
ROCKY MOUNTAIN WEST PAVEMENT PRESERVATIO
PARTNERSHIP
PEPPERMILL HOTEL, RENO NEVADA
OCTOBER 4-6, 2012
NCHHRP SYNTHESIS 411
MICROSURFACING

NCHRP Synthesis 411 Microsurfacing

- National Cooperative Highway Research Program
- A Synthesis of Highway Practice
- Transportation Research Board
- Cooperation with FHWA

Organization and Execution

- Choose a topic panel
- Hire a consultant to do the research
- Agree on what information should be in the research.
- Send surveys to 50 DOT Maintenance Engineers and all Canadian Provinces
- Compile the information from surveys into the synthesis

Organization and Execution

- Comprehensive Review of the Literature; ISSA, DOT'S, FHWA, Individual Information
- 87 question survey; 88% response from US and 93% from the Canadians
- Evaluation of all 50 state DOT microsurfacing specifications as well as one from the FHWA/FLHD
- Case studies of six micro surfacing projects from five U.S. states and one Canadian province

Topic Panel

Simone Ardoin, Louisiana DOT

Lita Davis, County of San Diego

Amir H. Hanna, TRB

Thomas A. Kane, New York DOT

Robert E. Lee, Texas DOT

Frank N. Lisle, TRB

David Peshkin, Applied Pavement Technologies

Mary Stroup-Gardiner, California PP Center

Thomas J. Wood, Minnesota DOT

Stephen R. Mueller, FHWA

Rusty Price, Intermountain Slurry Seal, Inc.

Consultant

- Douglas D. Gransberg
  Iowa State University
  Ames, Iowa

Synthesis Contains 9 Chapters, 115 pages

- 1. Introduction
- 2. Summary of Information Collected
- 3. Design Practices
- 4. Contracting Procedures
- 5. Construction Practices
- 6. Equipment Practices
- 7. QC/QA and Performance Measures
- 8. Case Studies
- 9. Conclusions

CHAPTER ONE, INTRODUCTION

- Synthesis Objective; identify and synthesize accepted practices for microsurfacing PP programs
- History
- Environmental Impact
- Key Definitions
- Terminology

