RESEARCH

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Preventative Maintenance for Recreational Trails

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Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.	
MN/RC 2009-25			
4. Title and Subtitle Preventive Maintenance for Recreational Trails		5. Report Date July 2009	
		6.	
7. Author(s) Thomas Wood, John Pantelis, Mark Watson, and Roger Olson		8. Performing Organization Report No.	
9. Performing Organization Name and Address Minnesota Department of Transportation Office of Materials and Road Research 1400 Gervais Ave. Maplewood, MN 55109		10. Project/Task/Work Unit No. 11. Contract (C) or Grant (G) No. (c) LAB876	
12. Sponsoring Organization Name and Address Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code	
15. Supplementary Notes http://www.lrrb.org/PDF/200925.pdf			
16. Abstract (Limit: 250 words) The growth in recreational trails owned by the State, Cities, Counties, and Park systems over the last 20 plus years has exploded. Most if not all efforts related to recreational trails over these years has been focused on construction of new trails. There have been little organized efforts in trail preservation and or preventive maintenance (PM) methods to extend the usable life of the trails. The agencies that have a PM programs for their recreational trails rely on treatments that started out as highway or street treatments that may have been modified for use on the trails. The goals of this research project where to study existing treatments, how effective they are, promote new methods, and promote regular scheduled PPT for preserving trail systems.			
17. Document Analysis/Descriptors Recreational Trails, Preventive Maintenance, PM Treatments. Hot Mix Asphalt aging.		18. Availability Statement No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report) Unclassified	20. Security Class (this page) Unclassified	21. No. of Pages 50	22. Price

LRRB 876 – Preventive Maintenance for Recreational Trails

Final Report

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July 2009

Published by

Minnesota Department of Transportation
Research Services Section
395 John Ireland Boulevard, MS 330
St. Paul, Minnesota 55155-1899

Acknowledgements

Many thanks are given to the Local Road Research Board (LRRB) for sponsoring this project.

A debt of gratitude is owed to the field support staff provided by trail owners for their preparation of the test sites and continued support during installation. Everyone worked hard to make this project a success. It could not have been done without them.

Table of Contents

Chapter 1 1
Background 1
Conclusions 4
Recommendations 4
Future Research Needs 6
Appendix A: LRRB 876 – Preventive Maintenance for Recreational Trails, Task 1 Report: Available Products for Trail Owners (2007)
Appendix B: LRRB 876 – Preventive Maintenance for Recreational Trails, Task 2 Report: Preventive Maintenance Products for Trail Systems (2008)

List of Figures

Figure 1: DNR Gateway Trail Prior to Treatment 1
Figure 2: Gateway Trail Treated Section 1
Figure 3: Treated Trail in Eagan, MN 2
Figure 4: Treatment DNR Gateway Trail 2
Figure 5: NCAT Field Permeameter in use 3
Figure 6: Typical Sand Patch Test 3
Figure 7: Dual Distributors in Eagan, MN 4
Figure 8: Rec. Trail Chip Seal at McCarrons Lake Roseville, MN 4
Figure 9: Flush Fill Crack Sealing 5
Figure 10: "Trail Work Ahead" Signage 5
Figure 11: Demonstration of Difficulty Clearing Trails for Fog Sealing 5

Executive Summary

The growth in recreational trails owned by the state, cities, counties, and park systems over the last 20 plus years has exploded. Most, if not all, efforts related to recreational trails over these years have focused on construction of new trails. There have been few organized efforts in trail preservation and or preventive maintenance (PM) methods to extend the usable life of the trails. The agencies that have PM programs for their recreational trails rely on treatments that started out as highway or street treatments that may have been modified for use on the trails. The goals of this research project were to study existing treatments, how effective they are, promote new methods, and promote regular scheduled Pavement Preservation Treatments PPT for preserving trail systems.

This research project consisted of two tasks. The first task was to compile a list of the currently used methods and products for preventive maintenance. This task also describes the treatments. Specifications and special provisions for non-proprietary treatments are included in this task.

The second task was to apply as many as possible of the currently used treatments and create test sections. Contractors and suppliers were also encouraged to supply new or modified methods or treatments for evaluation. The treatments were then reviewed for ease of construction, how successfully they sealed the surface, and the trail users' opinions of the new surface. With the short duration of this project, all of the treatments performed as expected. Future reviews over the next three to five years will help to determine which treatments are the most cost effective.

The final chapter of this paper contains conclusions and recommendations for further research needs as related to recreational trails.

Chapter 1
Background

The growth in recreational trails owned by the State Cities, Counties, and Park systems over the last 20 plus years has exploded. Most if not all efforts over these years has been focused on construction of new trails. There have been little organized efforts in trail preservation and/or preventive maintenance (PM) methods for recreational trails.

Figure 1: DNR Gateway Trail Prior to Treatment

With increased cost of construction and rapid reduction of natural resources, the practice of "pave it and leave it" is over. It is important for all agencies to maintain their infrastructure using the most cost effective methods. Nationwide pavement preservation has become the widely accepted to maintain roadways at the best service level the most cost effective way. Over the years recreational trails have been overlooked as pavement preservation treatments have been developed or improved for roadways. The Agencies that believed in pavement preservation for recreational trails and the use of pavement preservation treatments (PPT) have applied roadway treatments with some modification to meet the needs of trails.

Figure 2: Gateway Trail Treated Section

The methodology of this research project was made up of two main tasks. Task 1 (Appendix A) outlines preventive maintenance treatments and activities that are currently used on roadways, but can, and have been applied to recreational trails. Some of the methods listed are proprietary products. This list does not include all of the proprietary products available to trail owners to use. Every effort was made to include the most commonly

available products. Specifications and special provisions for products that are currently used on State roadways that are not proprietary in nature are listed in Task 1. No specifications for the proprietary products are given.

Task 2 (Appendix B) outlines the construction of the test sections of numerous products placed on trails during the summer of 2008. Using these test sections the researchers wanted to try to answer the following questions:

- How easy was the treatment to apply?
- Does the current equipment need to be modified to be successfully used on the normal recreational trail?
- How long will the trail be out of service after the application?
- What do the users think of the new surface?
- Does the treatment extend the usable life of the trail?
- What effort does the Owner have to take to plan their PM project for the different types of treatments?

