Tech Brief

U.S. Department of Transportation
Federal Highway Administration

PAVEMENT PRESERVATION HOW

The fourth round of Every Day Counts (EDC-4) innovations promoted quality construction and materials practices that apply to both flexible and rigid pavements. For flexible pavements, these include using improved specifications for thin asphalt surfacings such as chip seals, scrub seals, slurry seals, micro surfacing, and ultrathin bonded wearing courses; following improved construction practices; and using the right equipment to place these treatments. Rigid pavement treatments include the rapid retrofitting of dowel bars to reduce future faulting; the use of new, fast-setting partial- and full-depth patching materials to create a long-lasting surface; advanced pavement removal techniques to accelerate patching construction times; and advancements in diamond grinding that contribute to smoother and quieter pavement surfaces with enhanced friction.

BACKGROUND

Regional peer-to-peer exchanges between states were initiated to exchange knowledge on "How" to effectively implement pavement preservation. Adoption of a comprehensive pavement preservation program will ultimately result in an improved pavement condition and safety rating for the overall network, reduced agency and user delay costs, and decreased environmental impact. In order to achieve these objectives, an understanding of the concepts, capabilities, and applications relevant to constructing pavement preservation treatments with quality materials must be implemented via a technology program aimed at transportation agencies, contractors, consultants, and Federal Highway Administration (FHWA) staff.

PAVEMENT PRESERVATION HOW: MINNESOTA, MISSOURI, IOWA, AND WISCONSIN

EDC-4 PEER-TO-PEER EXCHANGES

INTRODUCTION

On February 27th, 2019, an FHWA-sponsored EDC-4 "How" Pavement Preservation State Peer-to-Peer Exchange was conducted in Minneapolis, Minnesota, with 2 attendees from academia, 1 consultant, and 11 department of transportation (DOT) representatives from Minnesota, 2 from Missouri, 2 from Iowa, and 1 from Wisconsin. Larry Galehouse with the National Center for Pavement Preservation and Larry Scofield with the International Grooving & Grinding Association and American Concrete Pavement Association facilitated the day-and-a-half-long meeting. Minnesota was the host state and provided meeting room facilities. Antonio Nieves of the FHWA provided the meeting background and kicked off the meeting.

The meeting format consisted of each of the states identifying their current procedures, issues, and successes for each of the topics discussed. Table 1 indicates the discussion topics.

Table 1. List of pavement preservation treatments discussed

Asphalt pavement preservation treatments	Concrete pavement preservation treatments
Chip seal	Partial-depth repair
Micro surfacing	Precast slabs
Cold in-place recycling (CIR)	Diamond grinding
Ultrathin bonded wearing course	—
Scrub seal	—
Cape seal	—

SUMMARY OF IMPORTANT ISSUES OR SUCCESSES

Asphalt Concrete Pavement Preservation

Chip sealing: All four states report successfully using this treatment. CRS-2P is the most common binder, and the most common top chip size is ⅜ in. One state uses ¼ in. chips to prevent property damage (e.g., windshield chips). The smaller aggregate size is less prone to damage windshields or paint. The fines content is typically limited to 1% passing the number 200 sieve size, which is difficult to attain, especially if limestone aggregate is used. One state imposes a penalty for amounts that exceed the requirement. Granite and trap rock are the more common aggregates types used, with one state having access to Haydite (a lightweight aggregate).

Most states sweep prior to opening to traffic. At least three states fog seal the chips after a delay period (typically three days to one week). One state has successfully placed chip seals on routes with average daily traffic (ADT) counts of up to 30,000. Chip seals are commonly placed by maintenance crews, with one state using county personnel. See Table 2.

