930025

Testing of Alternative Asphalt Trail Surfaces for Resistance to Damage from Snowmobiles With Carbide Studs

Pursuant to Laws of Minnesota ~~1998~~, Chapter 216

Minnesota Department of Natural Resources
in cooperation with the Minnesota Asphalt Pavement Association and the Minnesota Department of Transportation Office of Materials and Road Research

December 15, 1998

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Executive Summary

In 1998, DNR was mandated to "study improved paving methods for state trails that prevent wear from snowmobile and other uses, including the use of improved paving materials and the application of coatings to existing paving materials and the application of coatings to existing paved trails." (Laws of Minnesota, Chapter 216, Section 5, Subdivision 6)

Eight test segments were developed on the Luce Line State Trail in Hennepin County. Four different asphalt mixtures were applied at two intersections of the trail and county roads. Four different epoxy coatings were applied on a short segment of asphalt trail.

The surfaces were evaluated after one season of use, in which there was below normal snowfall in the metro area, and an extremely short riding season. Two types of analysis were used, a visual rating system and a quantitative measure of surface roughness. All four segments of asphalt were damaged by carbide studs affecting the quality of surface to an unacceptable degree. None of the four epoxy coatings worked well either. Conclusions of the study are:

- Based on the results of this study, it is unlikely that any current asphalt paving technology will significantly reduce or eliminate damage from carbide studded snowmobile tracks.

- Further study may be warranted to investigate the resistance to stud damage for new "Superpave" polymerized asphalt mixtures.

- Epoxy coatings resist stud damage well, but experience cracking due to differential thermal expansion and are currently too expensive for widespread trail use. Long term resistance to damage requires further study.

- The damaged areas of asphalt will not last as long because the surface is more porous and allows more water penetration, increasing freeze-thaw effects and weathering of the surface. Determining how much reduction in life will occur requires a long-term study. However, even after one winter season of exposure to studs, the surface quality was impaired to the point that it would create problems for other users.

- If snowmobiles with studded tracks must share a paved trail alignment, the best precaution for reducing damage is maintenance of a significant snow base. The best options for repair of stud damage are thin asphalt overlays and a new process called microsurfacing. These repair options will cost about 25% to 35% of original paving cost, and will likely not resist further damage any better than the original surface.

- Covering the asphalt surface with substances such as sand or wood chips will also reduce damage, but adds to maintenance costs to lay the materials in the fall and remove them in the early spring. Approximately 40 truckloads of material would be needed to protect one mile of ten foot wide trail.

Legislative Authorization

This plan has been prepared in accordance with the Laws of Minnesota, 1998, Chapter 216, Section 5, Subdivision 6. Trails and Waterways Management

> "The commissioner shall study improved paving methods for state trails that prevent wear from snowmobile and other uses, including the use of improved paving materials and the application of coatings to existing paving materials and the application of coatings to existing paved trails. The commissioner must report on the results of the study to the house environment and agriculture budget division, and the house and senate environment and natural resources committees by December 15, 1998."

Problem Statement

This report was prepared to answer the following questions:

1. What paving technology can be used to minimize the damage to asphalt trails caused by carbide studs?

2. Will varying the type and size of aggregate and type of asphalt binder used affect the level of damage?

3. Will an epoxy coating applied on the surface of the asphalt affect the level of damage?

History/Background of Stud Issue

Studs are after-market products that are inserted into the tracks of snowmobiles for improved traction. They have been in use for several years. Initially, studs were used by racers. They have become increasingly popular with trail riders and other non-racing snowmobilers.

The number of registered snowmobiles has been steadily increasing. The percentage of snowmobiles with studs is increasing as well. The first impact of studs was observed on the Willard Munger State Trail about 1992. Since then, several factors combined to elevate the issue in importance on the public agenda. The impact of studs on surface quality compromises the in-line skating experience. In-line skating has become an increasingly important use of asphalt trails in the last five years.

The issue surfaced in 1996 on the Paul Bunyan State Trail. In 1995, 49 miles of the Paul Bunyan State Trail were paved between Brainerd/Baxter and Hackensack. When the snow melted in the spring of 1996 the damage was visible and a protest by some trail advocates ensued. A task force of trail advocates, snowmobilers, local business leaders, and DNR staff met over the summer to explore a variety of alternatives. After painstakingly reviewing the options, the task force unanimously determined the only viable solution was to recommend a ban on studs for the asphalt trail. Alternate routes were created to link existing grant-in-aid trails and provide connections to towns and local services. The outcome was that people can get to where they want to go without using the blacktop.

Partly as a result of what happened on the Paul Bunyan Trail, a law was passed in 1997 restricting snowmobiles with studs from using any State paved trails (Minnesota Statutes 1997 Supplement, section 84.86, subdivision 1). On some sections of the affected State Trails, alternate groomed routes open to all snowmobiles were provided.

In 1998, the law was amended to ban studs on all asphalt trails in the state, unless exempted through local ordinances. In 1999, the law bans the use of studs statewide except for private land or frozen public waters. One catalyst for the ban was the damage that occurred on the Sunrise Prairie Trail in Chisago County. A 17-mile asphalt trail was constructed in the fall by Chisago County. Extensive plans were made to accommodate snowmobiles by grooming a parallel treadway adjacent to the asphalt surface and erecting orange snow fencing every 1500 feet down the asphalt trail. Extensive signing was also put in place. The trail was severely damaged after the first snowfall.

Another amendment mandated the purchase of a $51 sticker for all snowmobiles with studs in the winter of 1998-1999, with the proceeds going to the repair of damaged trails.

Summary of Current Surfacing Technology

Three types of surfaces are used in the development of state trails: asphalt, crushed rock such as limestone or granite, and grass or dirt surface. The surface used depends on a number of factors including the types of trail use, user preferences, the distance from the supplier of surface material, and the physical characteristics of the site, (soil, slope, wetlands). The type of surface selected is recommended during the planning process. The advantages and disadvantages are summarized below. **The advantages and disadvantages are subjective because what is a disadvantage for one type of trail user is an advantage to another.**

Asphalt:

Definition: Aggregate stone mixed with hot bituminous over compacted aggregate base

Development Cost: $50,000 - $100,000 per mile (cost varies with slope and soil conditions)

Maintenance Requirements: Crack sealing/patching

Life Expectancy: 20 years

Advantages:

- Studies show use and satisfaction levels of bicyclists on asphalt trails are very high
- Maintenance costs are less than other surface types
- Accommodates in-line skaters, wheelchair use, and strollers
- DNR staff who manage trails with both asphalt and stone surfaces state asphalt is better for snowmobiling because it holds the snow better due to less dirt/stones mixed with snow. (Discoloration speeds melting)
- Longer season of use than limestone (Limestone is soft in the spring)
- Clean, dust free
- Not affected by heavy rainfall
- Could be plowed in winter for use by walkers (if trail is designated as a non snowmobiling trail)

Disadvantages:

- Dark surfaces exposed to sunlight absorb more of the sun's warmth. This can accelerate snowmelt when there is little snow cover.
- Some do not like the look of asphalt in comparison to other surfaces
- Harder to do spot repairs
- Can crack as it ages, or be damaged by tree roots
- Requires sweeping for litter-free surface
- Disliked by many joggers and walkers
- Increases speed of wheeled uses
- Damaged by metal studs on snowmobiles
- Can be damaged by horse use

Mowed Grass Surface:

Definition: Graded, seeded and mowed natural earthen surface

Development Cost: Up to $5,000 per mile for clearing, drainage and erosion control. Costs depend on site conditions and whether fill is needed.

Maintenance Requirements: Mowing, erosion control, turf maintenance, drainage control

Life Expectancy: Depends on usage and maintenance

Advantages:
- Least expensive to develop
- Suitable for joggers or horseback use or off-road mountain bike use

Disadvantages:
- Limited uses
- Not accessible to handicapped users
- Not suitable by narrow-tired bicycles
- May experience severe erosion when heavily used
- Not suitable for in-line skaters
- Less desired by bicyclists

Concrete: (concrete has not been used for any State Trails)

Development Cost: $200,000 - $250,000 per mile

Maintenance Requirements: Crack repair

Life Expectancy: 20 years

Advantages:
- Same as for asphalt

Disadvantages:
- Development cost is very high
- Cracks during freeze-thaw cycle
- Expansion joints create regular "bumps"
- Disliked by some joggers and walkers
- Hard to do spot repairs
- Can be damaged by studs
- Requires sweeping

Crushed Rock:

Definition: Crushed stone aggregate that is laid down and compacted (limestone or granite)

Development Cost: $15,000 per mile (depending on distance to source)

Maintenance Requirements: aggregate needs to be replaced or added to every 3-5 years and the surface regraded regularly. Spot repairs and grading will be necessary in the interim.

