Asphalt Crack Treatment

FAQs and Technical Resources

Report #2023RIC05

Technical Assistance Panel

Dan Knapek, Chair, Sherburne County
Brian Boder, St. Louis County
Mark Daly, Faribault County
Andrew Giesen, Washington County
Bruce Hasbargen, Beltrami County
Eddie Johnson, MnDOT
Nick Klisch, Cottonwood County
Guy Kohlnhofer, Dodge County
Steve Meyer, Wright County
Trent Nicholson, Koochiching County
Cindy Voight, Duluth
Paul Nolan, MnDOT
Joel Ulring, MnDOT
Marcus Bekele, MnDOT
Michael Marti, SRF Consulting Group
Susan Miller, SRF Consulting Group
Nicole Bitzan, SRF Consulting Group
Dan Wegman, Braun Intertec

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OVERVIEW

Crack treatment is one of the most used pavement preservation practices and although the technique is simple, there are several nuances that make it more of an art than science. The purpose of this document is to provide:

- An overview of crack treatment,
- Guidance on several FAQs, and
- A high-level summary of several technical resources.

Crack sealing is an important preventive treatment in a pavement preservation program to extend a pavement's serviceable life. Many factors go into determining "if" and "how to" best implement a crack treatment program.

The following information is a compilation of synthesizing several technical documents and interviews with some local technical/industry representatives. Although much of this information is research based, some is anecdotal and/or advice from experienced practitioners. The intent is to provide an overview so agencies can draw their own conclusions on how to best implement a crack treatment program.

Technical/Industry Representatives Interviewed

Allen Gallistel, MnDOT Chemical Lab Director

Jerry Geib, MnDOT Research Operations Engineer

Brian Majeska, Adventus

Chris Stebbing, CRAFCO

Doug Welk, ASTECH

Joel Ulring, MnDOT Pavement Preservation Engineer

FAQS

Why do pavements crack?

Several different types of cracks can develop in asphalt pavements. Some cracks are load-related, and some are attributed to temperature or environment. As a response to vast temperature swings (-30F to +125F), asphalt pavement often cracks due to expansion and contraction. With respect to treating cracks, it is important to know “working” vs “non-working” cracks:

What are working vs non-working cracks and what method should be used to treat?

Simply put, all cracks should be sealed; knowing the type of crack and if it moves is important for product selection.

Crack Type	Preferred treatment
Working cracks, which mostly run in the transverse direction, are those that expand in the winter and contract in the summer due to thermal expansion and contraction also referred to as thermal crack.	**Crack Sealing** The placement of specialized materials (3723 or 3725) into working cracks using unique configurations to prevent the intrusion of water, incompressible and/or debris into the crack.
Non-working cracks are those that do not undergo notable changes in width between seasons and mostly develop in the longitudinal direction or at the paving joint.	**Crack Filling** The placement of ordinary materials (3719) into non-working cracks to reduce infiltration of water and to reinforce the adjacent pavement.

Why is crack filling/sealing important?

Once an asphalt pavement has cracked, water can enter and create more serious damage, like potholes which occurs when the base becomes saturated and weakens. This reduces support of the bituminous pavement resulting in its deterioration. The rate of deterioration is related to traffic loading and severity of environmental conditions (moisture, freeze/thaw cycles, etc.). Sealing and filling cracks in asphalt pavements are important preventive maintenance treatments for achieving a good service life. Properly implemented crack sealing and crack filling can minimize the intrusion of water into the underlying layers of pavements.

What are MnDOT's approved materials/specifications?

	MnDOT 3719	MnDOT 3723	MnDOT 3725
Type	Crumb Rubber Type	Elastic Type	Extra Low Modulus, Elastic Type
Adhesion/ Flexibility	More adhesion/less flexibility	Good adhesion, more flexibility	Good adhesion, most flexible
Other Info	"Filler"; Good winter application	Most commonly used; Cost effective for all types of cracks	Best for working cracks and when routing

Typically, Minnesota agencies choose one sealant type to use for their entire network.

