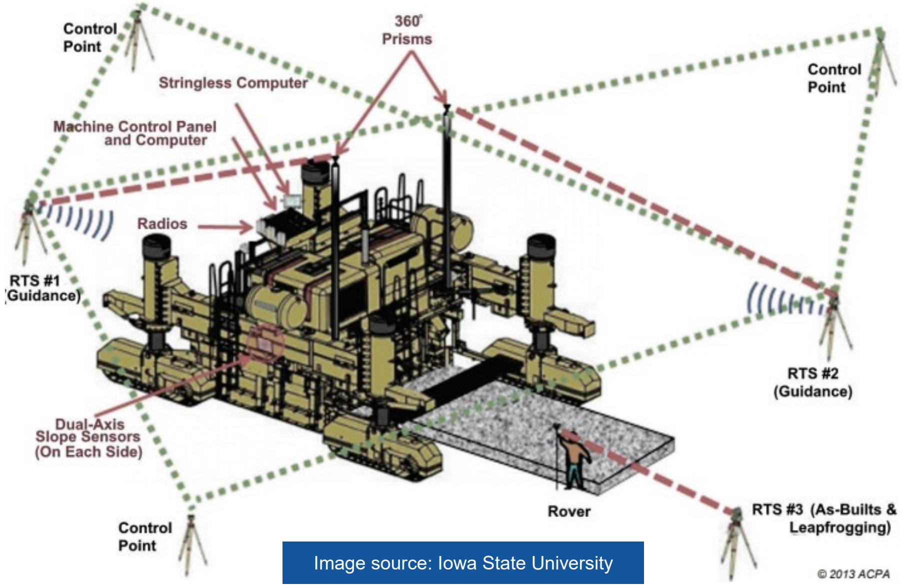


Image source: Iowa State University


Image source: Iowa State University

Concrete Overlay Curing

- Requires particular attention for overlays less than 8-in. thick.
- Because the ratio of surface area to volume is greater for thinner overlays than for typical concrete pavements, the same rate of evaporation will have greater detrimental effects on thinner overlays that are not properly cured.

Concrete Overlay Curing, Continued

Three primary issues impact the curing of concrete overlays:

1. Timing – Apply curing compound before surface evaporation
2. Compound – Use a good-quality curing compound, some state DOTs report great success with alpha-methyl-styrene
3. Coverage – Ensure full coverage of the surface and sides of overlay with no streaking or gaps (like a white sheet)

Image source: Iowa State University

COA-B Joint Sawing

- Closer joint spacing dictates the need for more saws than conventional concrete pavement
- Saw timing is influenced by many factors
- Success comes from proper planning
- HIPERPAV is a tool to predict the timing available for sawing