Life Expectancy: Indefinite, if maintained properly

Advantages:
- Many like the look of limestone, stating they like the rural appearance
- Preferred by some runners over asphalt
- Development cost is less than asphalt
- Easier spot repairs

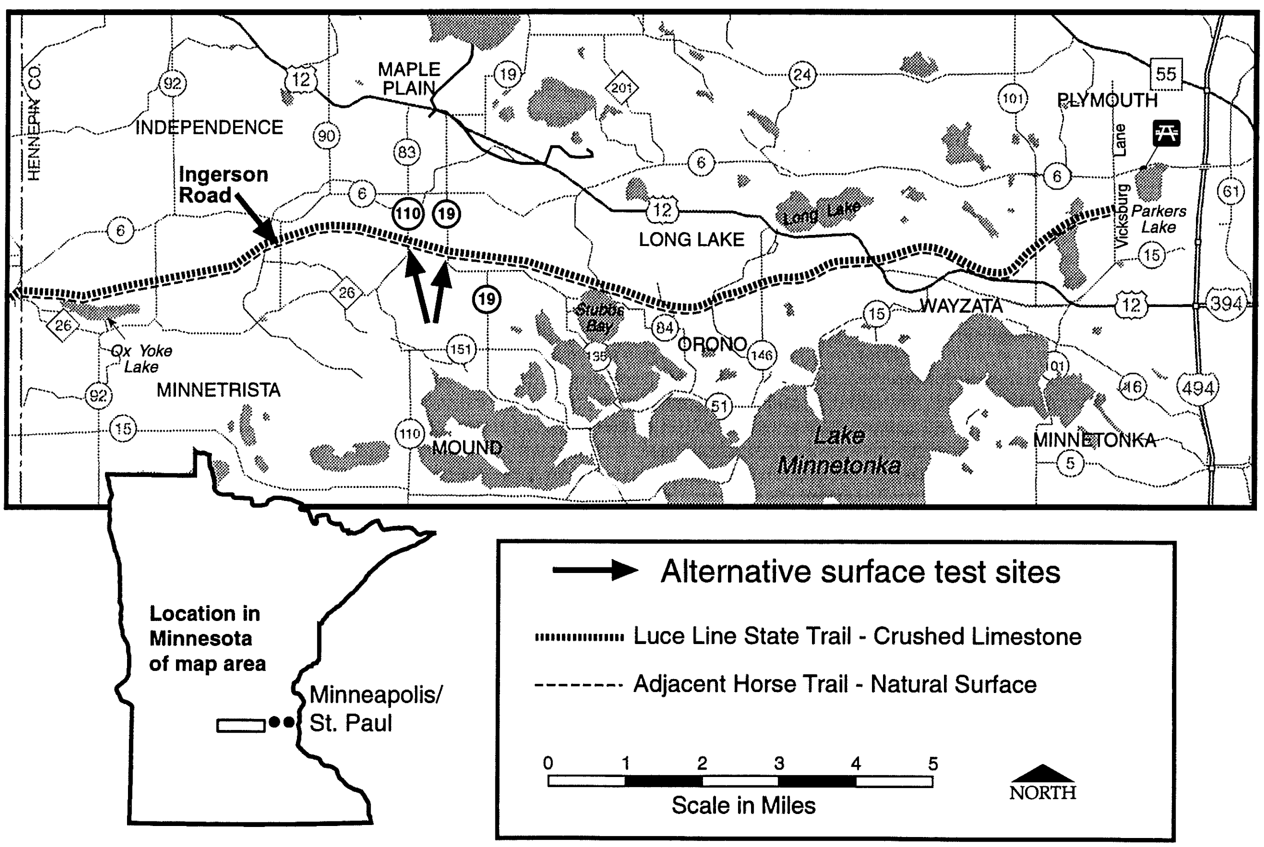
Disadvantages:
- Dust and dirt get into derailleur and chain of bicycles
- Hard to ride skinny tired bicycles on
- More frequent maintenance required
- Higher maintenance costs than asphalt
- Vegetation will grow on it if it is not used regularly
- Horse use damages surface
- May need herbicide in areas of low use
- Requires periodic dragging - 1-2 times a year
- Susceptible to spring damage/softness
- Erodes easily on inclines
- Does not accommodate winter plowing
- Not useable by in-line skaters
- Less accessible for handicapped users

Description of Test Site

The Luce Line State Trail was chosen as the test site. The Luce Line State Trail is located between Plymouth in Hennepin County and Cosmos in Meeker County. The eastern 30 miles are surfaced with limestone. The trail is currently used by snowmobilers, except for the eastern 7 mile segment which has always been designated as closed to snowmobiles. This trail was selected because there were no restrictions on use by snowmobiles with studs.

Three locations were selected: Hennepin County Road 19, Hennepin County Road 110 and Ingerson Road. Trail approaches to County Roads 19 and 110 were paved with asphalt test mixes, and Ingerson Road received epoxy test mixtures as the approaches were already paved at this site.

Four different asphalt mix designs were tested, along with four different types of epoxy coating over asphalt. Each asphalt test segment was 100 feet long, installed on a trail approach to a roadway crossing. Each epoxy section was ten feet long, installed on a previously paved trail approach to a roadway that was paved with asphalt the previous year.



Weather Conditions and Amount of Snowmobile Use During the Study Period

The snow conditions of the 1997-1998 season were representative of the type of conditions that exist at the beginning and end of a typical snowmobile season when the most damage by studs is likely to occur due to minimal snow cover.

Figure 1
Snow Conditions During the Winter of 1996-1997

	Date	Depth of Snow in Area(inches)	Depth of Snow Base on Trail (in)	Condition	Groomed
1.	12/31/97	1.5	1.5	Closed	no
2.	01/15/98	3.0	2.0	Good	yes
3.	01/22/98	6.0	3.0	Fair	yes
4.	01/29/98	10.0	2.0	Poor	no
5.	02/05/98	6.0	1.0	Poor	no
6.	02/12/98	10.0	1.5	Poor	no
7.	02/19/98	2.0	0.0	Closed	no
8.	03/05/98	0.0	0.0	Closed	no

Snow conditions during the 1997-1998 snowmobiling season were extremely poor. A 4-6 inch snow base on the trail is minimal for providing and maintaining a snowmobile trail. As illustrated above, this threshold was never reached during the 1997-1998 snowmobile season. The trail was only groomed during two weeks of the season.

Snowmobile Use During the 1997-1998 Winter

It was intended that the determination of the amount of snowmobile use be included in this study. A sampling plan was devised so that a prediction of how much snowmobile use was received on the test segments could be made. However, due to the extremely poor snow conditions, a sufficient number of samples could not be obtained to make the projection. Forty-eight of 87 scheduled survey periods were completed. A total of 204 snowmobiles were counted during the sample periods. Sixty-three percent of all snowmobiles counted occurred on two days, Saturday 2/7 and Sunday 2/8. These were the only days of the entire survey period when snow conditions were good for snowmobiling.

The number of snowmobiles that used the trail is less than would be expected in a typical winter.

Asphalt Test Segments

(Photos show sites prior to placing test material)

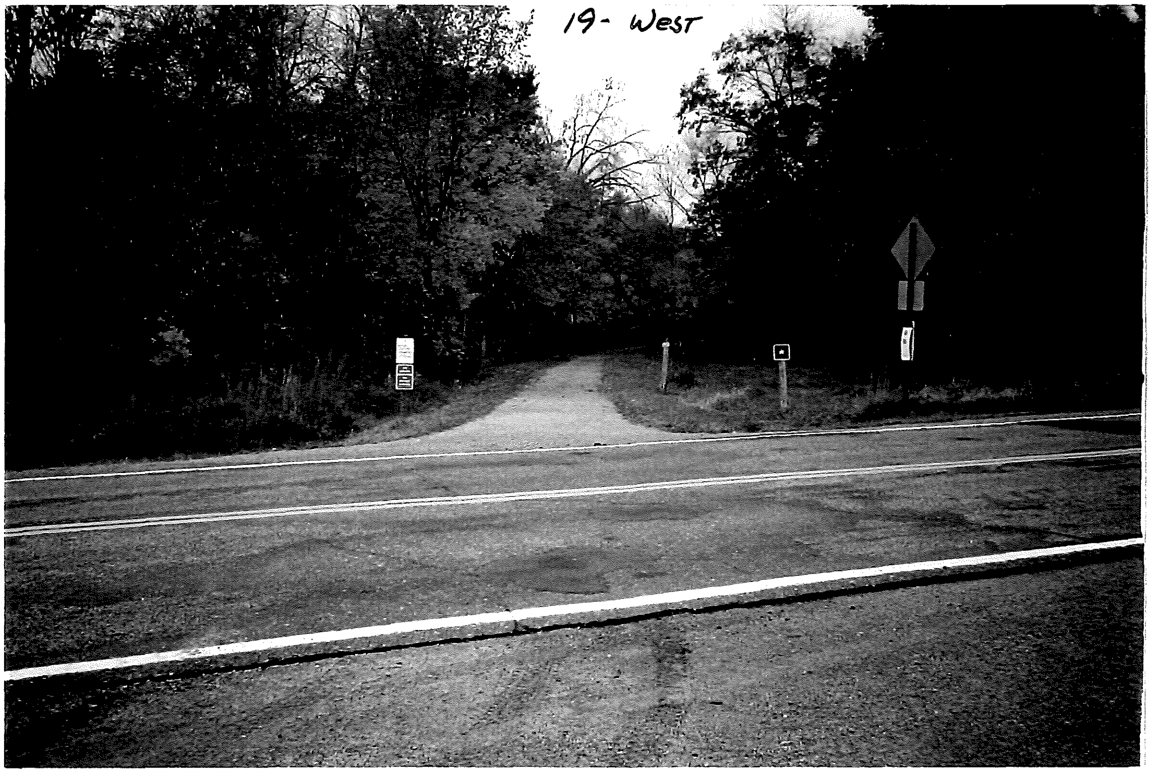
Segment 1: Luce Line State Trail & Hennepin County 19, East Approach