Rout-and-seal vs Clean-and-seal

Rout-and-seal method is where a reservoir is routed over the existing cracks and then sealants are poured into the reservoir. Rout-and-seal is more time consuming and approximately 2x the cost of clean-and-seal.	 Typical reservoir ¾" x ¾"	1. Crack cutting (routing, sawing, etc.) 2. Crack cleaning and drying 3. Sealant preparation and application 4. Sealant finishing and shaping 5. Blotting
Clean-and-seal method is where cracks are treated by blowing out the debris and then sealing the cracks with rubber sealant materials.		1. Blowing 2. Applying sealant

Although there is no definitive best practice, the consensus is:

- **Rout** is best for working cracks (provides more sealant to address expanding/contracting).
  - » It should be used with a high-end sealant (3725).
  - » Typically, on newer pavements with tighter cracks (<¾ crack width).
  - » Most feel the rout dimension should have a 1:1 ratio with ¾" x ¾" a common dimension. Recently, some other states and an unpublished MnDOT field study have suggested shallower/wider reservoir outperforming the square type reservoirs. (Note: there has been reported issues with snowplows pulling the material out of both the square and shallow reservoirs.)
  - » The expense and dust issues are downsides. Proper PPE should be worn when routing.
- **Clean and Dry**, it is critically important that the crack surfaces be clean and dry! Cleaning with compressed air (100CFM) is usually adequate. A heat lance helps dry moisture in the crack, remove residue dust from routing and warms the asphalt for better adhesion; but if not used properly, can do more harm than good. During winter crack sealing, if a heat lance is used when cracks contain ice, the moisture can "wick" to the sidewalls and can adversely affect adhesion.
- **Fill** is recommended if doing a winter application and for non-working cracks.

Timing - When should cracks be treated?

- The best time to apply crack treatments is in the fall or spring (due to thermal activity). Pavement temps should be 40°F and rising. If sealing during warmer weather (when crack width is narrower), routing can help with getting adequate amount of sealant in the cracks.
- Regarding surface treatment; crack seal prior to surface treatment to allow some "aging" of the sealant, preferably, seal the cracks a year prior to the surface treatment.
- Regarding overlays, if sealing within a year of an overlay, fill using 3719. 3723 and 3725 have a potential of expanding from heat of HMA causing bumps in the overlay.

What to know about overbands?

- Most agree overbanding is beneficial. It aids in applying more material which assists with improving adhesion.
- Overband should be less than 3" wide. Typically, the overband should extend 1" past each side of a crack's edge. Excessively wide overbands do not improve crack sealing performance. In fact, they can cause other issues such as aggregate loss when areas are chip sealed after crack sealing.
- Overband height should not exceed 1/16" (approximate thickness of a credit card). Excessively thick overbands are more susceptible to plow damage or can increase road noise such as "tire slap." To keep the sealant close to the surface, use squeegees or application tips.
- Flush fill is advised if the pavement will be receiving an overlay or surface treatment within the next year.

What to know about using double fill method?

- Used with routing and overbanding.
- Consists of first partially filling reservoir, allowing sealant to cool (and settle), then filling reservoir along with creating an overband. It is not necessary for the first pass to completely cool before installation of the second pass; the second pass is typically done within the same mobile operation to utilize the same traffic control and minimize the chance of debris re-entering the reservoir.
- Aids in minimizing "bumps" creating a smoother ride.

How should crack sealing be contracted (road station, pounds, linear foot)?

There is no definitive answer. Each has pros and cons. Ultimately, it depends on level of trust an agency has with a contractor and how much time/involvement the agency is willing to invest (either early in measuring/estimating or later in inspecting).

- Road Station: requires less inspection
- Pounds: requires inspection
- Linear feet: requires agency to measure (or accept/trust contractor)

What are some common issues to avoid?

- Not cleaning nor drying the crack adequately.
- Misuse of a heat lance and scorching the asphalt.
- Improper product temperature and/or not following the manufacturer's recommendations; including heating and/or handling. Using an infrared temperature gun periodically to ensure that proper application temps are achieved (as well as checking pavement temperatures) is imperative. Melter operators often err when keeping the melters fed (i.e., more frequent filling is better than adding too many blocks at one time).

What's new?

Although not new, mastic fillers (highly modified polymer asphalt binder blended with filler material (aggregate, fibers, etc.)) are being used more. (See Section 403 of MnDOT Pavement Preservation Manual).