Figure 3: Treated Trail in Eagan, MN

Figure 4: Treatment DNR Gateway Trail

All test sections have a control section left where no treatment was applied to aid in determining how effective the treatment maybe at extending the useable life of the trails. Due to the short time frame of this project long term performance could not be measured.

The test sections were tested using Sand Patch tests (ASTM E965) (Figure 6) to measure texture and National Center for Asphalt Technology (NCAT) falling-head field permeameter (Figure 5) to measure the change in permeability. The goal of the testing at time of construction was to establish a base-line value of the trails to compare any changes over the next three (3) to five (5) years. Using this data the researchers should be able to determine which treatments performed the best and then make recommendations on how and why to use them.

Figure 5: NCAT Field Permeameter in use

Early results show that all of the treatments reduce the permeability of the trail surface when compared to control sections. All of the spray applied fog seals did reduce the texture depths when compared control section. For more details see Appendix B.

Figure 6: Typical Sand Patch Test

Conclusions

Empirical data has shown that a properly planned pavement preservation program for trails will increase the life expectancy. For example one county applied a simple fog seal using an emulsion CSS-1h diluted at time of construction followed up with a second fog seal six (6) years later. The trail still appears like a new. The reason for success of this simple program is the fact the initial fog seal sealed the surface voids left in the pavement at time of construction. This seal slowed the infiltration of water and air in the surface and delayed aging. By including the treatment at time of construction the County received a very low cost treatment. The re-treatment was part of the County wide surface treatments program which yielded very reasonable priced application.

Figure 7: Dual Distributors in Eagan, MN

Recommendations

It is recommended that trail owners develop a planned program for trail preservation activities as part of their trail construction program to address Pavement Preservation Treatment.

Pavement preservation treatments normally used on streets and highway can be successfully modified for use on trails. One example would be chip sealing. The modifications for trails are the following. Reduce the size of the chip (⅛" minus) to yield a smoother surface, schedule the application during later part of the summer when the trail has maximum strength, and limit the weight of construction equipment.

Other treatments that need more research would be the slurry/micro surfacing technology. A properly designed slurry/micro system could not only protect the surface but also level a deteriorated trail.

New specifications for crack sealants need to be developed for trails that are user friendly. On roadways the sealants needs to be very soft and elastic to deal with seasonal movements.

Figure 8: Rec. Trail Chip Seal in McCarrons Lake Roseville, MN

The soft properties of the sealants could create tripping hazards. The sealant will need to be a balance of elasticity and stiffness to overcome safety issues. Two sealants were placed on trails as parts of this study that where recommend by sealant manufactures that are designed for parking lots. If these sealants provide acceptable performance Mn/DOT may write a new specification for use on trails. Wide over bands and routing of longitude cracks should not be used because they could cause trip or slip hazards.

Traffic control for trails is very difficult because of the large number of access points. The best method is early and aggressive notification to inform users of construction operations and also explain why the PM treatment is being applied.

Figure 9: Flush Fill Crack Sealing

Figure 10: "Trail Work Ahead" Signage

Figure 11: Demonstration of Difficulty Clearing Trails for Fog Sealing

Future Research Needs

- Evaluation of construction and design including the use of methods to improve trail performance.
- Develop a Trail Management system, automated measuring method similar to the lightweight profilograph.
- Patching and Reactive Maintenance methods that address need of recreational trails.
- Education on how and why to do PM for recreational trails being done by Research Implementation Committee.

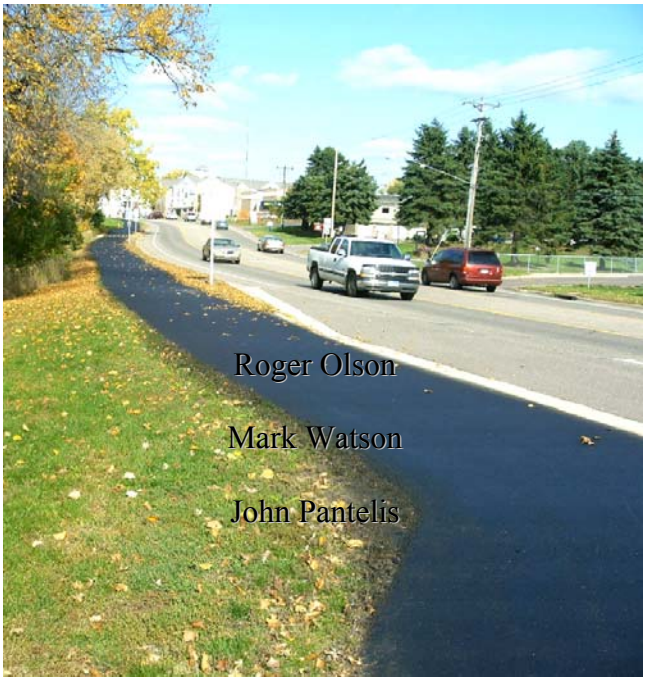
Appendix A

LRRB 876 – Preventive Maintenance for Recreational Trails

Task 1 Report:
Available Products for Trail Owners (2007)

LRRB 876 – Preventive Maintenance for Recreational Trails

Task 1 Report:
Available Products for Trail Owners (2007)



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June 2008

Table of Contents

Appendix A

Chapter 1 Background A-3

Introduction A-3
Preventive Maintenance Planning & Activities A-3
Asphalt Emulsions A-4
Special Considerations for Recreational Trail Users A-4

Chapter 2 Available Treatments A-5

Fog Seal & Rejuvenator Treatments A-5
- Definitions & Uses A-5
- Common Fog Seal Products A-5
  - CSS-1h, CSS-1, and SS-1h A-5
  - CRS-2, CRS-2P, and 2Pd A-5
  - LD-7 ..... A-5
- Gilsonite Sealer Binders (GSB) A-6

Common Rejuvenator Products A-6
- Pass®-QB A-6
- Reclamite® Asphalt Preservative Seal A-6
- ERA-1 and ERA-25 ..... A-6
- CRF® Restorative Seal A-6
  - How to Apply A-6
  - When to Apply A-7
  - Benefits and Risks A-7

Chip/Sand Seal Treatments A-7
- Definitions & Uses A-7
- How & When to Apply A-8
- Benefits and Risks A-10

Slurry Seal & Micro Surface Treatments A-10
- Definitions & Uses A-10
- How & When to Apply A-10
- Benefits and Risks A-11