Environmental Impact

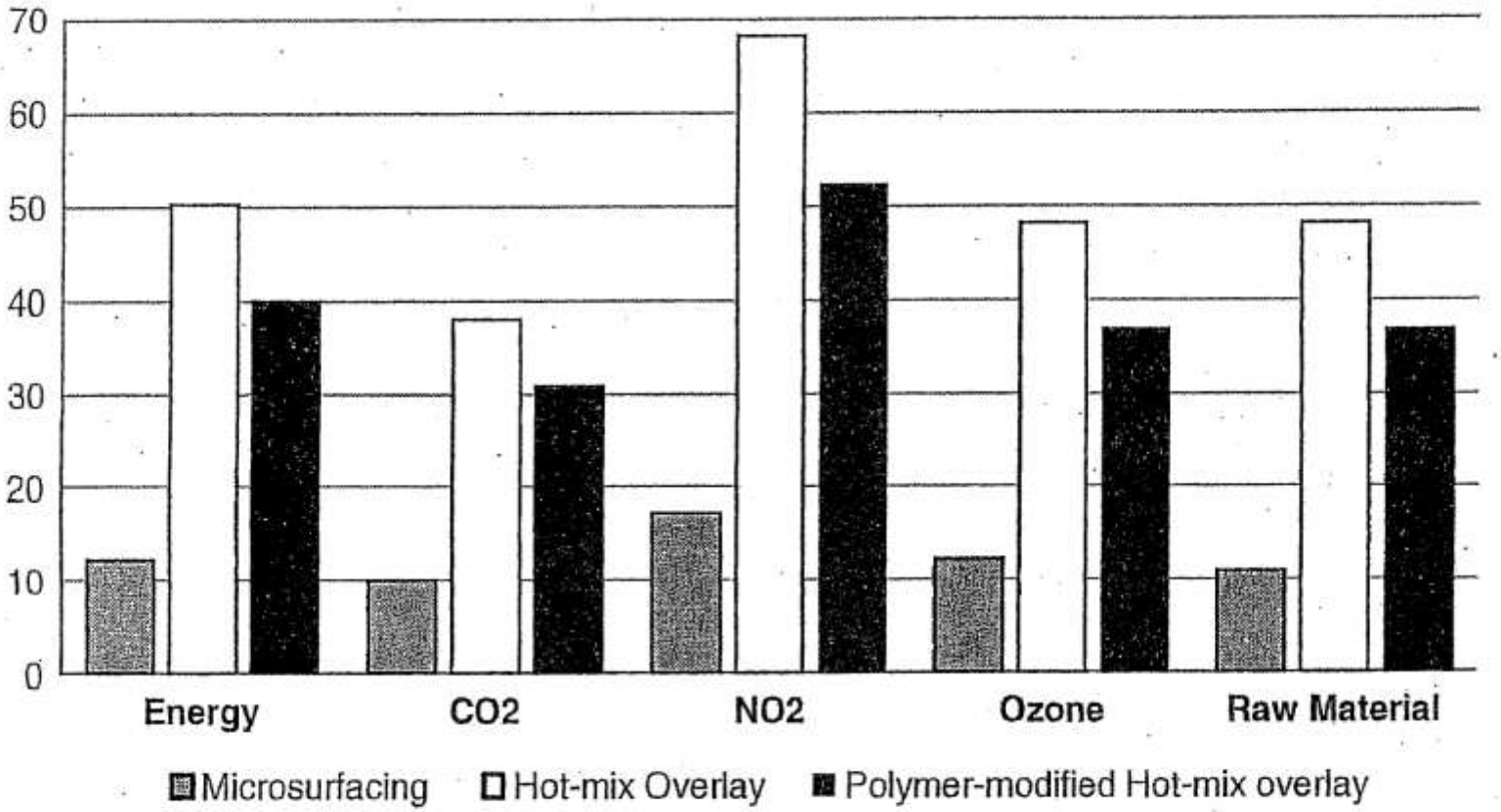


FIGURE 10 Comparative environmental impacts of three pavement preservation and maintenance treatments (adapted using data taken from Takamura et al. 2001).

Environmental Impact

TABLE 14
ENVIRONMENTAL IMPACT COMPARISON OF MICROSURFACING VERSUS HOT MIX ASPHALT OVERLAY

Treatment	Composition	Energy Use		Greenhouse Gas Emissions		Life Extension	Annualized Percent Savings vs. 2-in. Hot-Mix Overlay	
		BTU/CY	*MJ/CM*	*Lbs/SY*	*Kg/SM*			
Hot-Mix Asphalt Overlay	1.5 in. (3.8 cm)	46,300	59	9.0	4.9	5–10 yr	*Energy Use Savings*	*Greenhouse Gas Savings*
	2.0 in. (5.0 cm)	61,500	77	12.3	6.7	5–10 yr		
Micro-surfacing	Type III	5,130	6.5	0.6	0.3	3–5 yr	83%–86%	90%–92%
	Type II	3,870	4.9	0.4	0.2	2–4 yr	83%–84%	91%–92%

Adapted from Chehovits and Galehouse (2010).

Common Applications

- Correct Minor Surface Profile Irregularities
- Rut Filling
- Higher Durability
- Night Work or Cooler Temperatures
- Restore Surface Friction to Asphalt and Concrete

Key Definitions

- Pavement Preservation
- Preventive Maintenance
- Routine Maintenance
- Corrective Maintenance

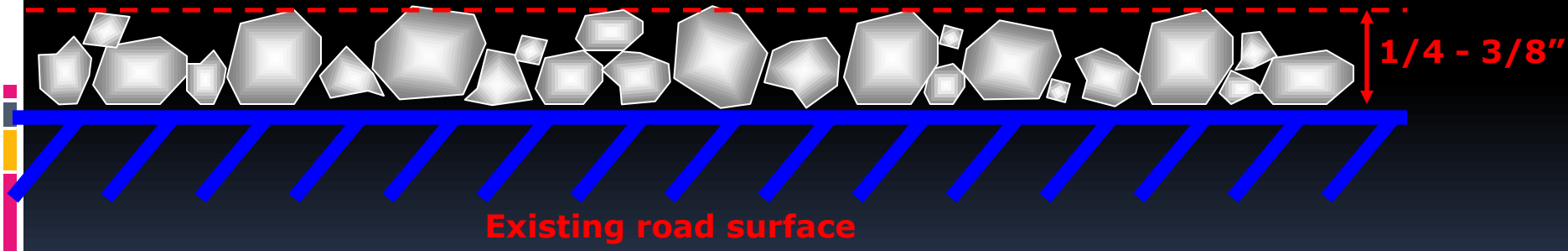
Microsurfacing Terminology

- Microsurfacing versus Slurry Seal Terminology-----Differences; specifications and performance
- Polymer
- Chemical Break---Quicker Return to Traffic
- Applied more than one stone deep