Mix Used: Mn/DOT Specification 2331, Type 41 Wear Course, Size A (1/2" maximum) 55% crushed aggregate, Asphalt Cement (AC) Grade PG58-28, AC 6.1% minimum

Segment 1 prior to placing test material

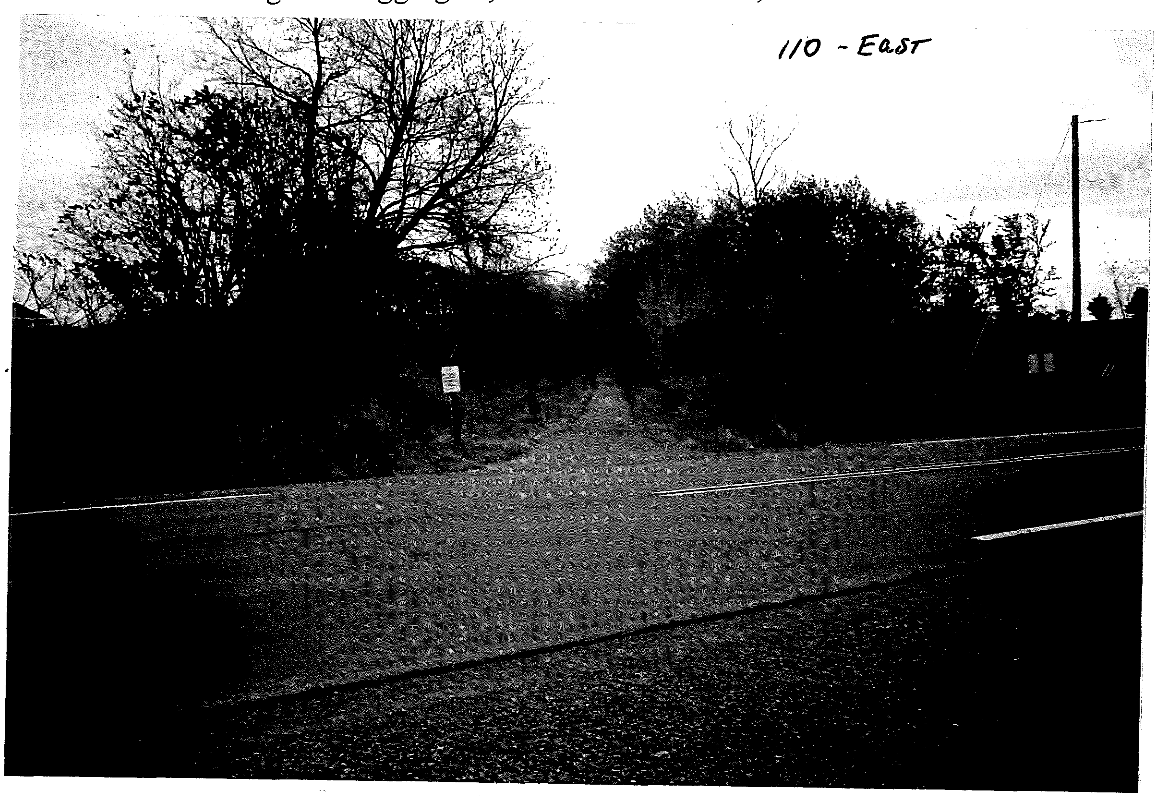
Segment 2: Luce Line State Trail & Hennepin County 19, West Approach

Mix Used: Mn/DOT Specification 2331, Type 41 Wear Course, Size B (3/4" maximum) 55% crushed aggregate, AC Grade PG58-28, AC 5.8% minimum



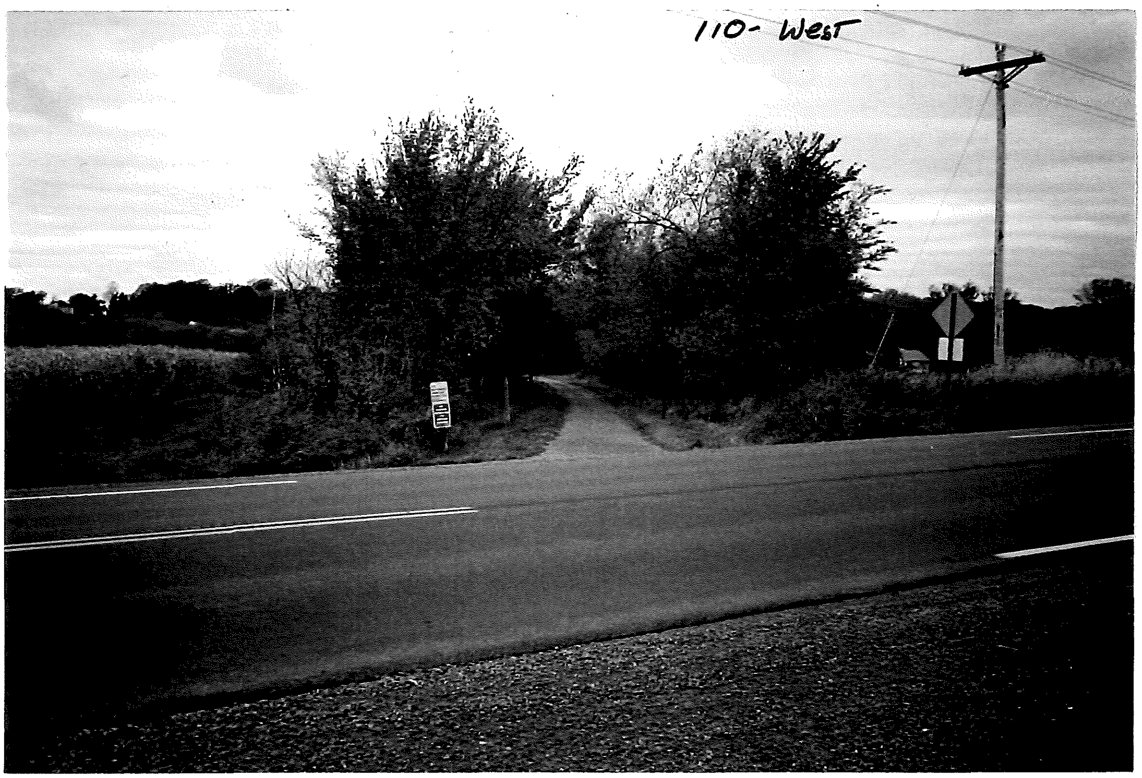
Segment 3: Luce Line State Trail & Hennepin County 110, East Approach

Mix Used: Mn/DOT Specification 2331, Type 61 Wear Course, Size A (1/2" maximum) 100% crushed granite aggregate, AC Grade PG58-22, AC 6.1% minimum



Segment 4: Luce Line State Trail & Hennepin County 110, West Approach

Mix Used: Mn/DOT Specification 2331, Type 61 Wear Course, Size B (3/4" maximum) 100% crushed granite aggregate, AC Grade PG58-22, AC 5.8% minimum



The mix designs used on Segments One and Two (Type 41) are representative of asphalt mixes used on a number of DNR paved trails. Some of the older trails such as the Douglas Trail and the Willard Munger Trail (Hinckley to Barnum) would have used Type 31 or 41 mixes with 3/4" maximum aggregate size, and some of the more recently paved trails such as the Paul Bunyan State Trail and the Willard Munger Trail (Barnum to Carlton) would have used a Type 41 mix with 1/2" maximum aggregate size. See Figure 2 for a summary of asphalt mix specifications used over the years on DNR-administered state trails.

The mix designs used on Segments Three and Four (Type 61) are representative of more durable mix designs typically used on high-volume roadways and airport runways. DNR has not used any Type 61 mixes on the state trail system. The increased durability of these mix designs under traditional vehicular traffic is due to harder granite aggregate, a greater percentage of angular crushed stone, stiffer asphaltic cement, and increased density requirements.