Table 2. Chip sealing

State	Design		Material type				Construction procedures						
	Design procedure	Maximum ADT	Aggregate	Binder	Top size	P200	Aggregate rate	Binder rate	Rollers	Sweeping	Fog seal	Stripe pretreatment	Pilot vehicle
Minnesota	Yes	NA	Granite/Trap	CRS-2P	⅜ in.	0%– 1%	NA	Determined by the mix design	Three self-propelled pneumatic-tire rollers in accordance with 2360.3.B.2.e(2)	Before traffic	Apply from 0.07–0.18 gal/yd² diluted	Yes, apply CRS-2P	NA
Iowa	No	NA	Limestone	CRS-2P	½ or ⅜ in.	Up to 4%	10 lb/yd² for shoulders, 15 lb/yd² for winter seals, 30 lb/yd² for other applications	See Table 2307.03-B2	Minimum 2 pneumatic-tire rollers for other cover aggregate and 1 for sand cover aggregate	Yes	CSS-1, CSS-1H, or SS-1H diluted at 7:1 at 0.12 gal/yd²	NA	Yes
Missouri	See Sections 409.2 and 409.3	NA	Haydite/ Trap	CRS-2P and HFE	¼ in.	Grade A1: 0%–1% Grade A2: 0%–1.5% Grade B1: 0%–2% Grade B2: 0%–2.5% Grade C: 0%–2%	Within ±5 lb/yd² of mix design	0.35	Equipment capable of seating of aggregate without causing aggregate fracture	Yes	No	NA	Yes, 35 mph
Wisconsin	Section 475	NA	See Sections 475.2 and 460.2.2	CRS-2P or HFRS-2P	See Sections 475.2 and 460.2.2	See Sections 475.2 and 460.2.2	18 lb/yd² or per engineer	0.36 gal/yd² or per engineer	Two 6–9 tn steel-wheel rollers and pneumatic-tire roller	Before traffic	Some projects	Some projects	Some projects

Table 3. Micro surfacing

State	Design method	Material type				Construction procedures						
		Aggregate	Binder	Type	Cement	Application rate	Crack seal in advance	Tack in advance	Sweeping in advance	Test section	Number of courses	Calibration verification
Minnesota	Yes	Granite	CQS 1P	2 and 3	Portland cement (Type I per 3101) or hydrated lime (per 3106)	NA	NA	On PCCP only	Clean the surface immediately before placing the micro surfacing	Yes, night	2	Yes
Iowa	ISSA	Limestone and dolomite or quartzite, granite, and slag (⅜ in.)	CSS1-h and CQS-1H	NA	Type I portland cement	Minimum 20 lb/yd² (may be modified for multiple course treatments)	1 year before	NA	Clean the surface immediately before placing the micro surfacing	Minimum 300 ft	1–2, depending on pavement condition	Yes
Missouri	See Section 413.10.2	Flint and crushed slag	See Section 413.10.3	2 and 3	Portland cement (Type I) or hydrated lime	Type II: 10–20 lb/yd² Type III: 15–30 lb/yd²	NA	Yes	Clean the surface immediately before placing the micro surfacing and pre-wet the surface	Yes, day or night	2, with Type 3	Yes
Wisconsin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Micro surfacing: Three of the four states use this treatment, with one of those three states using it as its main preservation treatment. Of the three states that use the treatment, two prefer the double-course application. Two of the three states require test sections, with one of these states requiring a nighttime test section. The advantage of a nighttime test section is that slurry seal binders cannot set in time to be successful, which ensures that a true micro surface product is used. Aggregate sources range from granites to quartzite to limestone, with limestone being the least desirable. Binder content specifications range from 5.5% to 10.5% in one state and from 13% to 16% in another state. The higher binder content was recommended based on performance. CQS-1P and CQS-1hP are the most common binders. It was noted that crack sealing in advance is preferred and that accounting for the micro surfacing in a pavement management system (PMS) can be challenging because the surface masks cracks very well, even though they still exist. See Table 3.

Cold in-place recycling (CIR): Three of the four states report successfully using this treatment. Two of those three states use emulsions, and one uses foamed asphalt. This technique is typically used to replace the top three to four inches of pavement, with the requirement that a minimum of three inches of existing pavement remain after the milling operation. A two-inch asphalt concrete (AC) overlay is typically required to cap the CIR. The CIR pavement must sufficiently dry before the AC overlay can be placed. Drying time can range from 3 days to 14 days. If rains occur after placement of the CIR, it may be necessary to roll the surface to increase its density. See Table 4.

Ultrathin bonded wearing course: Although all four states have tried this treatment, only two currently use it. The two states using it have spray pavers in the state and have had good success, with reported performance periods of 7 to 15 years. CRS-1P is often used as the emulsion tack. Winter icing is a concern and must be managed properly by maintenance crews. Of the two states that do not use this treatment, one of them does not do so because its soft limestone aggregate wears down under winter snow plowing, resulting in friction issues. The use of this treatment was therefore discontinued. The other state used the treatment at one time but does not currently have specifications. See Table 5.

Scrub sealing: Although all four states have used this treatment, only one state regularly uses it. The other three states have placed test sections/projects for evaluation purposes. In the state that regularly uses scrub seals, the aggregate is trap rock and Haydite with a top size gradation of ¼ in. CRS-2P is principally used, though emulsion suppliers are currently recommending CMS-2P because it breaks more slowly. The scrub seals are placed by maintenance crews. See Table 6.