Slurry Seal application

Slurry surfacing

- Laid at one-stone thickness
- Largest stone bears traffic load
- Not designed for multiple layering



Micro-surfacing - definition

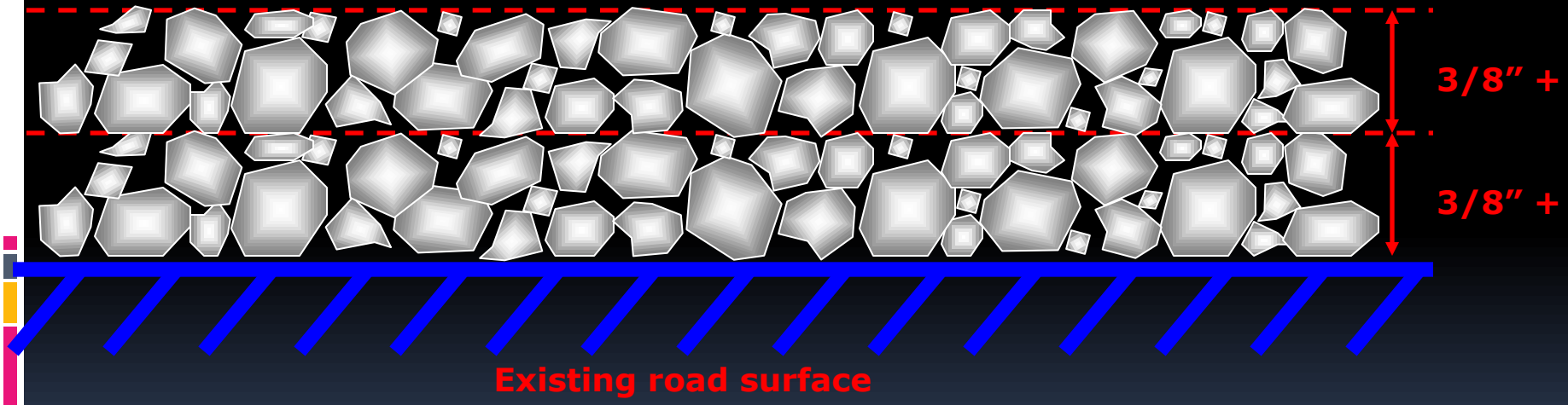
"… a mixture of polymer modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives, properly proportioned, mixed and spread on a paved surface… in variable thick cross-sections… which resists compaction"

- ISSA Technical Bulletin A143

Microsurfacing application

Micro-surfacing

- Applied in multi-stone thickness
- Stone interlock and modified binder bears traffic load
- May be applied in multiple layers



CHAPTER TWO, SUMMARY OF INFORMATION COLLECTED

- Synthesis Methodology; Reponses from 44 US State DOT and 12 Canadian Provinces
- General Agency Information
- Chapter Conclusion:

  "Microsurfacing is fundamentally viewed as a tool to extend the service life of the existing pavement and thus it is used primarily as a pavement preservation treatment"