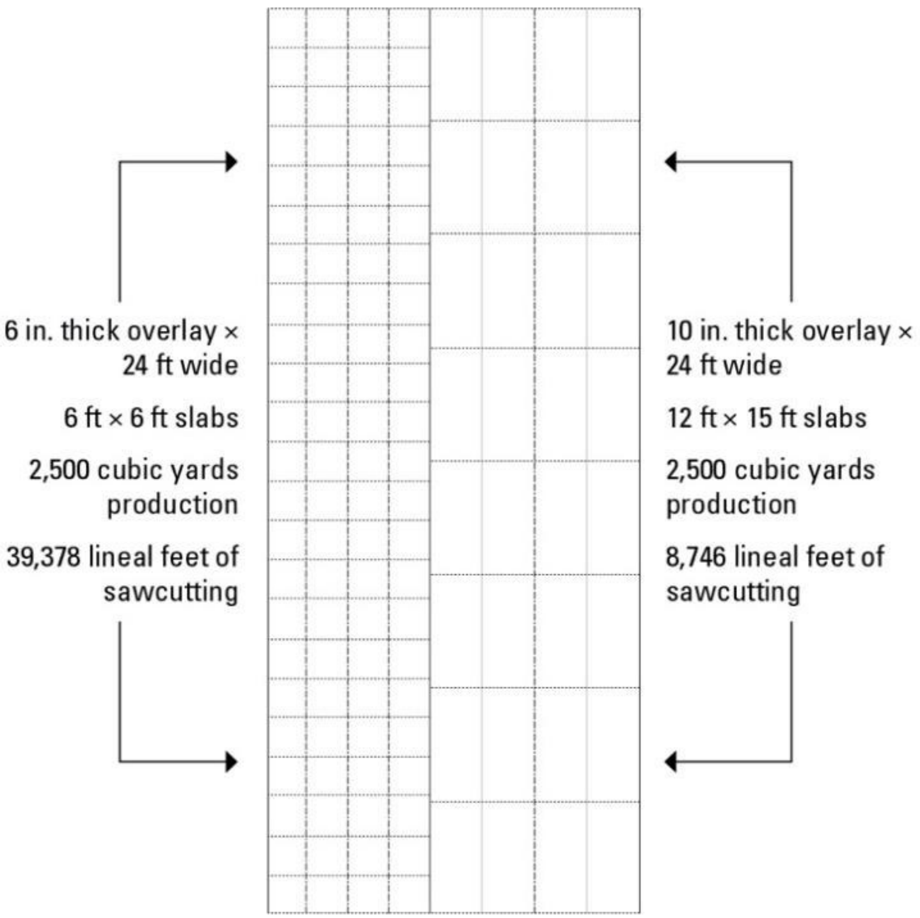


Image source: Iowa State University

Good Curing and Timely Sawing Addresses

- Influence of stiff underlying layers that increase the internal stresses in the early-age concrete.
- Added restraint from bonding.
- Higher ratio of surface area to concrete volume affecting moisture evaporation impact.
- Faster strength gain due to solar radiation and increasing sensitivity to drops in ambient temperature.
- Moisture and temperature differentials within the slab which can cause early-age curling and warping.

Image source: Iowa State University

Traffic Opening for COA-B

- Commonly opened at compressive strengths: 3,000 to 4,000 psi
- Other factors considered include:
    - Type and volume of traffic
    - Slab dimensions
    - Locations of the loads relative to the edges of the slabs, and
    - Particular cement chemistry and strength gain properties of the mixture
- Early traffic loading assists joint activation.
- Where acceleration needed, some agencies have had success with Type I Cement and SCMs.

How Do You Get Started?