Crack filling/sealing are pavement preservation techniques (used on cracks no wider than 1.5" wide). Mastic is a crack repair material that is very effective in fixing cracks and voids that are either too wide for traditional hot-pour crack sealant or are cupped and significantly impacting ride quality. Therefore, it is considered a next level of crack repair when traditional crack filling is not effective. Unlike traditional hot-pour crack sealants, mastic has fine aggregate and polymer added into the material making it load-bearing. It has a reasonable life cycle cost when used to repair and improve ride quality of cupped and wide cracks. This is also a good repair material for deteriorated longitudinal cracks. It requires a high level of care during installation to ensure good ride quality improvement.

Mastic requires a good solid pavement surface to bond to; therefore, the existing pavement surface should be structurally sound and not highly raveled or deteriorated. Mastic manufacturers have different limitations on lift thickness and depth of repair. Consult the manufacturer's installation instructions for more information.

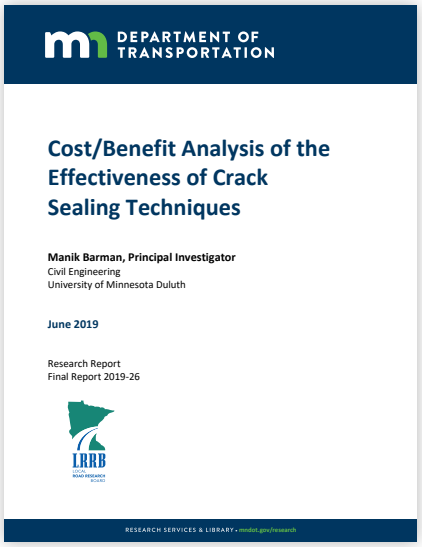
St. Louis County has effectively used mastic on cupped transverse cracks that are significantly deteriorated and impact the RQI. Most often, they place the mastic prior to a scrub seal. Although rated to 0°F, they have experienced that mastics are only good to about 20°F (they will crack but the scrub seal mitigates the cracking).

RESOURCES

The following were identified by the Technical Advisory Panel as key resources. Each is linked and summarized:

- Summary of LRRB 2019-26 Study - Rout-and-Seal Offers Slight Cost Benefit Edge Over Clean-and-Seal Repairs
- MnDOT Pavement Preservation Manual
- NCHRP Best Practices for Crack Treatments for Asphalt Pavements
- Validation of Hot-Poured Crack Sealant Performance Based Guidelines
- NTPEP DataMine (AASHTO's National Transportation Product Evaluation Program)
- Crack Treatment Checklist, FHWA-HIF-19-028
- MnDOT Approved/Qualified Crack/Join Products
- Asphalt Crack Treatment; Helpful Information for the Road. *(Although this LRRB video was produced in 1993, it still effectively highlights many basic elements of implementing a crack maintenance program)*

Cost/Benefit Analysis of the Effectiveness of Crack Sealing Techniques



Summary of LRRB 2019-26 Study

- **Executive Summary/Chapter 1: Introduction**
  The main objectives of this study were:
  - » to compare the service life and cost-effectiveness of the two crack sealing methods.
  - » to develop a criterion to select the most appropriate crack sealing method based on pavement type, functional condition, pavement age, and traffic characteristics, etc.
- **The Project conducted the following tasks:**
  - » literature review on crack sealant practices,
  - » crack sealant performance data collection and analysis (via survey/reviewing construction records),
  - » performance and cost-effectiveness analysis (35 locations periodically measuring performance index; b/c analysis), and
  - » development of a recommendation (developed two decision trees).
- **Chapter 2: Crack Sealing Practices and Sealants;** good overview of cracks, sealing vs filling, timing (best if done in spring or fall), equipment, preparation, application, materials, specifications (more details below following this outline).
- **Chapter 3: Synthesis of Previous Studies;** synthesis of crack sealant failures (most common failure is lack of adhesion during winter months), benefits of crack sealing.
- **Chapter 4:**
  - » **MN Survey**
    - 47 survey responses (22 counties, 20 cities, 4 MnDOT Districts, 1 consultant)
    - 68% Rout-and-seal; 32% Clean-and-seal
  - » **MN Field Study**
    - Series of field tests: interviews with agencies, monitoring new sealed sites, reviewing MnDOT Construction logs, reviewing performance of old sealed sites.
    - No significant conclusions were drawn.
- **Chapter 5: Effectiveness of Crack Sealing**
  - » Second winter (which was extremely harsh) caused a significant number of failures of the crack seals irrespective of the sealing method.
  - » Estimated service life: rout-and-seal 4-yrs; clean-and-seal 3-yrs.
  - » LCCA and B/C ratio: rout-and-seal slightly more effective, but not statistically significant.