Figure 2

Historic Summary of Asphalt Mix Types Used for DNR Trail Construction on Segments Designated for Snowmobile Use

Trail Project	**Year**	**Asphalt Mix Design**	**Maximum Aggregate Size**	**Asphalt Cement Type**
Heartland	1976	Mn/DOT 2331	3/4" (BA2)	?
Heartland Rebuild	1996	Mn/DOT 2331 Type 41 Wear (41WEA50055)	1/2"	PG 52-34
Douglas	1985	Mn/DOT 2341	3/4" (BA2)	120/150
Willard Munger Hinckley - Moose Lk	1984	Mn/DOT 2331	3/4" (BA2)	120/150
Willard Munger Moose Lk - Barnum	1989	Mn/DOT 2331	3/4"	120/150
Willard Munger Barnum - Carlton	1995	Mn/DOT 2331 Type 41 Wear (41WEA50055Y)	1/2"	120/150
Paul Bunyan / Baxter to Hackensack	1995	Mn/DOT 2331 Type 41Wear	1/2"	85/100
Paul Bunyan / Lk Bemidji to Miss.River	1997	Mn/DOT 2331 Type 41 Wear (41WEA50055)	1/2"	PG 52-34
Sakatah Singing Hills	1994-95	Mn/DOT 2331 Type 41 Wear	1/2"	120/150
Willmar to Richmond	1994	Mn/DOT 2331 Type 41 Wear	1/2"	120/150

Asphalt Cement Types: 85/100 = PG 58-22 = Stiffest or Hardest Oil
120/150 = PG 58-28 = Medium Stiffness or Hardness
200/300 = PG 52-34 = Least Stiff

For PG Graded AC, the first number (for example, 58) is the maximum temperature (degrees Celsius) at which that the mix will perform adequately without deformation, and the second number (for example, -28) is the lowest temperature (degrees Celsius) at which the mix will resist cracking.

Epoxy Test Segments

The epoxy test segments were applied to a section of trail east of the Ingerson Road intersection with the Luce Line State Trail. The intersection approach sections of the trail at this location had been paved with asphalt the previous year to eliminate some erosion problems that were occurring. The Keeweenaw Research Center (KRC) of Michigan Technological University was hired to select and apply various types of epoxy coatings to the asphalt, as the KRC already had an epoxy coating research project underway for the Michigan Department of Transportation. The Michigan 5 year research project is focused at protecting asphalt highways at snowmobile trail crossings. KRC selected four types of epoxy that had shown promising results in other tests in Michigan and applied them to ten-foot segments of paved trail. The four types applied were:

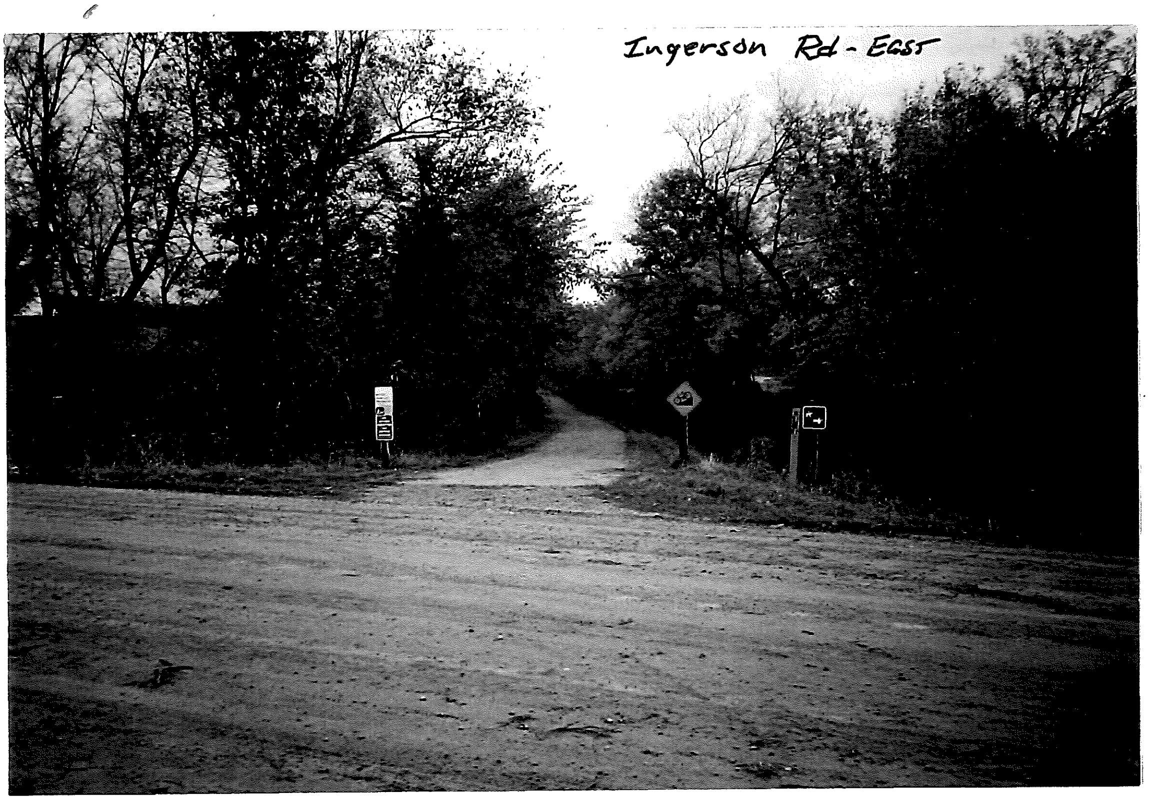
1) ProPoxy Type III DOT, manufactured by Unitex

2) CB700, manufactured by Axson Akemi

3) Sikadur 22 Lo-Mod, manufactured by Sika

4) Flexogrid, manufactured by Poly-Carb

See Appendix A for a complete report by KRC about application of the epoxy materials.



Evaluation of Test Segments after One Season of Use

In October 1998, the test segments were evaluated by a panel of DNR staff and asphalt paving experts. The evaluation was performed by the following people:

Kevin Arends, DNR Area Trails Manager, Moose Lake
Roger Olson, Mn/DOT Research Operations Engineer, Maplewood
Larry Peterson, DNR Engineering Design Supervisor, St. Paul
Gene Skok, Minnesota Asphalt Pavement Association Research Director
Dick Schmidt, DNR Luce Line Trail Technician
Joel Wagar, DNR Area Trails Manager, Rochester
Laurie Young, DNR Trails Planner, St. Paul

The evaluation consisted of a visual rating system and a quantitative measure of surface roughness. Results of the volumetric measurement of surface roughness follow and are tabulated in Figure 2. Results of the visual rating system are tabulated in Figure 3. Comments made about each segment are included with the corresponding photos.

Volumetric Measurement Test

Summary of Test Method

This test method determines the amount of voids and holes in the asphalt surface referred to as the average surface macrotexture depth (ASMD). A known volume of material is applied on the surface of the pavement, and the total area covered is measured. Thus, the deeper the holes and scratches, the less area covered. The material will cover a larger area where asphalt is relatively smooth, and a smaller area where asphalt is more porous and abraded.

The materials and test apparatus consist of a quantity of uniform material (glass spheres), a container of known volume, a suitable wind screen or shield, brushes for cleaning the surface, a flat disk for spreading the material, a ruler, spray paint for marking the location of the test, and chalk for marking the test sites.

The test procedure involves spreading a known volume of glass beads on a clean and dry pavement surface, measuring the area covered, and subsequently calculating the average depth between the bottom of the pavement surface voids and the tops of surface aggregate particles. This calculation will determine the average depth of the voids or scratches in the surface of the pavement in the test area (area covered by the material). There may be individual scratches deeper than the average depth of the surface voids. This test will not determine the maximum depth of the individual scratches within the test area.

Perhaps the easiest way to understand the following volumetric test data is to observe the size of the glass-bead circles in each photo. Larger diameter circles indicate relatively smooth pavement, with little abrasion or grooving. Smaller diameter circles indicate pavement that is more porous, with abrasion and grooving present.

Performing a volumetric test

Typical test area (Note the differences in diameter of circles. The smaller circles indicate asphalt that has more grooves and abrasion; the larger circles indicate smoother asphalt.)

Results of the Volumetric Measurement Test

Four circles along a horizontal line were created at each test site, using an equal volume of glass beads for each circle.