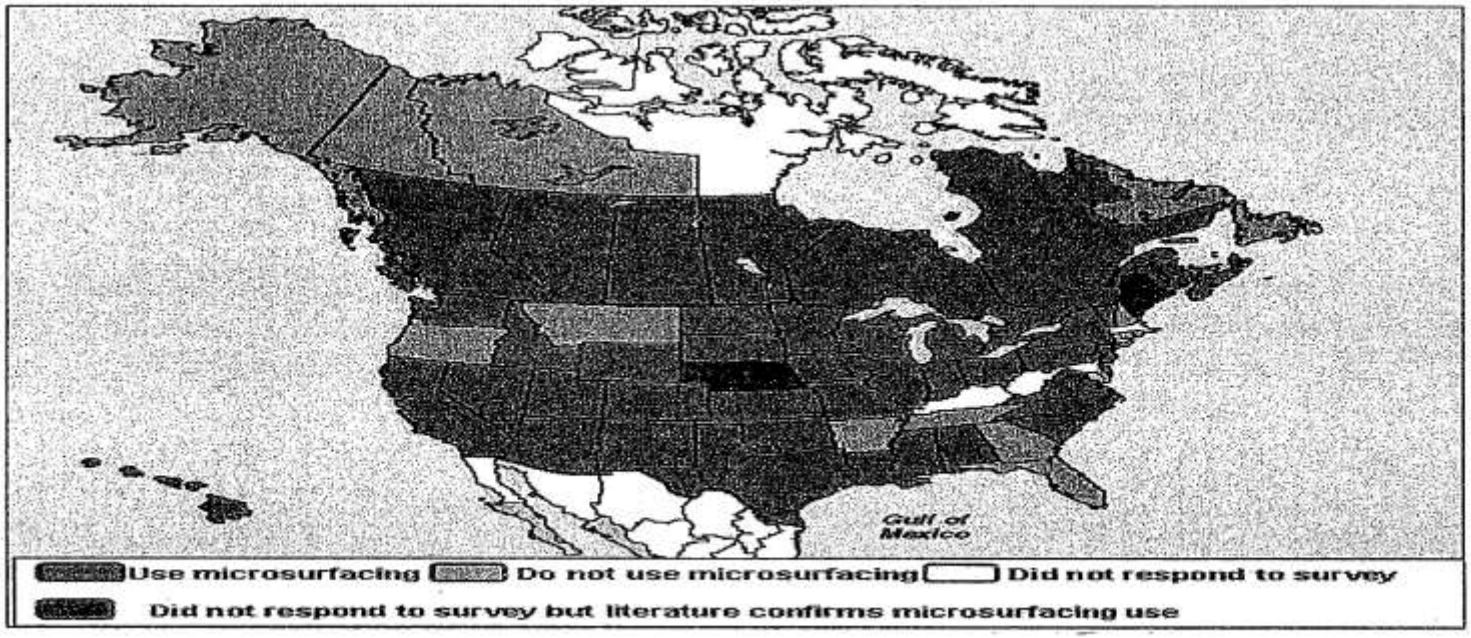


FIGURE 4 Survey responses from U.S. DOTs and Canadian MOTs.

TABLE 4
CASE STUDY SUMMARY

Agency	Reason for Inclusion
Georgia DOT	Agency with successful demonstration project but does not use in program. Also included road noise analysis.
Kansas DOT	Microsurfacing on jointed concrete pavement.
Maine DOT	Agency uses microsurfacing to maintain both roads that are built to DOT standards and roads that are not built to DOT standards.
Minnesota DOT	Agency has robust internal microsurfacing research program, including trials of softer binders to reduce cracking.
Oklahoma DOT	Agency has 9-year field performance monitoring program and an ongoing rigorous field test that focuses on microsurfacing skid resistance and macrotexture.
Ontario MTO	Agency has completed rigorous studies relating microsurfacing to traffic safety.

TABLE 5
SUMMARY OF MICROSURFACING PROGRAM STATISTICS FROM SURVEY RESPONDENTS

Characteristic	U.S. DOT	Canada
Percent of Rural Local Roads with Microsurfacing	2.2%	0.0%
Percent of Rural Interstate Roads with Microsurfacing	5.6%	9.1%
Percent of Urban Local Roads with Microsurfacing	6.0%	0.0%
Percent of Urban Interstate Roads with Microsurfacing	10.7%	0.3%
Percent Total Network with Microsurfacing	3.1%	6.9%
Average Microsurfacing Approximate Annual Volume	$3.0 million	$4.0 million*
High Reported	$12.0 million	$10.0 million*
Low Reported	$0.5 million	$0.06 million*
Average Microsurfacing Annual Program Size	60 miles (96.6 km)	57 miles (92 km)
High Reported	150 miles (241.4 km)	124 miles (200 km)
Low Reported	12 miles (19.3 km)	10 miles (16 km)
Agencies with Microsurfacing Installed by In-house Crews	1	2
Agencies with Microsurfacing Installed by Contractor Crews	30	6

*These are Canadian dollars, which at the time of this writing is trading at roughly par to the U.S. dollar.