- **Chapter 6: Draft Recommendations (decision trees)**
  - » Included two decision trees (p.114) for selecting an appropriate crack sealing method.
  - » Targeted for pavement management users requiring more detailed input information.
  - » Targeted for maintenance crews requiring less input information.
  - » Input variables:
    - crack severity/width
    - pavement age/type
    - traffic level
    - subgrade soil
    - cost
    - practitioner's preference
- **Chapter 7: Summary and Conclusions**
  - » Clean-and-seal is more appropriate for high crack severity.
  - » Clean-and-seal is more appropriate for sandy soil subgrades and the low initial budget scenario.
  - » Rout-and-seal method is preferred for clayey and silty subgrades, irrespective of other variables.

MnDOT Pavement Preservation Manual

Page	Description/details
13-14	Crack seal Ccandidates criteria and notes
15-17	401- Crack Filling • Specifications: (2331) BITUMINOUS PAVEMENT CRACKS TREATMENT, Under "Special Provisions 2020 Boilerplates" select the "Boilerplate SP2020 (Word)", (S161, page 265) • $3400 per lane mile • Estimated Performance Period: 1 to 3 years
18-20	402 – Rout-and-Seal Cracks • Specifications: Special Provision 2331 Bituminous Pavement Crack Treatment • $3700 per lane mile • Estimated Performance Period: 2 to 4 years
21-22	403 Mastic for Crack Treatment • Specifications: (2331) CRACK REPAIR SPECIAL (MASTIC), Under "Special Provisions 2020 Boilerplates" select the "Boilerplate SP2020 (Word)", (S160, page 264) • $2-3 per pound • Estimated Performance Period: 2 to 8 years

NCHRP Best Practices for Crack Treatments for Asphalt Pavements (2014)

Chapter 1 Introduction

Chapter 2 State-of-the-Art in Crack Treatments

- Literature Review/Project Selection (definitions, seasonal effect, crack development/types, reservoirs),
- Materials/Construction/Quality Control (general, national perspective), and
- Performance (older data): cold pour 1-2 yrs; hot pour typically 3-5 yrs but may be up to 8 yrs),

Chapter 3 State-of-the-Practice in Crack Treatments

- Summary of the Survey Results (28 DOTS, 106 counties, 3 cities, 3 contractors, 3 other)
- Project Selection: No universal answer, "Everyone has a different specification, which is a problem"
- Typical life span for sealing/filling (Table 3-1)

Table 3-1. Survey responses for typical life span for crack sealing and crack filling.

	Years	Major Roads	Minor Roads
Crack Sealing	1 – 4	46%	38%
	5 – 10	54%	55%
Crack Filling	1 – 4	56%	50%
	5 – 10	36%	33%

- Types of contracting (Table 3-7)

Table 3.7 Types of contracts used by respondents.

Contract Type	Percentage Use
Unit Price – Low Bid	90.0
Lump Sum/Firm Fixed Price	20.0
Cost Plus	6.7
Indefinite Delivery/Indefinite Quantity	6.7
Warranty	11.7

- Typical road preparation methods prior to crack sealing: 73% sweep, 63% dry the pavement
- Routing: 52 responses: 50% never rout a crack, 35% rout working cracks, 31% rout when using high-performance applications, 27% rout all cracks. Approx. rout depth: .85" x .85"
- Overband: 43% always do; 28% never do. Avg. overband widths routed (2.49") non-routed (3.28")
- Crack treatment prior to overlay: 54% indicated no changes to crack. Time to complete crack treatments prior to overlay varied from one to three years, with a one-year wait being a common response. If a same-season overlay is to be done, the sealant should be recessed (3/8").
- Crack treatment prior to surface treatment. 47% indicated no changes. Recommend a crack treatment the year prior. If it is in the same season, the crack treatment should be performed at least one month prior. Do not rout cracks if microsurfacing. Create a test strip to validate compatibility and do not perform Hot-In-Place recycling over crack seal material (fire risk).