Suggested Steps

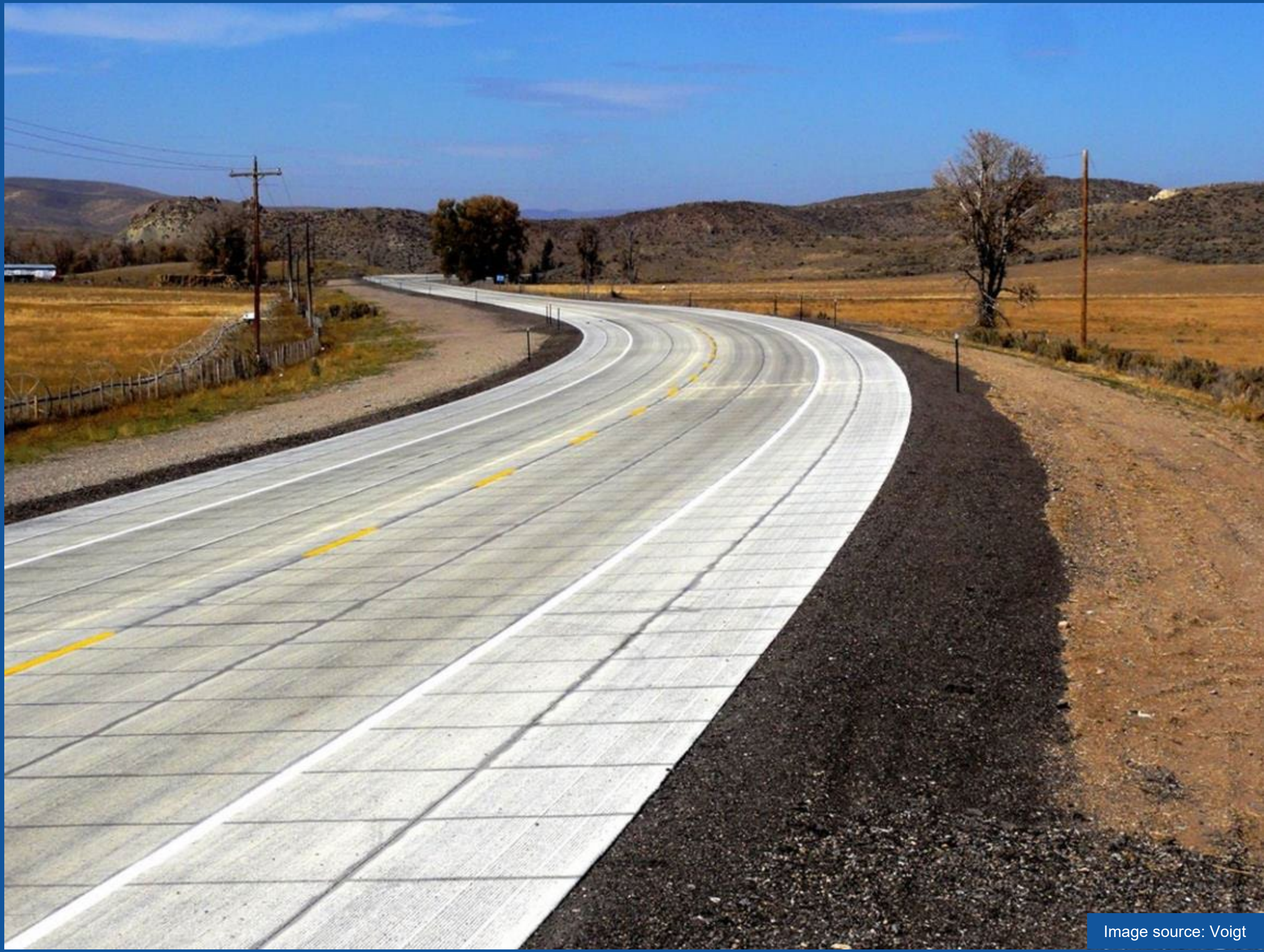


Image source: Voigt

Getting Started, Part 1

1

Start with simple projects:

A project with no complicated staging, low traffic volumes, or no tight completion requirements.

Getting Started, Part 2

2

Evaluate performance:

- Build a few projects per year
- Establish a process for annual field reviews and collection of performance data
- Allow the performance of the overlays to build your confidence in the technology

Getting Started, Part 3

3

Build your technical competency and experience while using all the available resources:

- Ready-to-Implement technology!
- Use the technical manuals and training materials
- Reach out to peer agencies to gain from their experience
- Consult FHWA for help

Getting Started, Part 4

4

Integrate concrete overlays into your “Mix of Fixes” over time:

- Collect local cost and performance data from your overlay projects
- As you build a database, include data from peer organizations and update that information with your data over time