Crack Treatments A-11
- Definitions & Uses A-11

Clean and Seal....A-11
Crack Filling....A-12
Rout and Seal....A-12
Crack Treatment Materials....A-12
How & When to Apply....A-12
Benefits and Risks....A-13
Chapter 3 - Preventive Maintenance Best Practices....A-15
Chapter 4 - Proprietary Products....A-16
Chapter 5 – Conclusions....A-17
Internet Resources....A-18
References....A-19

Chapter 1. Introduction

Background

The state of Minnesota, municipal, county, and regional park systems have developed a vast state-wide network of recreational trails designed to meet the recreational, fitness and economic needs of the public. A recent survey of 10 twin cities suburban communities revealed that there was over 1,900 miles of recreational trails in those places alone. To meet the needs of the users, the responsible agency must provide for a safe and smooth ride. Given the limited availability of funds for reconstruction, and the rising demand for new trails, there is a growing interest in preventive maintenance techniques that can extend the useful service life and maintain the high levels of service of the pavement at reduced cost.

It is generally accepted that stiffness of the asphalt cement of bituminous pavements increases due to both the short term, and the long term aging processes [1]. The short term aging process occurs during construction mixing and compaction, changes can be made to the asphalt binder rheology to account for these short term changes [1]. The long term aging process occurs during the service life as the pavement is exposed to the deleterious effects of solar radiation, oxygen, and water. This causes the pavement to become more brittle leading to increased crack susceptibility; once the pavement begins to crack the deterioration process accelerates as there are more avenues for oxygen and water to infiltrate the pavement surface [2, 3]. Also trails can be subjected to moisture damage due to dampness and general rain events. Moisture damage can be a cause of raveling and deterioration. The exposed pavement, if left untreated, can be at risk of increased susceptibility to various distresses.

This report will outline preventive maintenance treatments and activities that are currently used on automotive pavements, but can, and have been applied to recreational trails.

Preventive Maintenance Planning and Activities

Information was gathered from local trail owners to determine what types of products and services are currently used on trail systems. Mn/DOT, counties and municipalities utilize an array of preventive maintenance products to maintain their road

network, and most of the agency's experience and knowledge with roadway products can be applied to trail maintenance. The goal of this report is to provide some background information and preliminary guidance on the currently available treatment options including the appropriate Mn/DOT specifications, expected performance outcomes and cost. The treatment options will be compared and some common products will be introduced, but an extensive list of proprietary products and complete design procedures will are also available, but not provided in this report.

Asphalt Emulsions

Asphalt emulsions are used in many preventive surface treatment applications including fog seals, chip/sand seals and slurry seals. Asphalt emulsions can be defined as a mixture of asphalt binder, a surfactant, and water. Note that a cutback is a mixture of asphalt binder and a cutter, commonly diesel fuel. Cutbacks and coal tar products are not recommended for use as they are not environmentally friendly.

Special Considerations for Recreational Trail Users

Recreational trails are constructed for a variety of users that have very different expectations regarding the surface of the trail; these users can include walkers, runners, bicyclists, and in-line skaters. Within a specific user group, such as bicyclists there are different types such as the family bicyclist who rides comfort, or mountain bikes and travels at low speeds with children, and the fitness bicyclist who rides specialty race bikes long distances at high speeds. Often times a trail will have roughness, or friction acceptable by one group of users and not another. For example low speed comfort bikes can tolerate much more roughness than in-line skaters, and walkers need less friction than fitness bicyclists. It is important to understand the needs and expectations of the users and the impact that the treatment will have on the users before a treatment option is considered for a specific site. It is also recommended that regular inspections and measurements of pavement distress and quality be conducted in order to properly program maintenance operations, similar to current pavement management systems in place for automotive pavements.

Chapter 2. Available Treatments

Fog Seal & Rejuvenator Treatments (Mn/DOT Spec. 2355 Appendix A)

Definitions & Uses

Fog seals are defined by the Asphalt Emulsion Manufacturer's Association (AEMA) as a light application of dilute asphalt emulsion without the use of an aggregate cover [4, 5]. Fog Seals are used primarily to seal an existing asphalt surface against water, and UV radiation, reduce raveling, lock in chips from a chip seal and enrich dry and weathered surfaces [1-5].

Rejuvenators are defined as asphalt emulsions that have oils that soften the existing binder, thus reducing its viscosity [1]. Rejuvenators are used to improve flexibility, which reduces the chance of cohesive failure, and to restore maltenes lost to the oxidative aging process [6].

Common Fog Seal Products:

CSS-1h, CSS-1 and SS-1h

Standard fog seal emulsions that meet state or AASHTO M-140 (anionic) and M-208 (cationic) specifications. Note that the first letter indicates the charge of the emulsion, and the second two letters denote the rate at which the emulsion will set SS (slow set), MS (medium set), RS (rapid set) [1].

CRS-2, CRS-2P, CRS-2Pd

CRS-2 is a cationic, rapid-setting emulsion which can be polymer modified (P for "polymer" modified), and/or diluted (d for "diluted"). The emulsion is diluted by the manufacturer with 3 parts of emulsion to 1 part water solution, for a specified 51% asphalt residue content [1].

LD-7

LD-7 is a specialized asphalt emulsion originally developed to be a fast-curing trackless tack coat, and hasn't traditionally been applied as a fog seal over a dense HMA surfaces. The hard residue can be used on dense graded HMA surfaces, depending on the texture, and it provides a black surface that is resistant

to ultra-violet light degradation and improves aggregate retention (when applied over chip seals) [1].

Gilsonite Sealer Binders (GSB)

Gilsonite based emulsions are marketed as a pavement maintenance tool, and have been the subject of an unpublished FHWA laboratory study, and on MN TH 251 study in 2002 [1].

Common Rejuvenator Products:

Pass®-QB

This QB (quick break) emulsion soap is designed to penetrate into small pores on the pavement surface, and the residue contains asphalt, rejuvenator oil, and polychloroprene latex polymer [1].

Reclamite® Asphalt Preservative Seal

Reclamite® Asphalt Rejuvenating Agent has petroleum maltene base oil, and is produced as a cationic emulsion designed to penetrate the asphalt pavement surface and rejuvenate the top portion of the asphalt binder increasing the penetration and viscosity numbers of the asphalt, fluxing with and densifying the binder [1].