Service Life

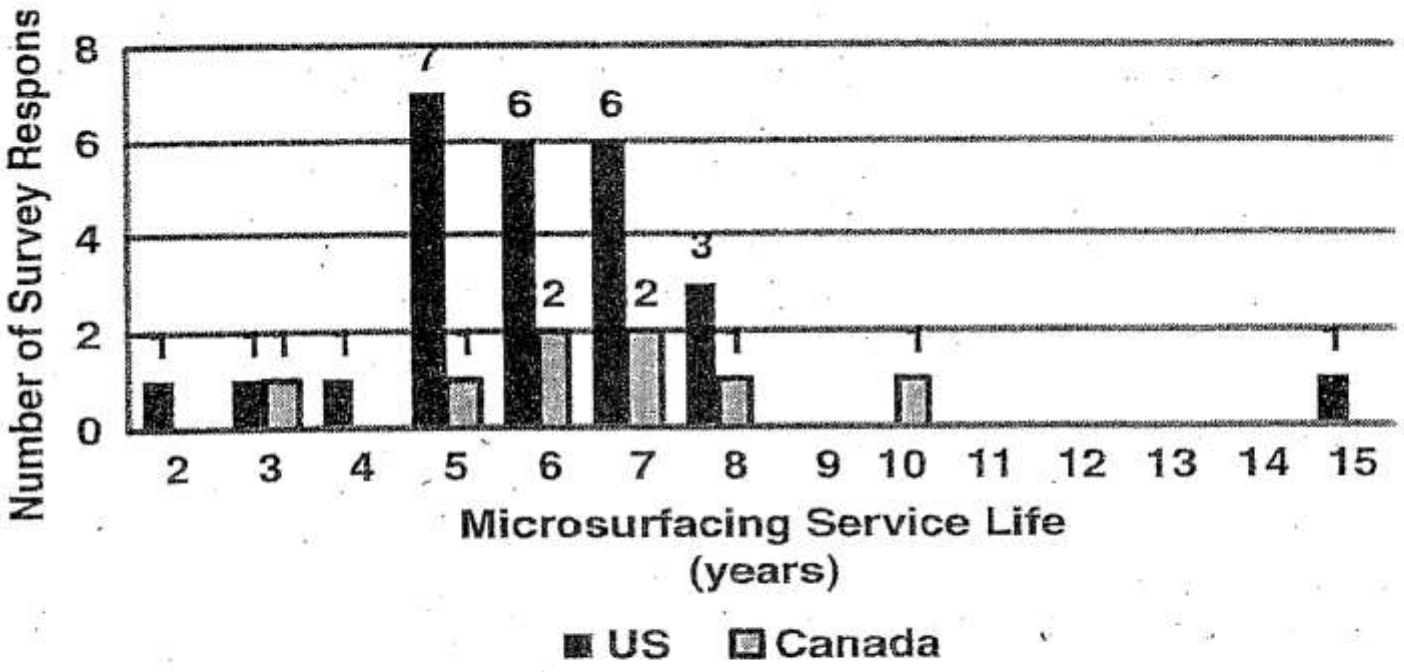


FIGURE 5 Summary of survey microsurfacing service life responses.

CHAPTER THREE, DESIGN PRACTICES

- Identify /characterize roads where micro surfacing treatment is appropriate
- Select materials
- Develop a JMF
- Laboratory testing or Mix Design
- Develop application rates
- Prepare construction documents