Segment 1: Luce Line State Trail and Hennepin County 19, East Approach

Mix Used: Mn/DOT Specification 2331, Type 41 Wear Course, Size A (1/2 inch maximum)
55% crushed aggregate, AC Grade PG58-28, AC 6.1% minimum

	(Average surface macrotexture depth) ASMD(inches)	Average Diameter (inches)
Circle 1	.050	7.84
Circle 2	.052	7.72
Circle 3	.026	10.94
Circle 4	.016	13.91

Segment 2: Luce Line State Trail and Hennepin County 19, West Approach

Mix Used: Mn/DOT Specification 2331 Type 41 Wear Course, Size B (3/4 inch maximum)
55% crushed aggregate, AC Grade PG58-28, AC 5.8% minimum

	ASMD (in)	Average Diameter (in)
Circle 1	.012	15.75
Circle 2	.019	12.68
Circle 3	.055	7.53
Circle 4	.022	11.84

Segment 3: Luce Line State Trail and Hennepin County 110, East Approach

Mix Used: Mn/DOT Specification 2331, Type 61 Wear Course, Size A (1/2 inch maximum) 100% crushed granite aggregate, AC Grade PG58-22, AC 6.1% minimum

	ASMD(inches)	Average Diameter (inches)
Circle 1	.018	12.94
Circle 2	.036	9.31
Circle 3	.096	5.69
Circle 4	.036	9.22

Segment 4: Luce Line State Trail and Hennepin County 110, West Approach

Mix Used: MN DOT Specification 2331, Type 61 Wear Course, Size B, (3/4 inch maximum) 100% crushed granite aggregate, AC Grade PG58-22, AC 5.8% minimum

	ASMD (in)	Average Diameter (in)
Circle 1	.018	13.00
Circle 2	.042	8.59
Circle 3	.063	7.00
Circle 4	.043	8.47

Figure 3

Average Surface Macrotexture Depths(ASMD)

	Segment 1	Segment 2	Segment 3	Segment 4
Circle 1	.050	.012	.018	.018
Circle 2	.052	.019	.036	.042
Circle 3	.026	.055	.096	.063
Circle 4	.016	.022	.036	.043

Perhaps the best way to interpret these results is to observe the differences between Average Surface Macrotexture Depths measurements across the width of the test segments. Pavement with little damage tends to have ASMD measurements in the 0.02 range, while pavement showing considerable damage tends to have ASMD measurements in the 0.05 range. The larger the average, the more damage. Repeating these ASMD measurements over several years in these same locations will provide a measure of how fast damage is progressing.

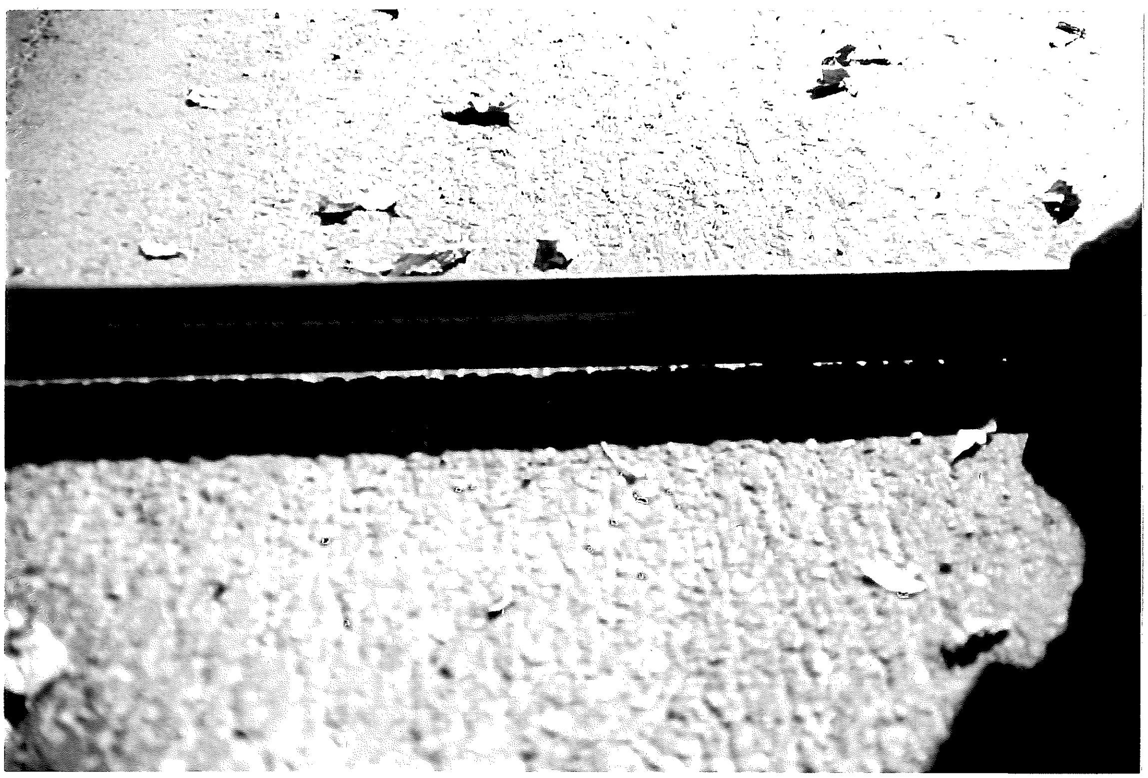
Visual Rating of Test Segments

Photographs of test segments with descriptions of conditions observed follow below. Tabulations of visual ratings are compiled in Figures 3 and 4.

Segment 1 (Hennepin County 19, East, Type 41A)

Segment 1 (19East, Type 41A): This segment showed considerable abrasion and loss of aggregate on the south half of the trail, which would probably be the acceleration lane for snowmobiles that have crossed the intersection. The northern half of the trail is not as heavily damaged.

Segment 2 (19West, Type 41B): Middle 1/3 of the trail is most heavily damaged, with some spalling of aggregate. Little or no damage on edges of the trail.



Straight-edge across the trail illustrates surface irregularities

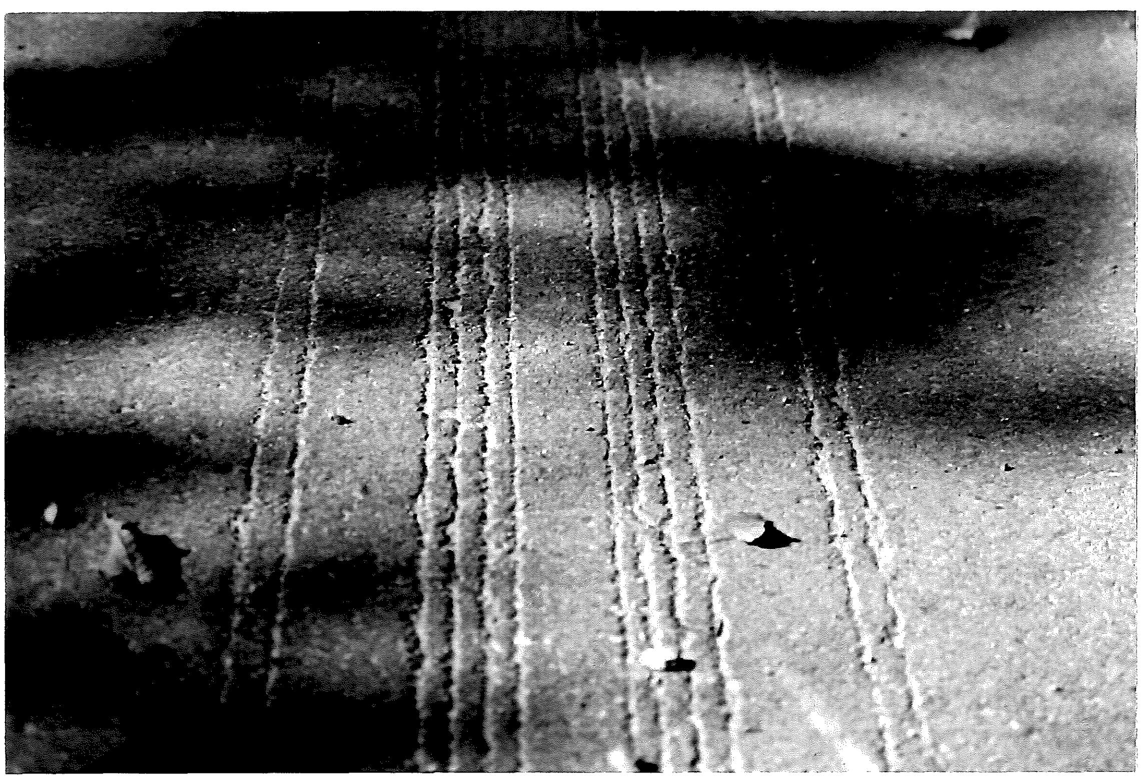
Segment 2 (19 West, Type 41 B)

Segment 3 (110 East, Type 61A Granite Aggregate): Damage over middle half of the trail, visible aggregate spalling. Damage appears worse than Segments 1 and 2.