Cape sealing: Although three of the four states have constructed cape seals, only one state regularly uses them and has tried different applications, such as the use of an interlayer. Since the cost of a cape seal approaches that of a thin overlay, the DOT in that state is trying to differentiate between the two in its treatment selection criteria. Two states currently do not use cape seals, and the fourth state has not placed one in four years. These states also are not aware of the treatment's performance. Stripe retention on cape seals was discussed and is a concern. Paint markings require more frequent application, while epoxy markings do not work at all because they are too brittle. See Table 7.

Table 4. Cold in-place recycling

State	CIR type		Construction procedures								
	Foamed asphalt	Emulsion	Plant type		Final surface	Cement admixture	Moisture testing	Cure period before overlay	Traffic restrictions	Minimum thickness	Minimum existing AC Remaining
			Central	Roadway							
Minnesota	Yes	NA	Yes	Yes	Minimum 2 in. OL	Yes, 0.5%	Yes, contractor	3–14 days	NA	NA	NA
Iowa	PG 52-34S	HFMS-2s	NA	Yes	Typ. 3 in. OL	NA	Yes	Moisture content <3.5%, moisture content <5% for 3 days or CIR completed for 21 days	NA	2 in.	NA
Missouri	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wisconsin	Yes	No	NA	NA	Based on SN and Spec 460.3.2 on nominal size mixtures	No	By contractor	Within 10 days and moisture content <2.5%	By contractor	NA	No

Table 5. Ultrathin bonded wearing course

State	Design method	Material type		Construction procedures				
		Aggregate type	Binder type	Crack seal in advance	Spray paver	Tack coat	Thickness	Used as interlayer
Minnesota	Yes, per Specification 2353.2	Meets MnDOT 3139.4	PG 58V-34	NA	Yes	CRS-1P	⅝ in.	Yes
Iowa	NA	NA	NA	NA	NA	NA	NA	NA
Missouri	See Sections 413.30.2 and 413.30.4	See Sections 1002.2 and 1002.3	See Section 1015	Yes, >¼ in. and any working crack	Yes	NA	Minimum ½ in. for Type A; minimum ¾ in. for Type B and Type C	NA
Wisconsin	NA	NA	NA	NA	NA	NA	NA	NA

Table 6. Scrub sealing

State	Material type			Construction procedures					
	Emulsion spec	Aggregate type	Binder type	Crack seal in advance	Blow out cracks in advance	Binder rate	Fog seal	Commerical broom	Contract work
Minnesota	Section 1015	NA	NA	NA	NA	NA	NA	NA	NA
Iowa	NA	NA	NA	NA	NA	NA	NA	NA	NA
Missouri	Section 1015	Haydite and trap	CRS-2P	NA	Yes	0.25	NA	No	NA
Wisconsin	NA	Section 475	Grade CMS-2P	NA	NA	0.3–0.4 gal/yd^2 or per engineer	Some projects	Yes	NA

Table 7. Cape sealing

State	Design method	Material type		Construction procedures						
		Aggregate type	Binder type	Chip seal top size	Chip spread rate	Chip binder rate	Surface type	Delay between layers	Marking problems	Rumble strip issues
Minnesota	NA	NA	NA	NA	15 lb	NA	NA	24–48 hours	Yes	NA
Iowa	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Missouri	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Wisconsin	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Table 8. Partial-depth repair

State	Distress type		Design		Construction practices					
	Materials-related distress	Spall repair	Repair material specs	Coring in advance	Defining patch limits	Use of milling equipment	Repair materials	Bonding agent	Grouting edges	Warranty
Minnesota	Yes	Yes	ASTM 928	Yes	Yes	Yes	3U18	Cement or epoxy	Yes	30 days
Iowa	NA	Yes	Yes	Yes	Yes	Yes	Modified portland cement, rapid set, high early strength	Grout (2 parts Type I or I/II cement, 1 part sand and water)	Yes	30 days
Missouri	No	Yes	Yes	Sometimes	Yes	Yes	Fibercrete or TechCrete, cementitous mix and epoxies	Cement grout, epoxy agent, or SSD surface condition	Yes	No
Wisconsin	NA	Yes	Section 416	Sometimes	Yes	Yes	Grade C mixes or 8-hour concrete mix	NA	NA	NA

Table 9. Precast slabs

State	Design				Use		Construction practices	
	Roman Stone	Illinois Tollway	Fort Miller	Caltrans	Demo project	Routinely use	Bedding type	Panels per shift
Minnesota	NA	NA	NA	NA	Yes	NA	NA	NA
Iowa	NA	NA	NA	NA	Yes	NA	NA	NA
Missouri	NA	NA	NA	NA	NA	NA	NA	NA
Wisconsin	NA	NA	NA	NA	Yes	NA	NA	NA