ERA-1 and ERA-25

ERA rejuvenator products represent different blends of asphalt with the same rejuvenator base oil used for Reclamite [1].

CRF® Restorative Seal

CRF® Restorative Seal is emulsion spray-applied by a distributor truck and sand spread over the surface. The surface is then drag-broomed to force sand into the voids and cracks [1].

How to Apply

In order for the treatments to be effective, they must penetrate and fill the voids of the pavement surface, thus the porosity of the pavement surface as well as the emulsion application rate are critical design factors. The pavement surface must be dry, clean, and in good repair before the application of the treatment [4].

Note that recreational trails are typically more porous, and less dense than automotive pavements, so the application rates must be adjusted accordingly.

When to Apply

As with all preventive maintenance treatments, the success of the treatment is highly dependant upon the condition of the existing pavement [1, 2]. Fog seals can be applied at the time of construction as a true preventive maintenance feature. This allows use of construction cost funds and can provide an initially sealed surface. The sealed surface will help to prevent weathering action and moisture infiltration [7]. Fog seals and rejuvenators can be applied as light to moderate raveling and/or oxidation develop in the pavement, but not when structural distresses are present [4].

Benefits and Risks

The visual service life of fog seals is relatively short (2-3 years), and depends on the exposure to sunlight. There are concerns about the loss of skid resistance and surface friction especially during rain events, which have caused some states to impose moratoriums on their use, but recreational trails have much less stringent friction requirements due to the lower speeds, lower volume and the nature of their use.

The effectiveness of the fog seal to provide a protective seal, and the rejuvenator to reduce viscosity and improve flexibility in the upper layer of the pavement, is dependant upon how much of the product is absorbed into the pavement.

Chip/Sand Seal Treatments (Mn/DOT Spec. 2356 Appendix A)

Definitions & Uses

Traditionally a chip or sand seal is defined as an asphalt emulsion layer that is covered by a layer of aggregate one stone thick [2]. Recreational trails require a more uniform, smooth, and even pavement surface, thus the use of coarse aggregate gradations is discouraged. A fine aggregate gradation (FA-1)

will allow the aggregate to distribute more evenly throughout the binder which will result in a smoother and more durable wear course [2].

Chip Seals are used primarily to seal an existing asphalt surface against water, and UV radiation, increase surface friction, seal small cracks, and extend the service life of the pavement [6, 2].

How & When to Apply

In order for the treatments to be effective, there must be the proper amount of asphalt binder to ensure that the aggregate chips are retained on the surface. Asphalt binder application rates are critically important and are dependant upon the aggregate properties, the surface condition of the pavement, and the residual asphalt content of the binder [2]. If designing a chip seal for an automotive pavement the traffic level must be considered as well, higher traffic volumes would require a lower asphalt binder application rate than lower traffic volumes [2]. Historically chip seals on recreational trails are constructed with 2/10 of a gallon of asphalt binder followed by 18-20 lbs. of FA-1 graded aggregate per yard. Note that additional aggregate, when compared to an automotive pavement, is required because of the additional asphalt binder. The combination of the thicker asphalt binder and the heavier application of fine graded aggregate eliminate the need of a fog seal for aggregate retention. As with chip seals applied on automotive pavements, sweeping is necessary within 24 hours of laying the chip seal [2].

The Minnesota Department of Natural Resources (DNR) recommends placing chip seals in the second year to prevent moisture from seeping into the surface cracks and voids [7]. Chip seals should be placed in the high summer months of July and August when the trails are in their most structurally sound state. The pavement surface must be dry, clean, and without any load related distresses such as block cracking, or deformation, but low severity raveling, transverse, or longitudinal cracking is acceptable [4, 2].

Benefits and Risks

Chip seals are expected to improve the recreational value of the trail by providing a smooth wearing course, and an extended service life. Chip seals should be applied on a regular maintenance schedule every six to seven years [2].

Chip seals can delaminate from the pavement surface in shady areas, or in high humidity. Three Rivers Park District has reported construction logistical concerns with the simultaneous application of two seal coats [8]. They have also reported difficulty in enforcing trail closures, which leads to tracking of the seal coat by park patrons [8].

Slurry Seal & Micro surface Treatments (Mn/DOT Spec. 2356 Appendix A)

Definitions & Uses

Slurry seals are defined as a mixture of fine aggregate, asphalt emulsion and mineral filler such as Portland Cement. Slurry Seals are used to retard surface raveling, seal minor cracks, and improve surface friction.

Micro surface treatments are similar to slurry seals, and chip seals except that they use a chemically controlled curing process. The additional mix stability, resulting from polymers, allows it to be applied in relatively thick layers making it ideal for filling ruts, and correcting other deformations.

Slurry seals and micro surface treatments, as well as chip seals, can seal the pavement surface from moisture infiltration, and the resulting moisture related damage.

How & When to Apply

Slurry seals should be applied on a pavement surface with a thin film of water to control premature breaking and to improve the bond with the existing pavement. The best time to apply slurry seals is when light cracking develops, or moderate raveling, and/or oxidation [4]. There are several propriety products on the market that could be considered in the slurry seal category. Type FA-1 gradation should be used for smoother surfaces.

Micro surface treatments should be applied on clean pavements, and may be used when there is excessive oxidation and hardening of the surface [4]. Micro surface treatments can be applied to correct rutting when it reaches a certain threshold, but this load related distress is not common on recreational trails.

Benefits and Risks

Both slurry seals and micro surface treatments can be applied as preventive maintenance treatments which will extend the service life of the pavement. They both help to prevent moisture infiltration, and micro surface treatments can correct structural deficiencies such as rutting. Slurry seal treatments can be expected to last approximately three to five years, which is shorter than micro surface treatments which typically last more than seven years. Micro surface treatments also have a much faster set rate, allowing the trail to be given back to users in a shorter time span.

As with the chip seal surface treatment, trail closures may be difficult to enforce, and there may be logistical concerns regarding heavy construction equipment.

Crack Treatments (Mn/DOT Specs. 3719 – 3725)

Definitions & Uses

There are several different types of crack treatments that are currently used in Minnesota, which are defined and described below. All treatments are designed to prevent moisture infiltration into the base and sub grade which can weaken the pavement's subsurface structural layer, a primary contributor to pavement deterioration [4]. Mn/DOT prefers to apply crack treatments within the first five years after construction [12].