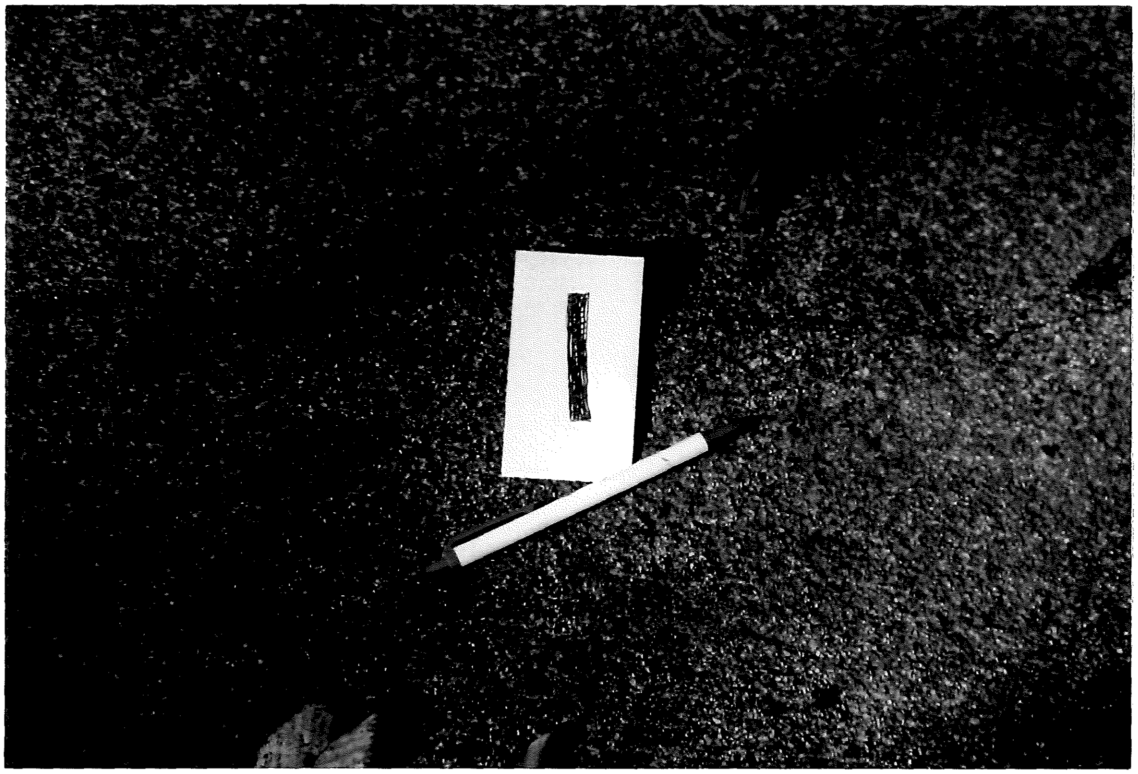
Segment 3 (110 East, Type 61A)

Segment 4 (110 West, Type 61B Granite Aggregate): Some damage across entire trail width. 1/4" grooves on edges of the trail. Visible spalling of 3/4" aggregate, damage appears worse than Segments 1 and 2.

Segment 4 (110 West, Type 61 B Granite Aggregate)

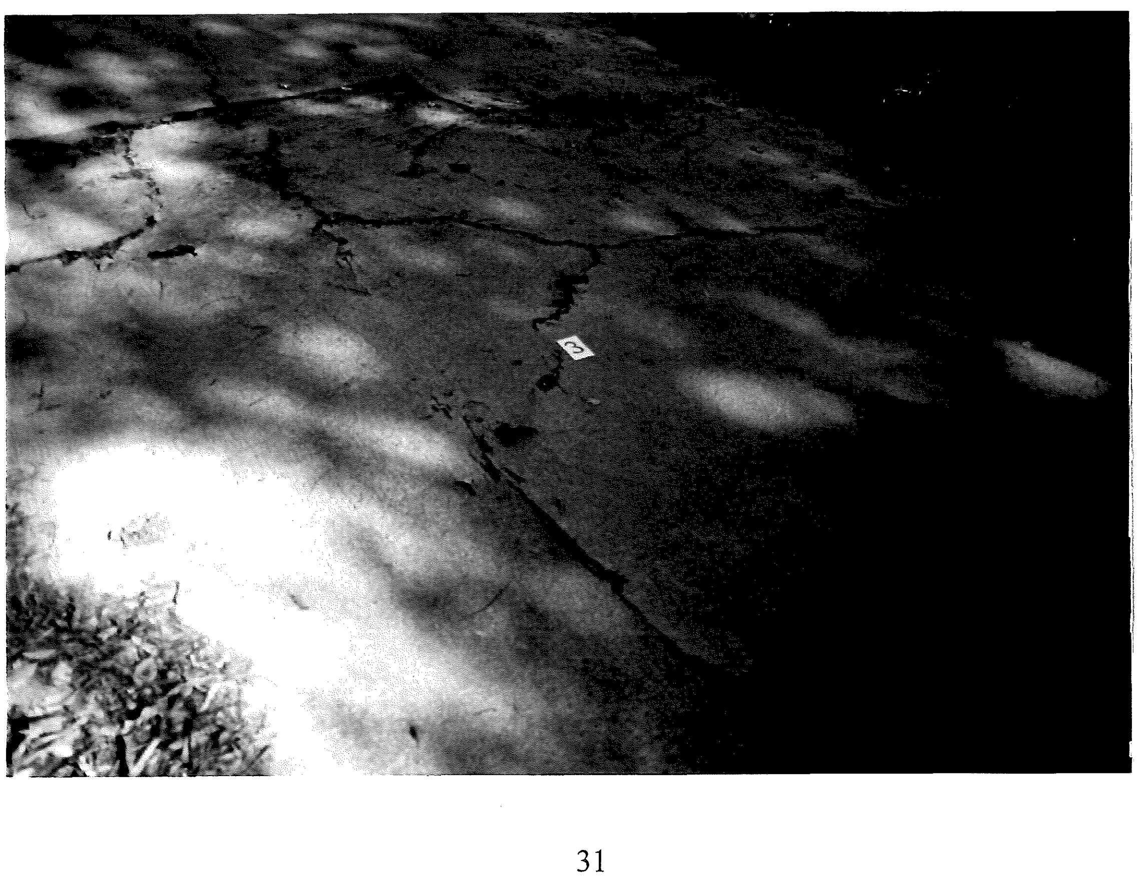


Segment E1 (ProPoxy): No penetration or grooving, little abrasion. However some longitudinal cracking is present, separating from the asphalt and pulling the asphalt surface apart. Cracking seems to be due to epoxy expanding and contracting at a different rate than asphalt during temperature changes.



Segment E2 (CB700): No penetration or grooving, little abrasion. However, severe longitudinal cracking is present, separating from the asphalt and pulling the asphalt surface apart. As in the previous segment, cracking seems to be due to epoxy expanding and contracting at a different rate than asphalt during temperature change.

Segment E3 (Sikadur): Epoxy seems to have delaminated and much of the coating is missing. Not suitable for trail use.



Segment E4 (Flexogrid): No penetration or grooving, little abrasion. However some longitudinal cracking is present, separating from the asphalt and pulling the asphalt surface apart. As in the previous segments, cracking seems to be due to epoxy expanding and contracting at a different rate than asphalt during temperature changes.

Figure 3
Visual Rating of Test Segments

Evaluation Criteria

DAMAGE LEVEL	SURFACE TEXTURE	MIX AGGREGATE	THICKNESS LOSS
Level Zero	Normal for age of surface	Not visible or protruding	None
Level One	Shows marks and scratches with little penetration	Not visible or protruding	None
Level Two	Some grooves visible, rough surface on less than 1/3 of trail width	Some visible aggregate protrusions, no spalling	0" to 1/4"
Level Three	Numerous grooves, surface is roughened up to ½ of trail width	Up to 50% of top aggregate is spalling	1/4" to 1/2"
Level Four	Very rough surface over more than ½ of trail width, original surface texture mostly gone	More than 50% of top aggregate is spalling	Greater than 1/2"

Definitions:

Surface Texture: refers to the relative smoothness or tightness of the trail surface, as compared to its condition when originally installed.

Mix Aggregate: 3/4 inch and smaller stones that are held together by the bituminous material or oil; these stones are generally visible or raised only after the thin surface layer of bituminous material has been worn off.

Spalling: individual stones have become dislodged from the mix and are loose or gone.

Thickness Loss: maximum reduction in thickness of the surface as measured below a straight edge placed across the entire width of the trail.

Figure 4
Tabulation of Visual Ratings

Rater Number

SEGMENT	1	2	3	4	5	6	7	8	AVE.
1) 19East	3	3	2.5	4	3	3	2.5	3	3.0
2) 19West	3	3	3	4	2	2.5	3	2	2.8
3) 110East	3	3	3	3	3	3	3	3	3.0
4) 110West	3.5	3	3	3	3	3	3.5	3	3.1
E1) Propoxy	1	1	*	0	2.5	1	1	0	0.8*
E2) CB700	1.3	2	*	0	2	1	1	0	0.9*
E3) Sikadur	2	2	*	0	2	1	4	4	1.8*
E4) Flexogrid	1	2	*	0	2.5	1	1.5	0	1.0*

* Epoxy segments were difficult to rate under these criteria; while they resisted grooves and abrasion, they exhibited severe longitudinal cracking and separation from asphalt. Although resistant to stud damage, the surfaces would be unacceptable for trail use with this type of longitudinal cracking.

Visual Rating Conclusions

Of the four asphalt mixtures tested, all showed significant abrasion and damage after one season of use. Some of the damage is probably accelerated due to minimal snow conditions present during the evaluation period. Contrary to original expectations of some, the segments using larger (3/4 ") aggregate, harder (granite) aggregate, and stiffer asphalt binder, (Type 61) fared no better than the Type 41A mix typically used in trail construction. All segments would probably be considered unacceptable for use by in-line skaters.