Table 10. Diamond grinding

State	Purpose of grinding				Construction practices			
	Ride quality	Friction	Noise	Buried treasure	Blades per foot	Head width	Smoothness spec	Construction issues
Minnesota	Yes	NA	Yes	Yes	NA	NA	NA	NA
Iowa	Yes	NA	Added benefit	One project	Per contractor based on aggregate type	Minimum 3 ft	Yes	NA
Missouri	Yes	Yes	No	No	Based on CA type	Minimum 3 ft	Yes	No
Wisconsin	Yes	Yes	Yes	NA	Based on aggregate type	Minimum 3 ft	Section 420	Elastomeric patches

Concrete Pavement Preservation

Partial-depth repair: All four states report successfully using this treatment. Two of the states use milling removal techniques and replace the removed material with conventional mixes (3U18) following the National Concrete Pavement Technology Center's (CP Tech Center's) spall repair guidelines. Two states use elastomeric repair materials such as Fibercrete™ and TechCrete™. It was noted that it is important to conduct a pre-design inspection to establish the condition of the joints. Retrieving cores was recommended, but recent experience suggests that the use of an ultrasonic tomography device (such as the Ultrasonic Shear-wave Tomography technique, or MIRA) is safer and much more efficient than coring. One agency uses a 30-day warranty that commences upon completion of the subsequent diamond grinding activities. See Table 8.

Precast slabs: Although three of the four states have used this treatment, those states only used it for a test or demonstration project constructed 3 to 10 years ago. The states believed that precast slabs are a specialty product. See Table 9.

Diamond grinding: Three of the four states reported considerable experience with diamond grinding, and it has been a successful treatment for those states. Although most states have used diamond grinding for smoothness, one state uses it to restore friction. One state is removing previous AC overlays from concrete pavements and diamond grinding them to return the surface to concrete. One state has two different smoothness requirements for grinding based on posted speed limits, one for urban areas and one for other areas. See Table 10.

Miscellaneous

MnDOT Knowledge Books: The Minnesota Department of Transportation (MnDOT) presented an overview of its Knowledge Book concept. The state contracted with a consultant to conduct a process known as the Method of Analyzing and Structuring Knowledge (MASK). The resulting product is an interactive PowerPoint file with charts, photos, videos, and more that document an individual's experience and judgement in a specific area. MnDOT is making a Knowledge Book for concrete and one for asphalt.

Snowplow blade wear: Damage due to snowplow operations is a concern for several preservation treatments. As a result, states are using technology such as Joma specialty blades so that preservation treatment selection is not dictated by winter maintenance operations.

KEY OBSERVATIONS

During this peer-to-peer exchange meeting, personnel representing four state agencies, a consulting business, and a university identified and discussed pavement preservation successes and challenges.

Preservation Successes

- A chip seal design program provides the starting asphalt emulsion and aggregate application rates. Adjustments can then be made in the field if necessary.
- Requiring a maximum fines content of 1% passing the No. 200 sieve improves chip seal performance.
- The use of incentives/disincentives is often effective at improving compliance with aggregate requirements.
- The use of nighttime test sections in micro surfacing construction helps to ensure that slurry seal emulsions are not being used because they do not set properly at night. Placement should begin at least one hour after sunset or at least one hour before sunrise.
- When using CIR on older pavements constructed with rounded river gravel, stability problems sometimes result. This is solved by adding 0.5% of portland cement during the mixing phase.
- One state has experienced fewer concrete repairs since it reduced the allowable water-to-cement ratio to 0.4. The state further suggested that construction-related problems should be corrected when the pavement is about five years old, including resealing of joints and diamond grinding, because any shrinkage and curling and warping of the pavement would have developed by then.

Preservation Challenges

- A pavement preservation program should have the support of DOT leadership to be successful.
- Because micro surfacing is prone to cracking, it can cause problems with the performance prediction models used by pavement management systems.
- If rain events occur after CIR construction, it may be necessary to re-roll after a few days to increase surface density. Additionally, the CIR treatment needs to dry out before an overlay is placed on top as the final surface.
- When planning partial- or full-depth concrete repairs, determining the underlying condition of the pavement is an important activity during design, particularly in areas with joint-associated distress. This can be accomplished by retrieving cores or using nondestructive methods such as ultrasonic tomography (via MIRA).