- Performance Measures - Common Failures (Table 3-10)

Distress Type	DIstress Observed, %	Most Common Distress, %
Lack of Bond	78.9	57.5
Cohesive Failure	48.1	20.0
Raveling of Crack	25.0	10.0
Spalling of Crack	17.3	12.5

Factors Affecting Performance (Table 3-11)

Factors to Minimize Defects	Average Ranking Value	Order of Importance
Proper Crack Cleaning	5.61	1
Sealant Used	4.68	2
Precipitation at Installation	4.21	3
Construction Procedures/Techniques	3.75	4
Temperature at Installation	3.71	5
Proper Crack Routing	3.33	6
Equipment Used for Installation	2.71	7

Chapter 4 Best Practices for Crack Treatments

- Routing: higher cost, less than half respondents routinely routed.
- Cleaning: crack must be clean and dry. Sweep the entire pavement, use high pressure air to clean cracks. Hot air lance is preferred.
- Materials. Follow manufacturer's recommendations.

References Suggested references (pared down by including those published within the past 20 years and in similar climates to MN)

- Best Practices Handbook on Asphalt Pavement Maintenance, Chapter 4: Crack Treatments, Minnesota LTAP, MnDOT, 2000
- Crack Seal Manual, Montana Department of Transportation
- Guidelines for Sealing and Filling Cracks in Asphalt Concrete Pavement: A Best Practice by the National Guide to Sustainable Municipal Infrastructure, Federation of Canadian Municipalities and National Research Council, Canada, 2003
- Recommended Performance Guideline for Crack Treatment, ISSA A175, 2012.
- Validation of Hot-Poured Crack Sealant Performance-Based Guidelines, Illinois Center for Transportation Research, 2014.

Validation of Hot-Poured Crack Sealant Performance Based Guidelines

FHWA/VTRC 16-R

The purpose of this pool fund study was to (1) validate laboratory tests using field performance; (2) determine the thresholds using field performance data; and (3) develop guidelines for crack sealant installations and applications. New guidelines were developed and validated for full implementation as AASHTO specifications.

- 18 sealants were evaluated in 6 sites (MN, NH, NY, VA, WI, Ontario) along with a few control sites (IL, MI); all on State, US, or Interstate highways. Both rout-and-seal (w/various reservoir geometries) and clean-and-seal techniques were applied:

Table 3. Site-Specific Experimental Plan for Field Investigation of Sealant Performance

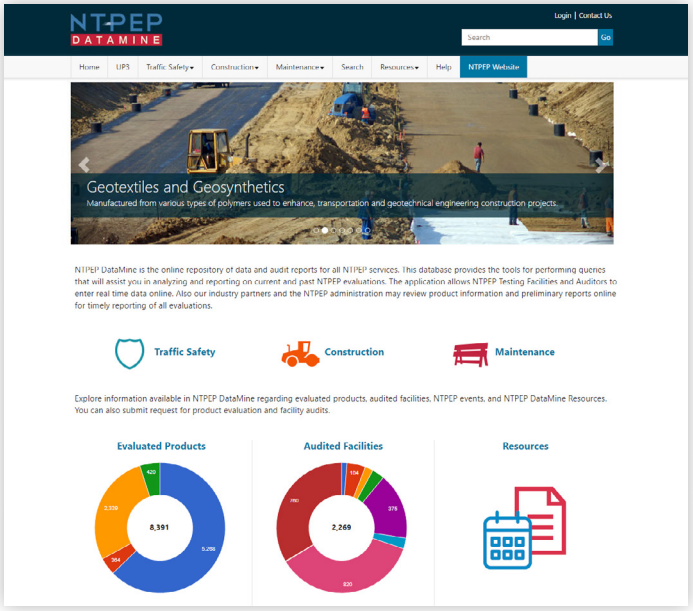
Test Site	Climatic Region	Crack Treatment Variables	Reservoir Geometry (mm)	Materials
Wisconsin	Wet-Freeze	Crack Seal only	20 x 20	Five materials from three different manufacturers
Minnesota	Wet-Freeze	Crack Seal & Fill, Variable Route Size	12.5 x 12.5 20 x 20 30 x 15	Seven materials from three different manufacturers
Ontario	Wet-Freeze	Crack Seal & Fill, Variable Route Size	20 x 20 12.5 x 12.5 30 x 15 40 x 10	Seven materials from four different manufacturers
New Hampshire	Wet-Freeze	Crack Seal & Fill, Variable Route Size	12.5 x 12.5 20 x 20 30 x 15	Five materials from three different manufacturers
New York	Wet-Freeze	Crack Seal & Fill, Variable Route Size	12.5 x 12.5 20 x 20 30 x 15	Eight materials from four different manufacturers
Virginia	Wet-Freeze	Crack Seal & Fill	20 x 20	Four materials from same manufacturer
Michigan	Wet-Freeze	Crack Fill only	NA	Sixteen materials from seven different manufacturers