All four epoxy coatings tested appeared to resist abrasion and penetration by studs well. However, significant longitudinal cracking developed in all four sections, damaging underlying asphalt. This cracking is likely due to the epoxy expanding and contracting at a different rate than the underlying asphalt. Late season application of the epoxy may have also been a factor in the longitudinal cracking, although the pavement was heated and kept warm during the application and curing period.

Repair Costs

The expected life of an asphalt mat is approximately twenty years. Stud damage makes the surface of the mat more permeable by creating grooves and voids where aggregate spalls. Water will collect in the grooves and voids and the freeze-thaw process will tend to loosen aggregate in the remaining mix and accelerate abrasion and cracking. While no hard research exists as to how much stud damage will shorten the life expectancy of the pavement, paving experts from Mn/DOT and the Minnesota Asphalt Pavement Association estimate that damage such as this might reduce pavement life by 35% to 50% (or more) if not repaired. The following table summarizes various repair options and related costs. None of the repair options will be impervious to further damage from carbide studs (with the possible exception of epoxy), and will need to be redone periodically as damage reoccurs.

Figure 7
Repair Costs

Repair Method	Estimated Cost	Advantages	Disadvantages
Fog Seal	$2,000 / mile	Low cost Has short term sealing effect	Not durable, does not fill large voids
Sand Seal Coat	$6,000 / mile	More durable than fog seals	Rough surface
Slurry Seal	$10,000 / mile	Smooth	Can peel and delaminate
Epoxy Coating	Unknown in large quantity; estimates are $3-$5/sq.ft or $150,000-$200,000/mile	Tough, durable	Longitudinal cracking, high cost Delaminations
Microsurfacing	$15,000 / mile	More durable than seal coats, smooth, thin profile	Cost similar to overlay
1 1/2" Asphalt Overlay	$15,000 / mile	Smooth	Raises trail profile

Description of Repair Methods

1) ***Fog Seal:*** Fog sealing is the application of a dilute asphalt emulsion to existing asphalt surfaces. Fog seals coat the road surface and may fill small cracks and voids (up to 1/8" in size).
2) ***Sand Seal Coat***: A layer of asphalt emulsion is applied by a truck-mounted spray bar and then sand is spread over the asphalt. The mixture is allowed to harden, then excess sand is swept off the surface. Voids up to 1/4" are filled.
3) ***Slurry Seal***: A thicker mixture of asphalt emulsion, aggregate, water, and additives is applied with a squeegee-like applicator bar. No additional sand is added to the surface. Voids and minor surface deficiencies up to 1/4" are filled.
4) ***Epoxy Coatings***: A thin layer of expoxy material is applied to existing asphalt, then a small amount of fine sand or grit is added to make the surface less slippery. This type of coating would not fill existing grooves or voids but could be used to prevent further damage.
5) ***Microsurfacing:*** A special type of slurry seal that uses higher quality materials and a special polymerized binder. Microsurfacing is applied to existing asphalt surfaces with a specialized machine.
6) ***Asphalt Overlays***: A single 1-1/2" lift of hot-mix asphalt is applied by a traditional asphalt paving machine and compacted with a steel or rubber-tired roller. This method fills all voids and depressions up to several inches in size, and produces a surface that looks like new asphalt pavement.

Recommendations for Further Study

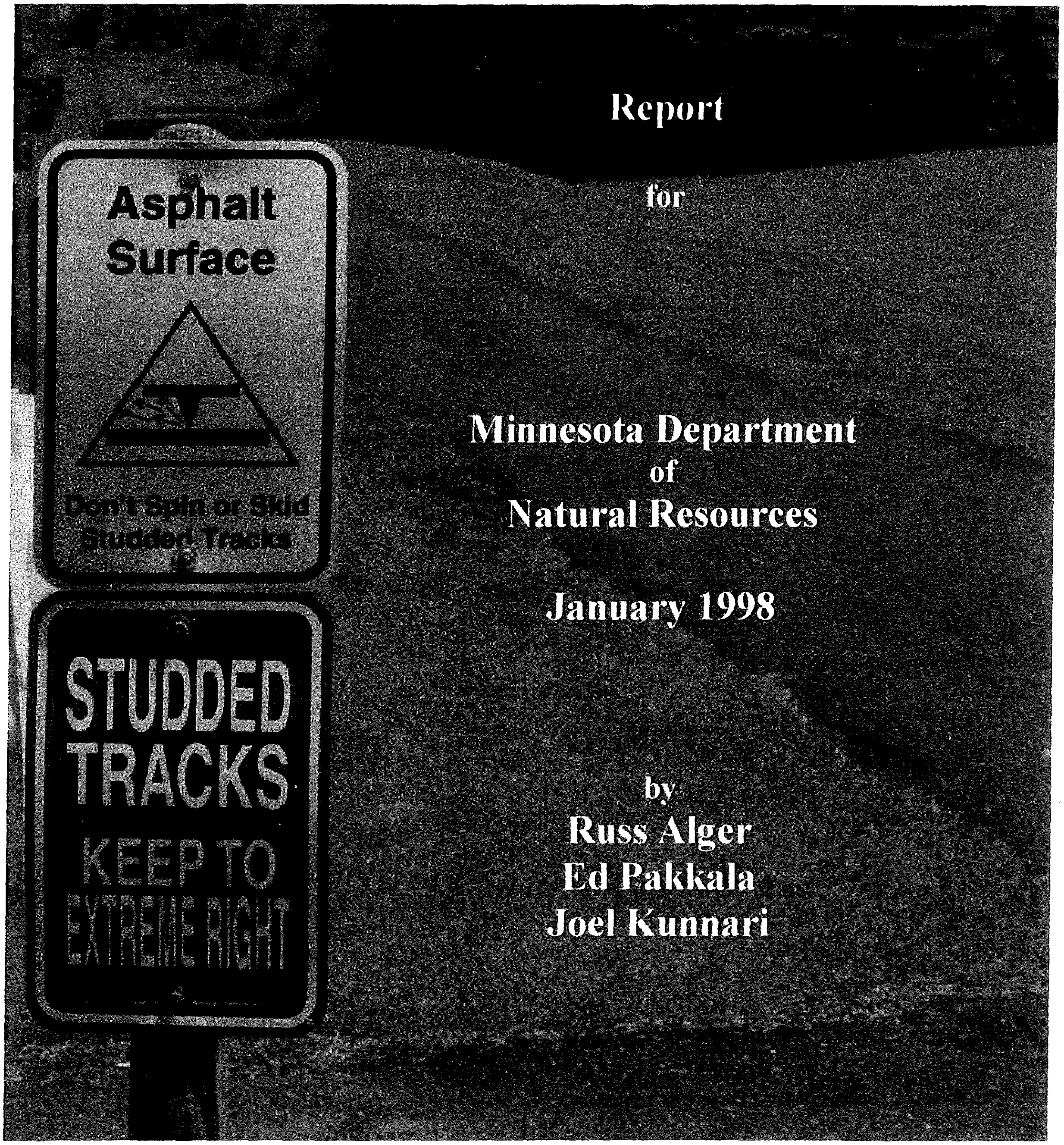
One of the emerging developments in asphalt paving technology is the use of some modified asphalt mixtures that have generally been labeled "Superpave" technology, after the federal Strategic Highway Research Program that used that title. Some Superpave mixtures normally use polymer additives to the asphalt oil and tight gradation controls to customize various properties of the mixture. The PG (performance graded) oils described previously in this report are one element of Superpave mixtures. There has been some anecdotal evidence that Superpave mixes may provide slightly better resistance to carbide stud damage. Further research would be helpful to investigate and verify what advantages (if any) these Superpave mixtures provide. Superpave mixtures are more expensive than traditional asphalt.

Epoxy coatings would only warrant further study, if there is evidence that they are becoming more cost-effective. Progress would also need to be made on the differential expansion/contraction problems that caused the longitudinal cracking in these test segments. Ongoing research conducted by the Keweenaw Research Center may address this issue in the future.

The Microsurfacing repair method should also be studied further, with some test applications on damaged trail segments. Since this repair method is much thinner than traditional overlays, it would require less reconstruction of trail intersections and shoulders.

Appendix A

Field Application of Elastomeric Coatings on a Paved Snowmobile Trail



Report

for

Minnesota Department
of
Natural Resources

January 1998

by
Russ Alger
Ed Pakkala
Joel Kunnari

Keweenaw Research Center
Michigan Technological University
Houghton, Michigan 49931

Introduction

The use of carbide studs and wear bars has become a topic of interest throughout the snowmobile community. The question to be answered is whether or not the added safety afforded by these devices outweighs the apparent damage caused to pavements, wooden bridge decks, etc, that are trafficked by these devices. It appears that the question of safety enhancement has been answered leaving only the search for methods to minimize damage.