Clean and Seal: Cracks are prepared by blowing out debris with compressed air and heating the crack face with a hot air lance before filling with sealant [13]. This technique is used on all types of pavement systems in Minnesota and typically uses MnDOT Specs. 3719, 3723.

Crack Filling: Differs from crack sealing mainly in the preparation given to the crack prior to treatment and the type of material used. Various fillers may not exhibit the same type of adhesive or elastic properties that is expected of the sealant. Crack filling is most often reserved for more worn pavements with more random cracking that is usually wider than ¾ inch [13].

Rout and Seal: Pavement is prepared by using a saw or router to create a reservoir centered over an existing transverse crack. The routed crack is then filled with sealant [13]. This is used on transverse cracks on all pavement types in Minnesota. Due to the narrow width of recreational pavements, it is not recommended to rout longitudinal cracks, as this may induce block cracking.

Crack Treatment Materials

Currently there are three active Mn/DOT material specifications for HMA pavement crack treatments.

Mn/DOT 3725**:** Has low modulus properties, and is recommended sealant for transverse rout and seal applications. It is also the recommended sealant for agencies that saw and seal. However, for recreational trails, 3723 may be better suited since 3725 may be too soft for users, particularly in-line skaters.

Mn/DOT 3723**:** Exhibits good adhesion qualities. This product can also be used for the clean and seal method and for rout and seal.

Mn/DOT 3719 (Crumb Rubber)**:** Is the recommended sealant for crack filling where wider reservoir widths are needed.

How & When to Apply

In general, cracks wider than 3/8 inches should be filled using the clean and seal, or the crack filling procedure, and those wider than 1/2 inch should be cut out and patched using the rout and seal procedure [7]. Longitudinal cracks are generally structural problems and should be cut out and patched using the rout and seal procedure, however due to the narrow width of recreational pavements, it is not recommended to rout longitudinal cracks, as this may induce block cracking [7]. Crack sealing or filling may be the best option when the crack density is

moderate and crack edges have some or little deterioration; crack treatments are not recommended for a pavement in an advanced state of decay, or one scheduled for reconstruction within a few years. It is recommend that both crack filling and crack rout and fill treatments occur during the spring or autumn time frame and in dry conditions. In addition to using the appropriate sealant for the crack type, 3725 is not recommended for any crack type on recreational pavements, it is important to follow manufacturer recommendations with regard to sealant heating and placement temperatures, and to avoid mixing different manufacturer's brands or different types of sealants.

The appropriate equipment is important for a successful crack treatment application. The air compressor should be able to produce a continuous stream of clean, dry air with a pressure between 517 and 1034 kPa [75 to 150 psi] and a minimum flow rate of 3.5 m^3/minute [125 CFM]. The use of backpack blowers (leaf blowers) is not recommended. The use of vacuum cleaning equipment is acceptable if the equipment can successfully clean the cracks. The heat lance should operate with propane and compressed air in combination produce heated air at the exit orifice of 982° C [1,800° F] and a discharge velocity of 914 m/sec. [3,000 feet per second]. A pavement cutter of 20 horsepower should be used to cut the standard rout dimensions of ¾" by ¾", note that a width to depth ratio ≥ 1 may increase performance, but excessive widths have been found to be prone to failure.

If the rout and seal, or the clean and seal procedure is used, the sealant should be of minimal width to address patched problems with trail users, especially in-line skaters and fitness bicyclists. A flush fill with little to no over-band should be used.

Benefits and Risks

Crack treatments can be expected to prevent moisture infiltration into the pavement's subsurface structural layer which should extend its' service life. Crack treatments may also significantly improve the ride quality, especially for in-line skaters and fitness bicyclists. Crack treatments are a superficial solution, and do not address the underlying cause of the distress which may be vegetation,

or sub-grade movement. Sub-grade movement can affect the performance of the crack treatment necessitating re-application of the treatment.

Chapter 3. Preventive Maintenance Best Practices

The surface and crack treatments described above work best when viewed as preventive maintenance that are part of a preservation strategy, as opposed to temporary fixes that are part of a reactive maintenance strategy. The preventive treatments have relatively short lives when compared with overlay treatments and consequently must be re-applied on a regular basis to obtain the maximum preservation benefit.

Given that pavement degradation commences from the time of construction, due to the environmental factors of solar radiation, oxygen and water, it is recommended that fog seals be applied at the time of construction in order to best preserve the pavement at its' peak condition. Applying fog seals at the time of construction can be done with construction funds for the project.

Crack treatments should be first applied within five years of construction in order to prevent moisture infiltration, and the resulting distresses. Afterwards the treatments can be applied as needed.

Typically a PG 58-28 binder is used, but a PG XX-34 binder is recommended on highways since it has been shown to significantly reduce the propagation of transverse cracks caused by low temperature cracking.

Chapter 4. Proprietary Products

There are numerous proprietary products that fit under the above mentioned available treatment categories. There are no Mn/DOT Specs. for these products as many of the details about the products' composition are closely guarded by the company offering the product. Proprietary products can typically be more expensive initially than standard products and treatments, but in some cases may be more cost effective in the long term. These products can offer some of the same, or improved, benefits and need to be evaluated on an individual basis. When evaluating a proprietary product one must consider the quality of construction, as even a good product will perform poorly, if applied improperly.

Chapter 5. Conclusions

The extensive state wide bituminous trail network provides economic and recreational benefit to many different kinds and types of users. Maintaining this network at an acceptable level of service for all users within the limited economic constraints of the owner agency is a significant challenge. Several relatively inexpensive treatment options, as well as numerous types of materials and combinations of treatments, are available to assist agencies in meeting their recreational trail preservation and maintenance needs. These treatments are designed to address distresses, or potential distresses, before they reach a moderate, or severe state; this reduces life cycle costs, and in many cases improves certain ride quality characteristics such as friction and smoothness. Most preventive maintenance treatments present logistical concerns with construction vehicle access and operation, and maintaining and enforcing unpopular trail closures.