- Field performance data (visual) was collected annually (Feb-March) for 3-years (2011-2014) and analyzed/compared to a series of laboratory test results. The report contains descriptions of the field sites and very detailed information on the numerous laboratory tests and how they compared the field results.
- Overall Conclusions/Recommendations:
  - » Adhesive failure was the predominant type of failure for rout-and-seal sections, whereas the clean-and-seal sections failed either because of complete loss of overband or cohesive failure).
  - » Rout-and-seal had better performance than clean-and-seal.
  - » Overbanding had a clear and positive impact on performance; however, overband wear (snowplows and traffic) accelerated initiation and progression of adhesive failure.
  - » The severe temperature drops in winter 2013 and 2014 significantly affected the performance of sealants.
  - » Most sealants failed (fell below a performance index [PI] threshold of 70%) after 3 years.
  - » The ASTM standards/specifications currently used to select crack sealant were established based on material properties that are generally empirical and do not measure the fundamental properties of sealants. Also, the specification limits vary from one state to another; also, many states specify different limits creating difficulties for suppliers. Therefore, performance-based guidelines were developed as a systematic procedure to select hot-poured asphalt crack sealants: “Sealant Grade” (SG) system to select hot-poured crack sealant based on environmental conditions see pages 59-61).

NTPEP DataMine

(AASHTO's National Transportation Product Evaluation Program)

- An online repository of data and audit reports that provides queries to assist in analyzing current and past NTPEP evaluations. MnDOT is a member.
- Easy to filter (Maintenance tab). Filter on either Material Type or Product Application and view test data on 60 HMA crack sealer products. Database provides manufacturer details, product information, test data with photos and timeline.
- MnDOT's Allen Gallistel (651.366.5545) is the Technical Committee Chair of NTPEP - PCC Joint Sealants and HMA Crack Sealers



Crack Treatment Checklist

FHWA-HIF-19-028

Step-by-step guidance on how to do crack sealing

- Material checks
- Pre-application inspection (surface prep, equipment inspection)
- Weather requirements
- Traffic control
- Project inspection
- Reservoir cutting
- Crack cleaning
- Sealant application
- Clean up
- Problems and solutions
- Training
- Sources

MnDOT Approved/Qualified Crack/Joint Products
(January 2023)