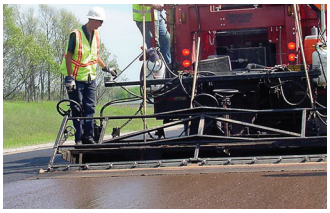
SUMMARY

Six asphalt and three concrete pavement preservation treatments were discussed in depth (see Figures 1–9). Chip sealing is the primary AC preservation treatment used in three of the four states, with micro surfacing being the primary treatment used in the fourth state. Although the various treatments were not always commonly used, all four states had some experience with them.

The attendees also discussed the impact of winter maintenance on preservation treatments and previewed one state's future Knowledge Book, a system intended to transfer institutional knowledge.

Slurry Pavers, Inc.

Figure 1. Chip sealing



National Center for Pavement Preservation

Figure 2. Micro surfacing

Pavement Recycling Systems

Figure 3. Cold in-place recycling

All States Materials Group

Figure 4. Ultrathin bonded wearing course

Saskatchewan Ministry of Highways and Infrastructure

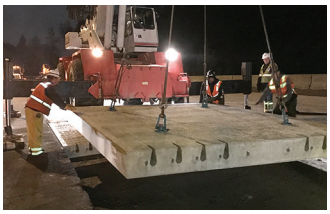
Figure 5. Scrub sealing

Strawser Construction Inc.

Figure 6. Cape sealing

ACPA

Figure 7. Partial-depth repair



Shiraz Tayabji

Figure 8. Precast slabs

International Grooving and Grinding Association

Figure 9. Diamond grinding

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DISTRIBUTION AND AVAILABILITY
This tech brief can be found at https://www.fhwa.dot.gov/pavement/preservation/.

KEY WORDS
pavement, preservation, peer-to-peer

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AGENCY SPECIFICATIONS

The relevant agency specifications are available at the following websites:

Minnesota: http://www.dot.state.mn.us/pre-letting/spec/index.html

Iowa: https://iowadot.gov/specifications/

Missouri: https://www.modot.org/missouri-standard-specifications-highway-construction

Wisconsin: https://wisconsindot.gov/Pages/doing-bus/eng-consultants/cnslt-rsrces/rdwy/stndspec.aspx

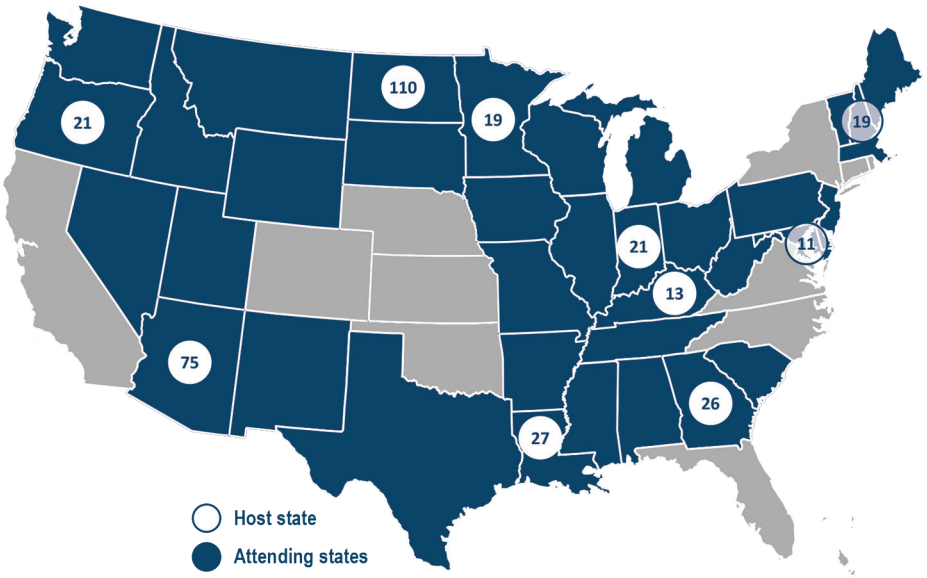
ONLINE RESOURCES

National Center for Pavement Preservation (https://www.pavementpreservation.org/)

National Concrete Pavement Technology Center (https://cptechcenter.org/)

Federal Highway Administration (https://www.fhwa.dot.gov/pavement/preservation/)

Pavement Preservation & Recycling Alliance (https://roadresource.org/)



Host state	AZ	DE	GA	IN	KY	LA	MN	NH	ND	OR
Attending states	NM	MD	AL	IL	TN	AR	IA	ME	MT	ID
	TX	NJ	SC	OH	WV	MS	MO	MA	SD	NV
	UT	PA	—	MI	—	—	WI	VT	WY	WA
Number of attendees	75	11	26	21	13	27	19	19	110	21

Regional state peer-to-peer exchanges were held in 10 states with 342 total attendees from 37 states