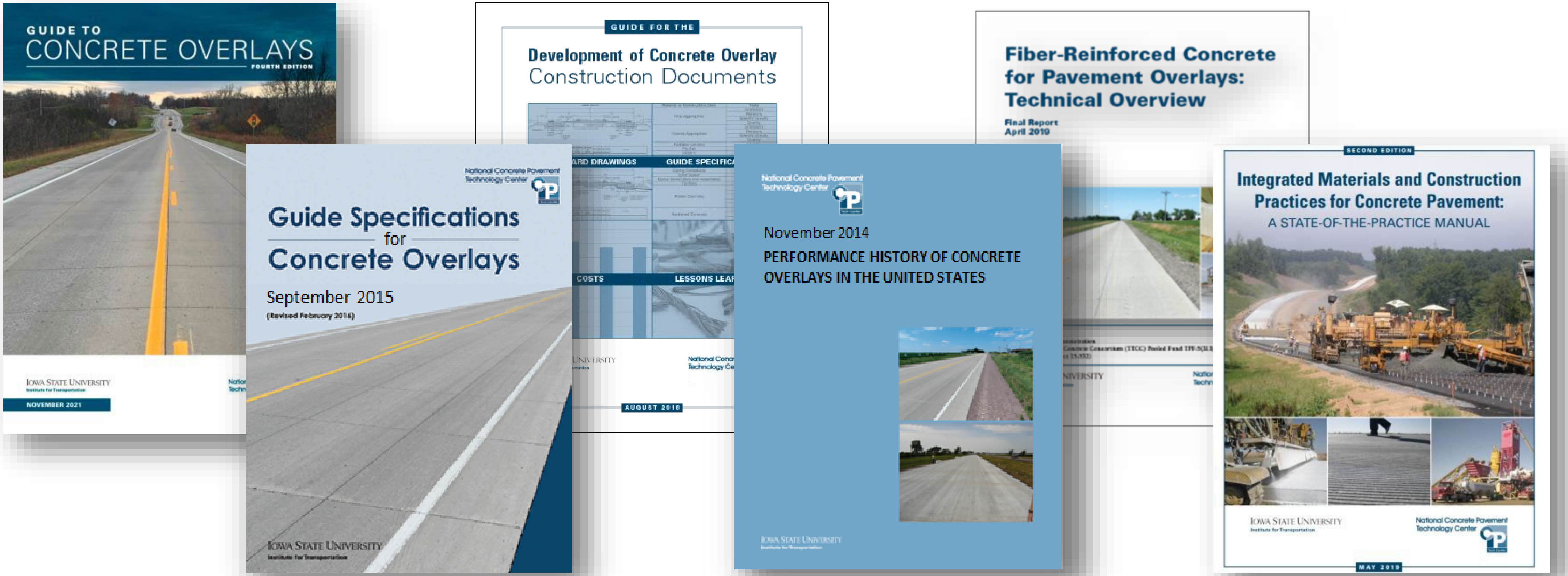
Getting Started, Part 5

5

Collaborate/reach out to peers when needed:

- Get technical support from FHWA
- Consortiums and peer exchanges

Use These Technical Resources!



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Colorado DOT Case Study

Concrete Overlay Case Study: SH 13 North of Craig, Colorado

Presenter:

Eric Prieve, P.E.

Concrete & Physical Properties Program Manager

Photo: HDR, used with permission

Project Description

Existing Asphalt Prior to Concrete Overlay
Source: Google Earth Image dated 09/02/2014

- 6 miles long (MP 98-104)
- 20% Truck Traffic
- Alternate Bids:
  - 6” HMA on Full Depth Reclamation
  - **6” PCCP on Existing Asphalt Pavement**

  Concrete bid was 1st Cost Low
- Guardrail Replacement
- Culvert Repairs
- Shouldering & Striping

Contractor's Approach to Milling

Photo: Castle Rock Construction Company, used with permission

- CDOT specifies a minimum HMA thickness to pave on
- Milling is optional so the contractor can optimize milling vs extra concrete to fill ruts
- Surveyed existing roadway & developed a milling plan
- Identified largest cuts & cored those areas to ensure minimum asphalt thickness
- Maintaining a consistent thickness was key to success (pay item by square yard only)

Millings Made an Excellent Track Pad Line & Great Shouldering Materials

- Stable track pad leads to smoother pavement
- Millings as shouldering reuses materials & provides a weather resistant surface

Photo: CO/WY Chapter - ACPA, used with permission

Recent Advances Further Improve Overlays

Performance Engineered Concrete Mixtures

Photo: Castle Rock Construction Company, used with permission

- Optimized aggregate gradations
- Lowers segregation & creates more workable mix even at lower slumps
- 20% Class F fly ash (recycled coal ash) for improved durability
- Reduced cementitious content
- Improves ride characteristics
- More consistent mixing
- Enhances durability

Aggregate Production

Photo: Castle Rock Construction Company, used with permission

Contractor used unconventional aggregate sizing to minimize segregation.