Microsurfacing Selection Criteria

TABLE 9
PROJECT PLANNING AND SELECTION CRITERIA SUMMARY

G =Good; F = Fair; P = Poor; N = Not			Pavement Condition									Parameters								Desired Benefits				
M = Microsurfacing (general); MII = Microsurfacing (Type II); MIII = Microsurfacing (Type III); S = Slurry Seal			Surface Condition				Rutting		Cracking			Traffic Volumes			Maintenance issues			Type						
Source	Reference	Type	Friction	Ravaling	Oxidation	Bleeding	< 1/2"	>1/2"	Alligator	Longitudinal	Transverse	ADT<3K	ADT = 3K to 5K	ADT >5K	Cool Temps	Stopping Points	Snow plow use	Urban	Rural	Early Opening to Traffic	Multiple Lifts Needed	Night-time Work	Minimize User Delay Costs	Expected service life
Caltrans	Hicks et al 2000	MII	-	F	G	N	G	N	N	N	N	G	G	G	F	G	F	G	G	G	G	F	G	3 TO 4
		MIII	-	G	G	N	G	G	P	N	N	G	G	G	F	G	F	G	G	N	N	F	F	3 TO 4
Ohio DOT	Hicks et al 2000	M	G	G	G	-	G	G	N	N	N	G	G	-	-	-	-	-	-	-	-	-	-	3 TO 8
Oregon DOT	Hunt 1991	S	-	G	G	-	N	N	P	N	N													
Asphalt Inst	AI 1983	S	-	G	-	-	-	-	F	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-
Iowa DOT	Jahren et al 1999	M	G	G	-	G	G	G	N	N	N	G	G	G	-	-	G	-	-	-	-	-	-	-
		S	F	G	-	G	G	G	N	N	N	G	P	N	-	-	F	-	-	-	-	-	-	-
Wisconsin DOT	Shober 1997	M	G	G	G	G	G	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2 TO 6
New York State DOT	NYSDOT 1999	M	-	F	-	-	G	G	P	P	P	G	G	G	-	-	-	-	-	-	-	-	-	-
		S	-	P	-	-	P	P	P	P	P	G	N	N	-	-	-	-	-	-	-	-	-	-
USACE	ASTM 1998	M	G	G	G	-	F	F	P	F	F	-	-	-	-	-	-	-	-	-	-	-	-	-
		S	G	F	F	-	-	-	P	P	P	-	-	-	-	-	-	-	-	-	-	-	-	-
Asphalt Contractor	Mouthrop et al 1999	M	G	G	G	G	G	G	F	G	G	G	G	G	-	-	G	G	G	G	G	-	G	-
		S	G	G	N	G	F	N	N	P	F	G	G	G	-	-	G	G	N	N	N	-	N	-
FHWA	FHWA 2007	MII	-	G	G	G	G	G	N	N	N	G	G	G	G	G	-	-	-	-	-	G	-	7 TO 10
		MIII	-	G	G	G	G	G	N	N	N	N	G	G	G	G	-	-	-	-	-	G	-	7 TO 10
FLHD	FLHD 2009	M	-	-	-	-	G	G	-	-	-	G	G	G	G	-	-	G	G	G	G	G	G	-
		S	-	-	-	-	N	N	-	-	-	G	N	N	-	-	-	N	G	N	N	-	-	-
Austroads	Austroads 2003	M	G	-	-	-	G	G	P	P	P	G	G	G	-	-	-	F	G	G	G	-	G	-
		S	F	-	-	-	F	N	N	N	N	F	N	N	-	-	-	G	N	-	-	-	-	-
Indiana DOT	Labi et al 2007	M	-	G	G	G	G	G	F	F	F	G	G	F	-	-	-	G	F	-	-	-	-	5 TO 6
Texas DOT	Smith and Beatty 1999	M	G	-	G	F	G	G	F	F	F	G	G	G	-	G	-	G	G	G	G	-	-	7 TO 10
Caltrans	Olsen 2006	M	G	-	G	G	G	G	F	F	F	G	G	G	G	G	-	G	G	G	G	G	G	5 TO 7
		S	G	-	F	F	-	-	P	P	P	G	G	G	N	-	-	G	-	N	N	N	P	5 TO 7
Iowa DOT	Jahren & Behling 2004	M	G	F	G	G	G	G	F	P	P	-	-	-	-	-	P	-	-	-	-	-	-	-

AI = Asphalt Institute.

Best Use of Microsurfacing

TABLE 10
QUANTIFIED OUTPUT FOR MICROSURFACING ONLY FROM TABLE 9

	Pavement Condition				Rutting		Cracking			Traffic Volumes			Maintenance Issues			Type		Desired Benefits			
Recommendation	Friction	Raveling	Oxidation	Bleeding	< 1/2"	>1/2"	Alligator	Longitudinal	Transverse	ADT<3K	ADT = 3K to 5K	ADT >5K	Cool Temps	Stopping Points	Snow plow use	Urban	Rural	Early Opening to Traffic	Multiple Lifts Needed	Night-time Work	Minimize User Delay Costs
Good	9	9	12	8	15	14	0	1	1	12	13	11	4	6	2	7	7	6	6	4	5
Fair	0	3	0	1	1	1	5	4	4	0	0	1	2	0	2	1	1	0	0	2	1
Sum1	9	12	12	9	16	15	5	5	5	12	13	12	6	6	4	8	8	6	6	6	6
Poor	0	0	0	0	0	0	4	3	3	0	0	0	0	0	1	0	0	0	0	0	0
Not	0	0	0	2	0	1	5	6	6	1	0	0	0	0	0	0	0	1	1	0	0
Sum2	0	0	0	2	0	1	9	9	9	1	0	0	0	6	1	0	0	1	1	0	0
Net	9	12	12	7	16	14	-4	-4	-4	11	13	12	6	6	3	8	8	5	5	6	6