KRC was contracted by the Minnesota Department of Natural Resources to set up a field evaluation of elastomeric coatings on a section of paved trail near Minneapolis. A crew was sent to the site and 4 test materials were applied. These sections will be monitored by MINNDNR personnel throughout the winter of 1997-98 to assess their individual effectiveness.

Test Set-Up

KRC was contracted by MINNDNR to set up an elastomeric coating test in the state of Minnesota. Upon receiving a contract, the necessary chemicals and supplies were obtained. Four coatings were chosen as candidates for application. These are the same elastomers used in tests by the Michigan Department of Transportation, MDOT, near Cadillac, Michigan, and in Mohawk, Michigan. These same chemicals are also being tested in the lab at KRC for MDOT. The four materials were as follows:

ProPoxy Type III DOT	Manufactured by Unitex
CB 700	Manufactured by Axson Akemi
Sikadur 22 Lo-Mod	Manufactured by Sika
Flexogrid	Manufactured by Poly-Carb

Each of the chemicals has been used for other applications on pavements and were obtained through this contract for this application. The cost for the chemicals ranges from $20 to $40 per gallon.

The aggregate used for the surface coating was obtained from Flat Rock Bagging in Flat Rock, MI and is what they categorize as #3. This is a silica sand that is primarily within the 10-16 gradation. 1200 pounds of this material was purchased and brought to the site.

Site Selection and Preparation

KRC personnel traveled to Minnesota in early November 1997. An asphalt paved section of snowmobile trail was chosen by MINNDNR to be used for the application of elastomeric coatings. This test site was located on a section of the Luce Line Trail where it intersects Ingerson road approximately 30 miles west of St. Paul. The test coatings were applied on the east side of Ingerson road where the paved section of the trail flattens out. Figure 1 is a photo of the section before preparation.

Figure 1. Test Site.

There was evidence of damage caused by studs and snowmobile traffic at this site. Grooves in the pavement were about 1/4" into the surface. Figure 2 shows these grooves.

Figure 2. Pavement surface before application.

The test sections were laid out on November 3, 1997. Using a MINNDNR sandblasting unit, the pavement surface was cleaned and roughened in preparation for the application of the coatings. All excess sand was swept from the surface. There was light snow covering the sections at this time and this was also cleared. Figure 3 shows the sandblasting work.

Figure 3. Sandblasting the surface.

Coating Application

The coatings were applied on November 4, 1997. Tom Miller of MDOT traveled to St. Paul to assist with the applications. He is the engineer in charge of the tests being performed in Michigan by MDOT. The ambient air temperature during the application was in the low 30's. This necessitated heating the pavement surface before application of chemicals was started. Since the pavement surface was also wet, this was also a means to dry it. This was achieved by covering the sections with a tarp and blowing hot air over the surface from a salamander as in Figure 4.

Figure 4. Pavement drying and heating.

The four elastomeric coatings were applied as each section was completely dry and warm. Each test pad was 10 ft. long along the trail and covered the width of the pavement, about 10 ft. The chemicals were kept warm inside a vehicle and were also warmed as they were mixed. The epoxies were mixed in batches of six gallons. The mix ratio prescribed by the manufacturers for 3 of the coatings, not including Flexogrid, is 1:1 (Resin : Hardener). Flexogrid is mixed at 2:1 (Resin : Hardener). The six gallon batch size was chosen as an estimate to cover 100 ft^2 . This amount was fairly close to the right amount in all cases. Mixing was accomplished using a power mixer as in Figure 5.

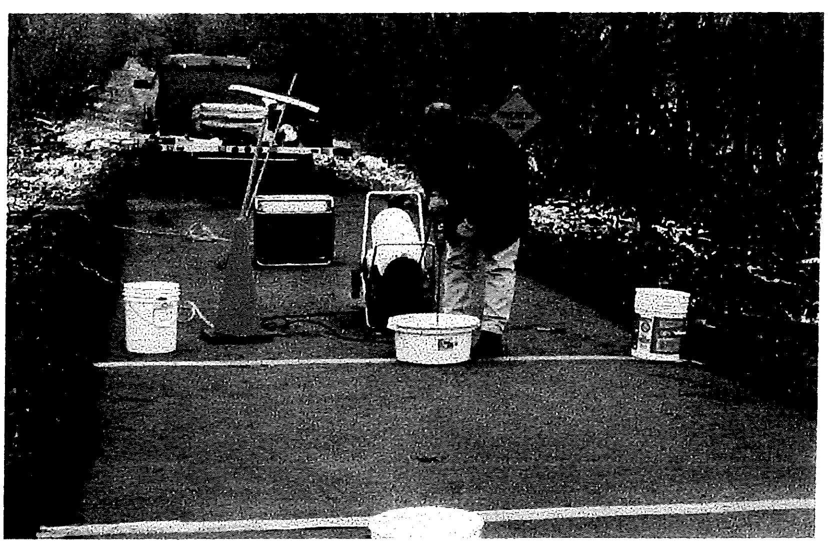


Figure 5. Mixing of epoxies.

The mixtures were applied on the surface using a notched rubber squeegee and thinned to approximately 1/8" thick. Figure 6 is a photo of the application of liquid epoxy.

Figure 6. Coating application.

Immediately after the layer of chemicals was spread, the surface was covered with aggregate. This is accomplished by putting a thick layer of the material across the surface and letting the epoxy harden around it. Since silica sand is quite durable, it is hoped that it will shield against some of the wearing action as well as keeping the surface from being slippery.

The test sections were applied in order from west to east along the trail as #1 - ProPoxy, #2 - CB 700, #3 - Sikadur, and #4 - Flexogrid. After all of the chemicals were applied, the entire test area was covered with a plastic tent and the salamander was used to keep the surface warm in order to speed up the set-up process. Figure 7 is a photo of the end product.

Figure 7. Completed test sections.

The final step in the application process was to sweep the excess sand off of the surface and a saw cut was made along the far west and far east end of the sections where the epoxies met the bare pavement perpendicular to the direction of travel. This is done to keep differential shrinkage of the surface from causing cracks within the test section. Figure 8 shows one of these cuts being made.

Figure 8. Saw cutting of boundaries.

The only real problem that occurred during application was with the second section, the CB 700. This chemical started to harden quite rapidly after application and in fact it was difficult to get sand to stick to the surface. The next coating applied was overlapped onto this one near the edge to rectify this problem. This will not affect the test, however.

Conclusions

The application of the coatings went well despite the fact that the weather did not cooperate. The final results will be obtained throughout the winter period as the test sections are monitored by MINNDNR personnel. KRC is also in the process of studying these coatings in the lab and field under contract to the Michigan Department of Transportation. The results from this study are to be finalized in June 1998. It is also hoped that a site visit can be made by KRC personnel during the winter if time permits.

Coating Company Information

Axson Akemi
Product: CB 700
1611 Hulls Drive
Eaton Rapids, Michigan 48827

Poly-Carb
Product: Flexogrid
33095 Bainbridge Rd.
Cleveland, Ohio 44139

Sika
Product: Sikadur 22 Lo-Mod
2190 Gladstone Court
Glendale Heights, Illinois 60139

Unitex
Product: Propoxy Type III DOT
3101 Gardner
Kansas City, Missouri 64120

MnROAD
Office of Minnesota Road Research

Mail Stop 645
1400 Gervais Avenue
Maplewood, MN 55109

Office tel: 612/779-5500
Fax: 612/779-5616

Building A Better Foundation For The Future

December 22, 1998

Mr. Larry Peterson
MnDNR Bureau of Engineering
500 Lafayette Road, Box 29
St. Paul, MN 55155-4029

RE: Effect of the Use of Carbide Studs By Snowmobiles on Paved Trails

Dear Mr. Peterson:

As we have been evaluating how the use of carbide studs on snowmobile tracks has affected the condition of surfaced recreational trails, we have surveyed the condition of several test sections on trails in Hennepin County. We have observed significant deterioration of the pavement surface as noted in the DNR report. The damage is most severe in areas of acceleration and deceleration. The damage does not appear to be reduced in the sections using high type asphalt mixes.

A number of factors have been presented which may have caused more rapid deterioration. One which has been brought up is that when the pavement is constructed late in the season, the mix may not have "set up" and, therefore, be more susceptible to wear. If an asphalt mix is placed late in the season and specifications are enforced, it will be compacted as well as mixes placed during the summer. The difference in susceptibility to wear will be negligible. The number of observations of deteriorated pavement surfaces at snowmobile trail crossings on county roads and trunk highways would point out that a wide variety of mixtures have been subjected to damage.

You also asked whether we were aware of any rehabilitation materials or procedures which could be used to repair damaged surfaces. One of the Luce Line Trail crossings was at a county road that had been seal coated. It was noted that the seal coat aggregate was picked clean in the area of the crossing. Any resurfacing, including microsurfacing, or other specialized mixes would not be significantly more resistant to carbide stud wear. Past studies on the effects of studded tire wear on highways noted that concrete highways also exhibited significant wear due to studded tire action. Relative effects could be attributed more to the