Contractor setup in an aggregate mine at the location and mined their own aggregates.

Concrete Paving Operation

- Portable concrete batch plant located within project limits
- Consistent & uninterrupted delivery of concrete in dump trucks
- Paved half-width (19’)
  - 12’ lane
  - 7’ shoulder

Photo: CO/WY Chapter - ACPA, used with permission

Traffic Control: Pilot Car

Photo: CO/WY Chapter - ACPA, used with permission

- Successful approach for 2-lane roads used extensively in CO.
- Allows for continuous roadway operations
- Enhances safety (construction and motorist)
- Process was optimized to minimize time in que
- Public outreach and communication essential
- Allows for accelerated construction and improved production rates

Safety: Rumble Strips & Longevity

Photo: Castle Rock Construction Company, used with permission

- Rumble strips placed during paving with drum behind paver
- Longevity of concrete overlay reduces need for work zones in the future, increasing safety

Finished Product

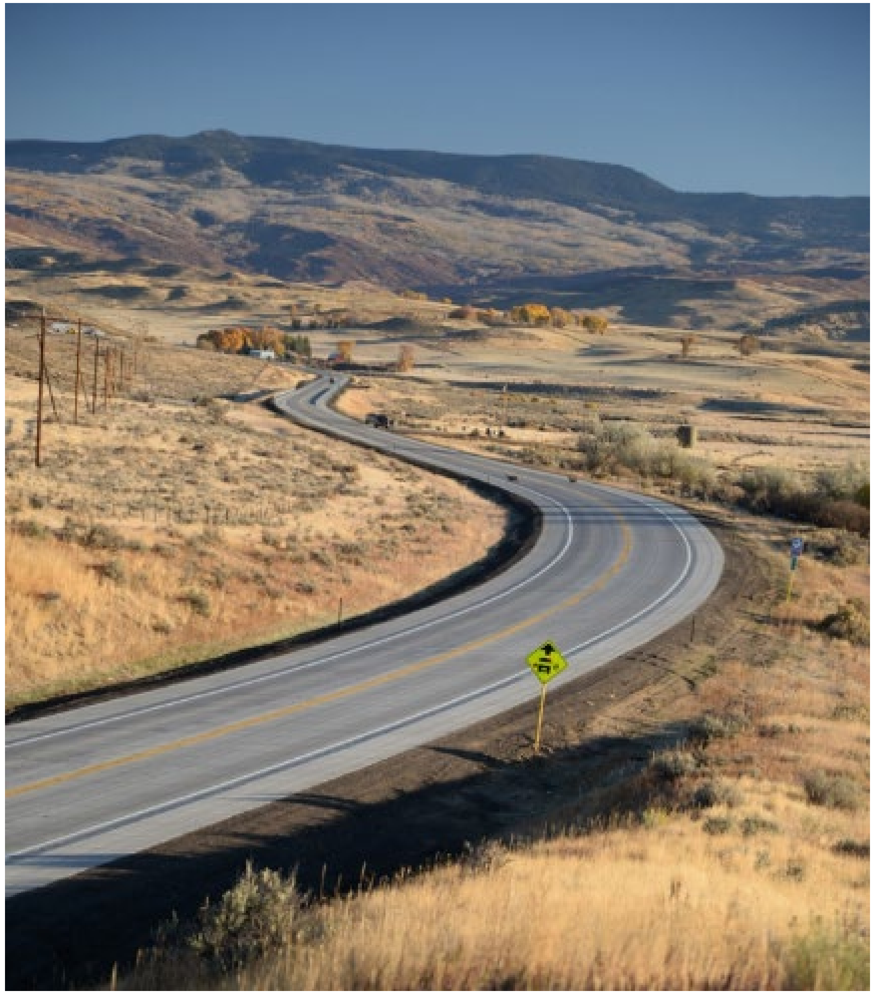


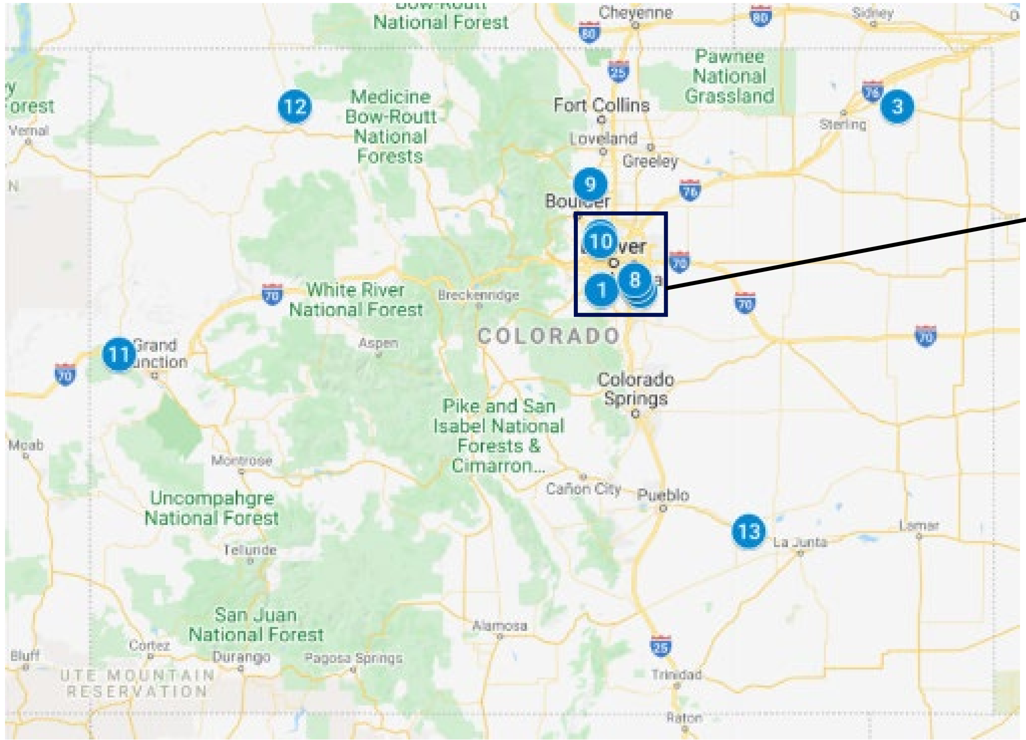
Photo: HDR, used with permission

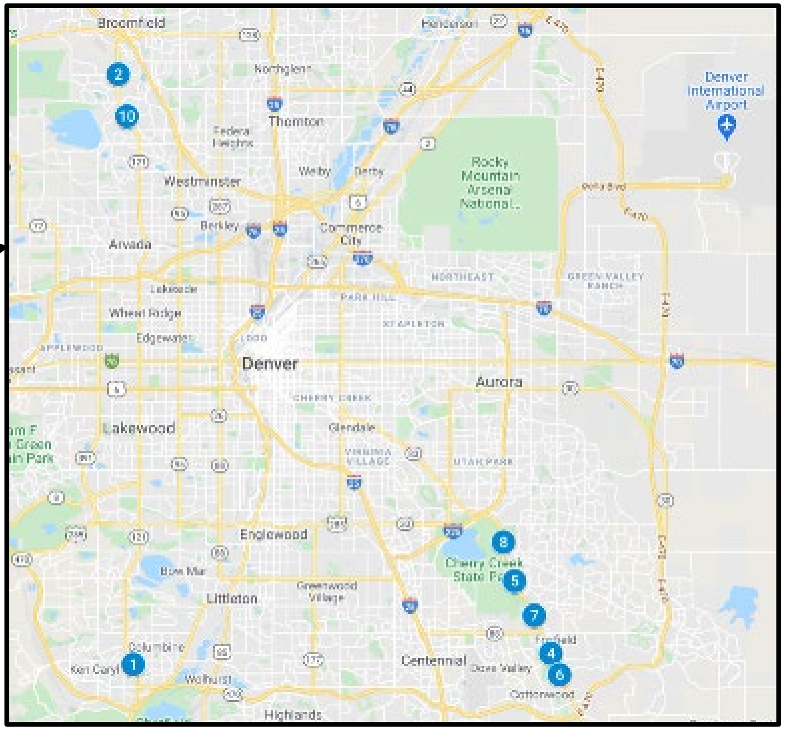
- Lots of compliments from motorists and CDOT maintenance
- Smoothness: 44 inch/mile IRI
- Awards:
  - CO/WY ACPA Award for Excellence in Concrete Pavement - Overlays
  - ACI – State Award for Excellence in Concrete
  - ACPA National Gold Award for Excellence in Concrete Pavement - Overlays
- Long-term solution to a distressed asphalt roadway at a competitive cost