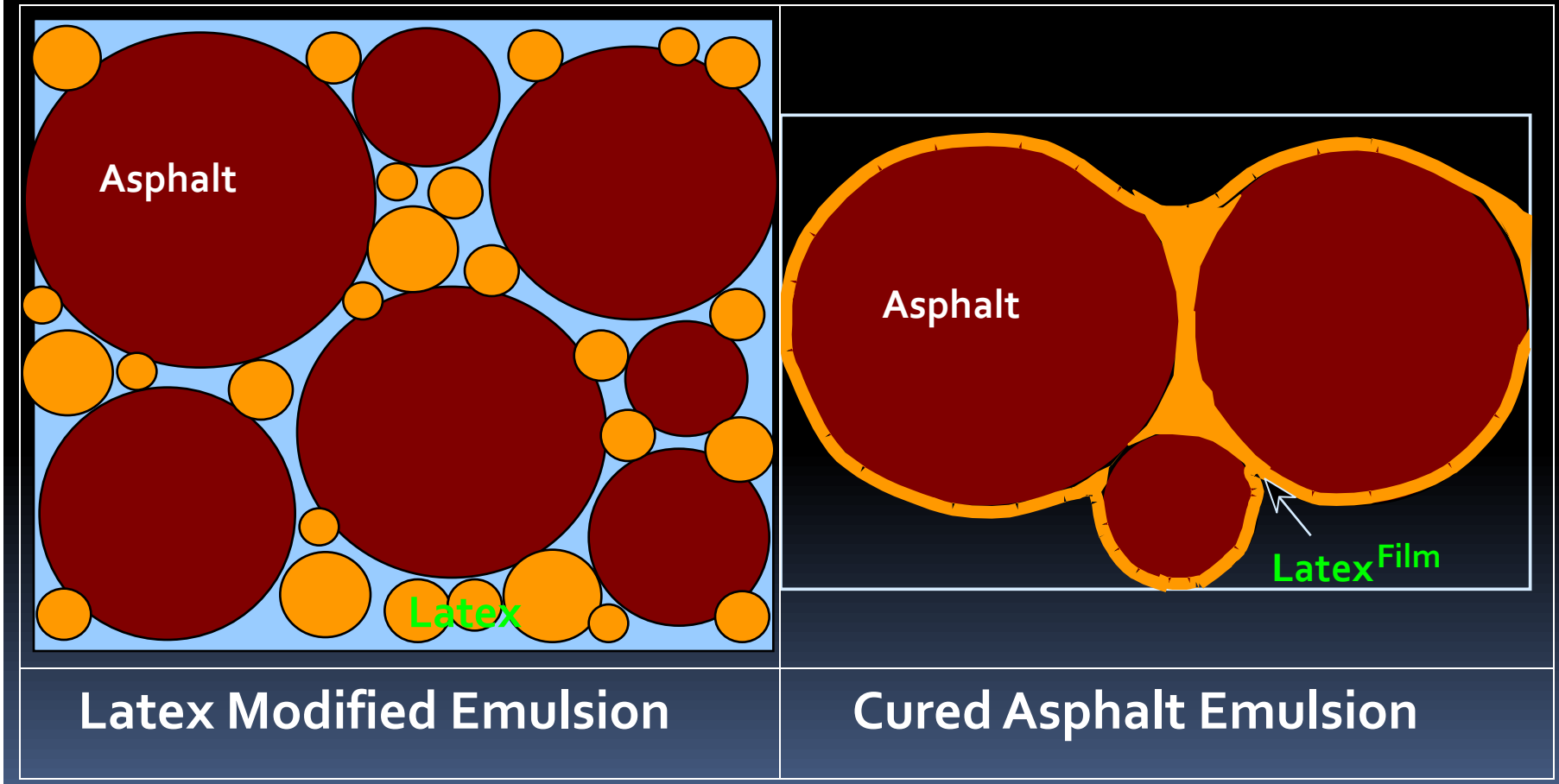
Micro surfacing Performance Ratings

Performance Rating	Excellent	Good	Fair	Poor	Very Poor
US	1	20	4	0	0
Canada	1	7	0	0	0

Mix Design Responsibility

Entity Develops Mix Design	Number of Responses US of 28	Number of Responses Canada of 8
Agency in house design	2	1
Agency in house maintenance group	2	0
Agency in house materials lab	1	1
Micro surfacing Contractor	21	6
Independent lab for contractor under the contract	1	0
Do not know	0	0

SBR Latex Emulsion Modification



Aggregate Gradation/JMF Target

Sieve Size	Type III Percentage Passing	Stockpile Tolerance
3/8 inch	100	
#4	70-90	+/- 5%
#8	45-70	+/- 5%
#16	28-50	+/- 5%
#30	19-34	+/- 5%
#50	12-25	+/- 4%
#100	7-18	+/- 3%
#200	5-15	+/- 2%