Internet Resources

1. MnDOT Specs & Standards:
   http://www.dot.state.mn.us/tecsup/spec/index.html

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Appendix B

LRRB 876 – Preventive Maintenance for Recreational Trails

Task 2 Report
Preventive Maintenance Products for Trail Systems
(2008)

LRRB 876 – Preventive Maintenance for Recreational Trails

Task 2 Report
Preventive Maintenance Products for Trail Systems
(2008)

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March 2009

Acknowledgements

Many thanks are given to the Local Road Research Board (LRRB) for sponsoring this project.

A debt of gratitude is owed to the field support staff provided by trail owners for their preparation of the test sites and continued support during installation. Everyone worked hard to make this project a success. It could not have been done without them.

This project would not have been possible without the help and support of contractors that donated or reduced labor and/or product costs to make this possible. These contractors are:

Allied Blacktop Co., Maple Grove, MN – Emulsions, Chip Sealing

Astech Corporation, St. Joseph, MN – Emulsion

Crafco Incorporated, Chandler, AZ – Crack Sealant

Commercial Asphalt Repair, Grand Rapids, MN – Spray Patching Demonstration

Deery American Corporation, Grand Junction, CO – Mastic Products

Fahrner Asphalt Sealers LLC, Eau Claire, WI – Slurry and Heat Patching Demonstration

Konrad Materials Sales, LLC, Stanchfield, MN – Mastic Product Install

Table of Contents

Chapter 1 Introduction B-4
Background B-4
Preventive Maintenance Planning and Activities B-4
Special Considerations for Recreational Trail Users B-4

Chapter 2 Treatment Matrix B-6
Surface Treatments B-6
CSS-1h B-6
CRS-2pd B-6
Gilsonite Sealer Binders B-7
Liquid Roads B-7
Chip Seal B-7
Treatment Test Sections B-8
Crack Sealing B-11
Patching Demonstrations B-11

Chapter 3 Preventive Maintenance Testing & Evaluation B-12
Sand Patch and Permeability Testing B-13

Chapter 4 Cost Information B-14
Installation Prices B-14

Chapter 5 Conclusions B-16
Future Research Needs B-17
Internet Resources B-17

Chapter1. Introduction

Background

The state of Minnesota, municipal, county, and regional park systems have developed a vast state-wide network of recreational trails designed to meet the recreational, fitness and economic needs of the public. Given the limited availability of funds and the rising demand for new trails, there is a growing interest in maintenance techniques that can extend the useful service life and maintain a high level of service at reduced cost.

This task 2 report represents the construction report of the Local Road Research Board (LRRB) funded study on preventive maintenance (PM) treatments for recreational trails. This report documents the application of several different products and techniques to metro area trails during the 2008 construction season.

Preventive Maintenance Planning and Activities

The task 1 report consisted of gathering information from a cross section of trail owners, literature and preventive maintenance practitioners to determine the types of products and services currently used on trail systems. A treatment matrix was developed for installation of these products on trails with varied age and condition.

Special Considerations for Recreational Trail Users

Recreational trails are constructed for a variety of users that have very different expectations regarding the surface of the trail; these users can include walkers, runners, bicyclists, and in-line skaters. Within specific groups, such as bicyclists, there are subgroups such as the family bicyclist who rides comfort bikes short distances at low speeds, and the fitness bicyclist who rides specialty bikes long distances at high speeds. Often a trail will have surface characteristics acceptable to one group of users and not the other. For example walkers need less friction and can tolerate more roughness than bicyclists. Family bicyclists can tolerate more roughness than fitness bicyclists, and in-line skaters. Users with disabilities require maximum 2% cross slopes, ADA access compliance and reasonable friction for wheelchairs. It is important to understand the

needs and expectations of these users and the impact that the treatments will have on user needs before a treatment option is chosen. It is recommended that owner agencies develop a pavement management system for their trails, similar to those in use for automotive pavements, to monitor pavement condition with time and assist with planning the appropriate treatments.

Proper project planning and attention to details are essential to the success of any preventive maintenance program. Elements to be considered when undertaking a project include: providing sufficient staff to maintain trail closures, ensuring adequate clearance for construction vehicles and minimizing public disruption by providing early notifications, coordinating treatments with garbage pickup days, school let out times, community events and residential parking needs. If the trail is used as a commuter route, detours should be clearly trail blazed for the users. A complete inventory of trail markings and signage should be taken before project starts, and arrangement made for temporary signage until markings can be replaced after the treatment has cured and the permanent signage have be replaced.

Traffic control and public relations are important aspects of the PM that must be address during planning of any PM activities. One currently available resource is the Minnesota Manual Uniform on Traffic Control Devices (MUTCD) does address sidewalk traffic control issues.

Recreational trails represent a wide range of structural capacities. Care must be taken during both the planning and construction phase not to damage the existing trail structure by over loading it with construction equipment.

Each treatment has different requirements for environmental conditions to maximize the chances of success. The project planner should seek recommendations from the suppliers of products that are planned to be used to make sure of what are the optimum weather conditions. Recreational trails have variable environments that must be taken into account when planning projects. Areas in full sun light will cure much faster then areas in full shade. The agency should plan the length of trail closure for areas with slowest curing rate.

Chapter 2. Treatment Matrix

Surface Treatments

Fog sealing is a light application of an asphalt base product that is applied to seal the surface of the pavement to fill voids, small cracks and reduce aging. Fog sealing products were applied over different trail segments as well as on top of a chip sealed trails with three different types of fog sealing products used.

Discussions with suppliers and manufactures to customize formulations of existing products proved difficult. During 2008 project, a polymer shortage was experienced within the asphalt industry. While every attempt to develop a truly "new" product for this market, roadway preventive maintenance products can accomplish the same PM goals for trail owners and maintain user expectations.

The application rates stated in this report are correct for the trails that received the treatments. The users of any product must take care to plan the correct application rate for their trails. The suppliers of the product are a good source for recommended application rates as related to current condition of their trails.

Suppliers were contacted for installation of proprietary products for evaluation, only Liquid Roads participated.

CSS-1h

CSS-1h is a slow setting asphalt emulsion. The recommend dilution rate is one part emulsion to one part water. Mn/DOT requires the dilution to be done at place of manufacture to insure proper dilution. This product has a low viscosity which allows it to soak into the pavement. The application rate is 0.06 to 0.15 gallons per square yard diluted, depending upon surface conditions of trails. The average curing time was 2-4 hours when proper weather conditions are present at time of application. Satisfactory installation was observed for all trail segments that received a fog sealing using CSS-1h.