Hot Poured, Crumb-Rubber Type - Spec 3719

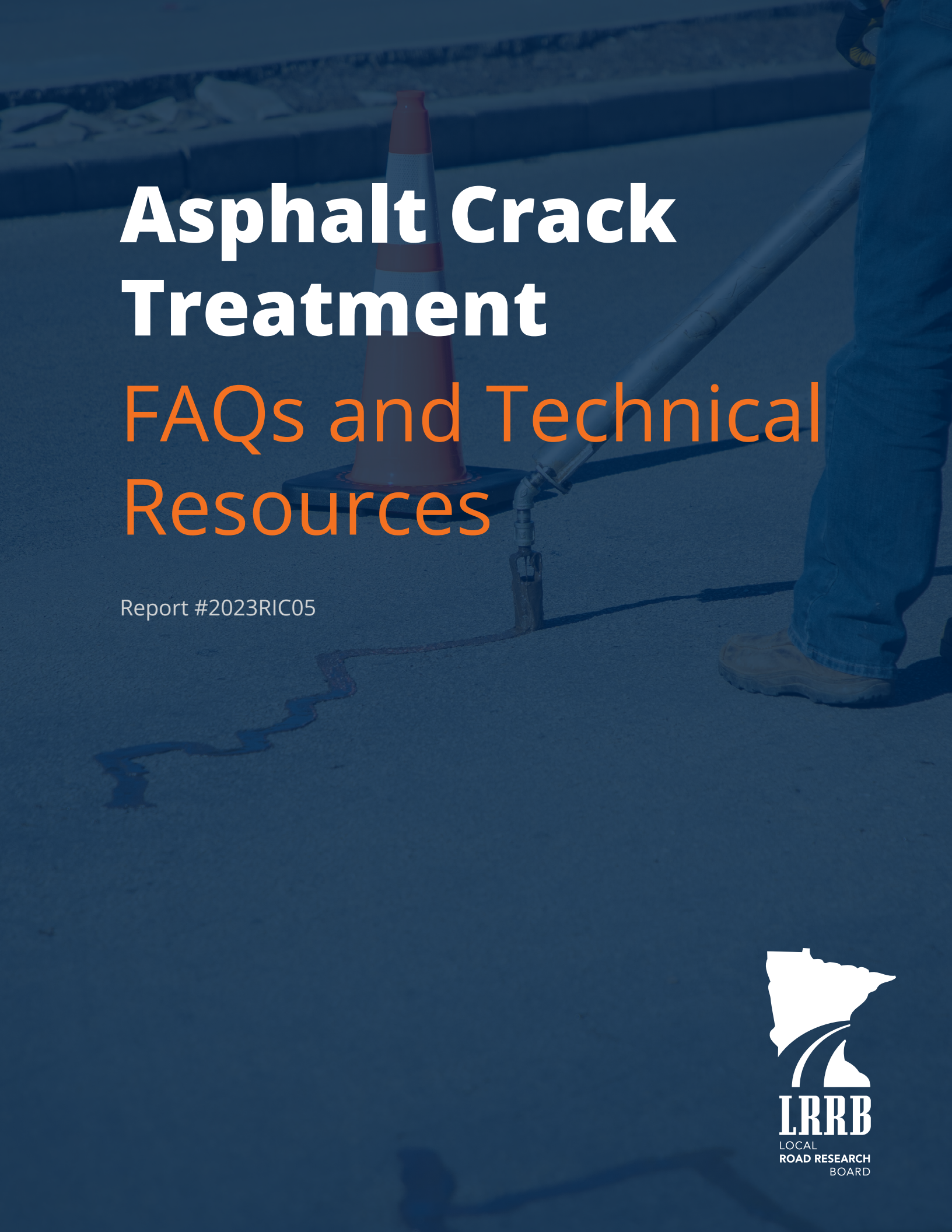
Product	Manufacturer
Deery 103 GL	Crafco
Asphalt Rubber Plus	Crafco
Elastoflex 410 (formerly Elastoflex 52)	Maxwell Products

Hot Poured Elastic Type - Spec 3723

Product Name	Manufacturer
MACSEAL 6690-2 (formerly Beram 195)	McAsphalt, Ind.
Deery 3723	Crafco
Roadsaver 515MN	Crafco
Durafill 3405	P & T Products
Sealtight 3405	W.R. Meadows
Elastoflex 63	Maxwell Products
Nuvo 3405	Maxwell Products
Pure Asphalt 3723	Pure Asphalt

Hot Poured, Extra Low Modulus, Elastic Type - 3725

Product Name	Manufacturer
MACSEAL 6690-4 MOD (formerly Beram 3060 LM)	McAsphalt, Ind.
Deery 101 ELT	Crafco
Roadsaver 522	Crafco
Durafill 3725	P & T Products
Sealtight 3405 MLR	W.R. Meadows
Elastoflex 72	Maxwell Products



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