Thin Concrete Overlays in Colorado

Thin Overlays (6" & less)

1. SH 121 - C-470 to Parkhill
2. SH 121- 104th to US 36
3. US 6 - Fleming to Haxtun
4. SH 83 - Pine Ln to Arapahoe
5. SH 83 - Rice to Orchard
6. SH 83 - S. of Jamison Ave.
7. SH 83 - Arapahoe to Orchard
8. SH 83 - N. of Quincy
9. SH 66 - US 36 to US 287
10. SH 121 - 88th to 104th
11. I-70 East of Mack
12. SH 13 - N. of Craig
13. US 50 - Fowler to Manzanola





Graphics developed with Google Maps

CDOT has built over 1.5 million SY of 6" concrete overlays & over 10 million SY of concrete overlays of all thicknesses

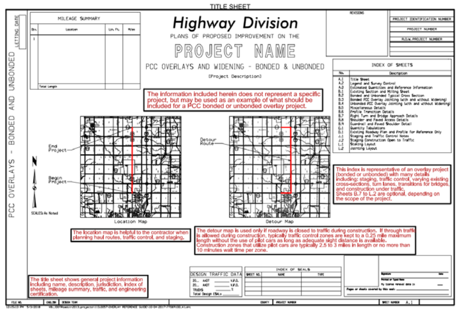
Concrete Overlay Resources

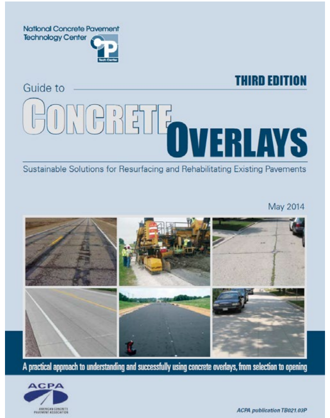
Design

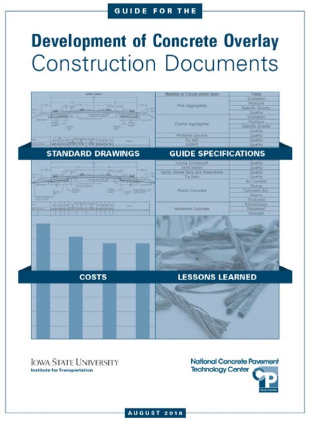
- CDOT’s Pavement Design Manual https://www.codot.gov/business/designsupport/materials-and-geotechnical/manuals/2021-m-e-pave-design-manual
- Bonded Concrete Overlay of Asphalt Mechanistic-Empirical design procedure: https://www.engineering.pitt.edu/Vandenbossche/BCOA-ME/
- AASHTO Pavement ME Design – BCOA-ME

Construction

- National Concrete Pavement Technology Center: https://cptechcenter.org/concrete-overlays/







Performance

- National Concrete Pavement Technology Center’s research on Iowa’s overlay performance: https://cptechcenter.org/research/completed/concrete-overlay-performance-on-iowas-roadways/

COLORADO
Department of Transportation

Thank you! Questions?

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Q & A

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