CRS-2pd

CRS-2p is an asphalt emulsion made with polymer modified asphalt originally developed for chip sealing. The CRS-2p is diluted three (3) parts emulsion to one (1) part water to reduce the viscosity and thus is called CRS-2pd. Mn/DOT requires the

dilution to be done at place of manufacture to insure proper dilution. CRS-2pd emulsion was applied at 0.08 to 0.13 gallons per square yard, depending upon surface conditions of the trails. This product did not penetrate as much as the CSS-1h. CRS-2pd exhibited the ability to fill surface voids and small cracks of any of the spray applied products. The curing time ranged from 4-6 hours, dependant upon weather conditions. CRS-2pd application was acceptable; however one application exhibited some tackiness for the first day. This should be considered a product for more aged, pocked, porous and cracked trail pavements.

Gilsonite Sealer Binders (GSB or CS-41)

Gilsonite, in the asphalt emulsion family, is a natural, resinous hydrocarbon found in northeastern Utah which is similar to hard petroleum asphalt. Gilsonite was applied at a rate of 0.11 to 0.15 gallons per square yard, depending upon surface conditions of trails. Gilsonite was able to soak into the surface of the trail at moderate rate. This product's curing time ranged just over ½ to 4 hours depending on weather conditions. Satisfactory installations were experienced over all segments.

All of the fog seal product were placed using a distributor.

Liquid Roads

Liquid Roads is a proprietary slurry surface sealer material. A typical application is to install with squeegees by a four person crew. The recommend the application is 0.50 gallon per square yard. The curing time ranged from ½ to 6+ hours.

Chip Seal

A chips seal was constructed using a base layer of CRS-2p emulsion and Dresser Trap Rock ⅛ "Trail Mix" aggregate. The trail mix gradation produces a much smoother surface than a typical chip seal aggregate. This section was then fog sealed with three different emulsions including CRS-2pd, CSS-1h, Gilsonite. An un-fogged control section was also established. Curing time was not an issue because walking traffic could return to the chip seal immediately.

Treatment Test Sections

The following table lists test sections the test sections established during Task 2. Control sections were established and will remain untreated for long-term evaluations. Application rates of spray applied products varied from 0.05 to 0.13 gallons per square yard, depending on surface conditions. The contractor installing Liquid Roads product reported an application rate of 0.50 gallons per square yard.

Table 2.1. Project Locations

Owner	Segment	Location	Treatment	Application Rate	Orig. Const.	Approx. Length
DNR	Gateway	Gateway Trail, Wash. Co. Jamaca to TH96	CRS-2pd Light Application	.05	2006	1.8 miles
DNR	Gateway	Gateway Trail, Wash. Co W. of Jewel Ave.	CRS-2pd 100% Coverage	.08	2006	750 ft.
DNR	Gateway	TH96 to Manning Ave.	CSS-1h	.12	2006	2.3 miles
TRPD	Fish Lake	North Peninsula Loop Trail	CSS-1h	.12	2007	2200 ft.
TRPD	Fish Lake	West side of Parking Lot Trail	CSS-1h	.12	1998	1800 ft.
Roseville	C.R. B2	S. Side of C.R. B2 Snelling to Lexington Ave.	Gilsonite	.13		1 mile
Roseville	Lexington Av.	W. Side of Lexington. Ave C.R. D to C.R. C	Gilsonite	.13		1.2 miles
Roseville	McCarrons Lk.	N. Side of S. McCarrons Dr. SE of Int. of Roselawn Ave.	Gilsonite	.11		150 ft.
Roseville	McCarrons Lk.	N. Side of S. McCarrons Dr. Rice St. to Fishing Doc.	Chip Seal, Fog Sealed with CRS-2pd	.14		700 ft.
Roseville	McCarrons Lk.	N. Side of S. McCarrons Dr.	Chip Seal, Fog Sealed with CSS-1h	.12		2200 ft.

Roseville	McCarrons Lk.	N. Side of S. McCarrons Dr.	Chip Seal, Fog Sealed with Gilsonite	.11		700 ft.
Roseville	McCarrons Lk.	S. Side of N. McCarrons Dr. Bayview Dr. to Villa Park	Chip Seal, No Fog Seal	-		700 ft.
Roseville	McCarrons Lk.	S. Side of N. McCarrons Rice St. to Hand Av.	CRS-2pd	.10		2600 ft.
Roseville	Reservoir Woods	N. of Alta Vista Dr. Parking Entry, West to Reservoir	Liquid Roads	.5		1000 ft.
Eagan	Pilot Knob- W	West Side of Pilot Knob Rd. Yankee D. to Lone Oak	CRS-2pd	.13		1 mile
Eagan	Pilot Knob- E	East Side of Pilot Knob Rd. Yankee D. to Lone Oak	CSS-1h	.13		1 mile
Eagan	Pilot Knob- NW	West Side of Pilot Knob Rd. South of Buffet Way	CSS-1h	.13		5200 ft.

Note: City Trails above are adjacent to a local roadways

Trail Owners:
DNR – Minnesota Department of Natural Resources
TRPD – Three Rivers Park District
City of Roseville
City of Eagan

Crack Sealing

Crack sealing was performed at the City of Eagan. Two crack sealant products were recommend by a manufacture for use on recreational trails. These products were considered better fit for recreational trails than the conventional Mn/DOT specified materials. One was recommended for cold weather climate area and the other was a standard parking lot crack sealant. The City of Eagan normally uses a sealant meeting Mn/DOT's 3723 specification. Crack sealing was installed using both Route & Seal and Clean & Seal method. The Route & Seal section was treated using both an overband treatment and a precision fill method to determine if an overband is appropriate or necessary for trails. Experience has shown that proper pay items for bidding will help guarantee successful projects. The Authors recommend bidding all crack sealing jobs by the trail station which is 100 foot segments of the trail. The next important step is good inspection of any PM treatment application.

Patching Demonstrations

A mastic product was demonstrated for level cracks that where too large to fill with normal crack sealants. Mastic products consist of a sealant materials containing aggregate.

Spray-Patching (or blow-patching) and Heat Patching methods were also demonstrated. Patching is classified as reactive maintenance. It is more cost effective to utilize preventive maintenance to prevent distresses that could later lead to reactive maintenance activities. There is a need for further research into best patching and repair practices for recreational trails.

Chapter 3. Preventive Maintenance Testing & Evaluation

The test sections were evaluated utilizing Sand Patch tests (ASTM E965) to measure texture and National Center for Asphalt Technology (NCAT) falling-head field permeameter to quantify the change in permeability from a treated & untreated section. Control sections were also tested with the same tests.

NCAT Field Permeameter Apparatus

Sand Patch and Permeability Testing

Bituminous payments age due to oxidation, UV, and all other weathering conditions. This exposure causes a loss of fine aggregate and asphalt binder from the pavement creating more texture or raveling of the surface. The purpose of sealing trails is to protect from environmental aging. Caution must be used when applying fog seal products as they can reduce the friction level. The owner must take care to balance between sealing and protecting the trail surface while retaining an acceptable friction for the users.

Permeability testing is used to measure the amount water intrusion into a pavement. The falling head permeability test is a measured rate of water flow versus time into a pavement. The unit of measure is centimeters of lost head versus time.

All the fog seal products did reduce the amount of texture by sealing the surface of the trail. The chip seal had an increased amount of texture due to the addition of the cover aggregate. None of the products reduced the texture to a level of concern. All the fog seal products did decrease the permeability levels of each test segment. Test data collected after construction will serve as a baseline to compare future test results and evaluate the performance of the products over time.

Chapter 4. Cost Information

Installation Prices

The installation cost of fog sealing and rejuvenator products are shown in table 4.1 below. The prices are considered to be higher due to relatively small project sizes, and dispersed metro locations. It is possible to reduce costs if the owner agencies let larger projects in close proximity and/or combined the trail preventive maintenance with the automotive roadway projects.

Table 4.1. Installation Cost of Fog Seal

Contractor	CSS-1h	CRS-2pd	Gilsonite	Liquid Roads
Allied Blacktop	$ 3.25	$ 4.25	$ 5.17 / $4.17 year end costs	n/a
Fahrner Asphalt				$ 4.00

All Prices are without sweeping or traffic control & quoted per gallon installed

Three purchase orders were processed for this project. The first was for 2,950 gallons of CSS-1h priced at $3.25/gal. for a total of $9,587.50 to treat various locations across the metro, as described previously. The second purchase for a small quantity of 100 gallons of Gilsonite product priced at the normal quoted rate totaling $517. In mid September, Allied Blacktop offered a discounted rate for Gilsonite because it will not store over the winter. That price for 1,200 gallons was $4.17 per gallon, totaling $4,992. A total of $15,096 of the original project budget was used.

The contractors stated that pricing for traffic control, trucking and sweeping vary greatly on the project location. A recreational trail located on a railroad bed will have fewer crossings, no walkway ramps and much less radius coverage requirements than working in an urban trail environment. Cities and Counties, in particular, will need to decide whether it is cost effective to provide staff to deal with traffic control, or pay the contractor to do the entire installation.

Another avenue to consider is gallon per square yard pricing for installation of emulsion products. It is important to compare the amount of residual asphalt in each product to determine what a product cost per square yard. An example would be CSS-1h

has 30 percent residual asphalt while CRS-2pd has 51 percent residual asphalt. Therefore you would need to apply 1.7 times more CSS-1h to receive the same residual asphalt.

The other consideration is to determine the life cycle cost of each product. Also the various products also serve a slightly different purpose. For instance, the CSS-1h is a product which primarily penetrates the surface. The CRS-2pd provides better surface coverage, the chip seal allows for a heavier binder application rate because of the additional surface aggregate. The Gilsonite provides an asphalt membrane and cured at a fast rate. The Liquid Roads product was applied by squeegee and can be placed around manholes and benches without overspray.

Chapter 5. Conclusions

The extensive state-wide bituminous trail network provides economic and recreational benefit to many different kinds and types of users. Maintaining this network at an acceptable level of service for all users within the limited economic constraints of the owner agency is a challenge. Several relatively inexpensive treatment options, as well as numerous types of materials and combinations of treatments, are available to assist agencies in meeting their recreational trail preservation and maintenance needs.

- Fog sealing of a recreational trail in good condition can extend the pavement life and provide a quality surface for trail users. Some considerations need to be addressed such as pavement age, location, surface condition and current distress of pavement to receive treatments.
- Adding preventive maintenance activities at an earlier pavement life can extend the serviceable life of a trail. It has been demonstrated that starting PM treatments at time of construction and continuing them on a regular base has slowed or stopped the aging of these trails. One example is the Heartland Trail that received a fog seal with CSS-1h as part of construction and was again fog sealed after some time as part of the County seal coat programs. This trail shows little aging. If a fog seal is applied at the time of construction, funds from original grant or construction budgets can be utilized.
- Within the time constraints of this study, a determination of which product will have a better value over the pavement life cycle cannot be determined. Any and all these products did result in a quality surface for users and should help reduce aging effects of these trails. A follow-up in-house project will be needed to monitor these trails in 3 to 5 years.
- For older trails which are pocked & porous, the CRS-2pd may be the best choice to seal and fill the surface caused by the lost fine aggregate and asphalt binder during aging of the bituminous.
- Not applying preventive maintenance techniques to recreational trail networks can result in unsatisfied users and costly corrective maintenance and increased reactive maintenance or earlier reconstruction.

Future Research needs:

- Evaluation of construction and design methods including studying mix design that would address specific properties that would enhance trail performance.
- An in-depth study of what types of sealant should be used for sealing cracks and develop materials specifications for the sealants needs to be done.
- Pavement Management System for recreational trails utilizing such devices as the light weight profilograph equipment that can identify and quantify distressed areas or identify trip hazards and record their location for repair.
- Patching and reactive maintenance methods need continued evaluation.

Internet Resources

5. Mn/DOT Specifications & Special Provisions:
   http://www.dot.state.mn.us/tecsup/spec/index.html

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

6. Mn/DOT Approved Products List
   http://www.dot.state.mn.us/products/index.html

7. Mn/DOT Seal Coat Handbook
   http://www.lrrb.org/pdf/200634.pdf

8. Best Practices Handbook on Asphalt Pavement Maintenance
   http://www.lrrb.org/PDF/200004.pdf

9. Minnesota Manual on Uniform Traffic Control Devices (MN MUTCD, See Part 9)
   http://www.dot.state.mn.us/trafficeng/otepubl/mutcd/index.html