Table 5

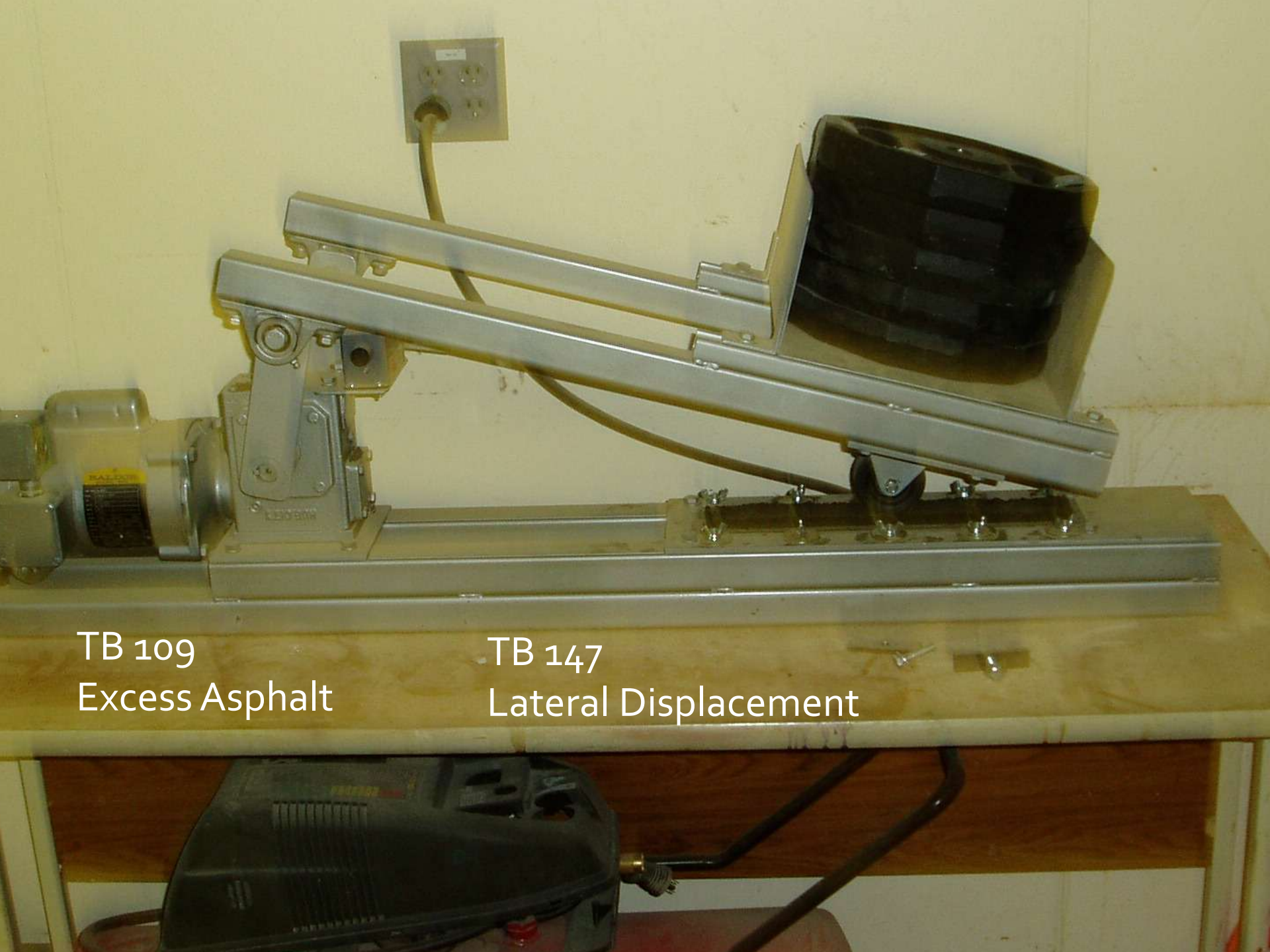
ISSA Specifications

ISSA TEST NO.	DESCRIPTION	SPECIFICATION
ISSA TB-139	Wet Cohesion @ 30 Minutes Minimum (Set) @ 60 Minutes Minimum (Traffic)	12 kg-cm Minimum 20 kg-cm Minimum or Near Spin
ISSA TB-109	Excess Asphalt by LWT Sand Abrasion	50 g/ft^2 Maximum (538 g/m^2 Maximum)*
ISSA TB-114	Wet Stripping	Pass (90% Minimum)
*ISSA TB-100	Wet-Track Abrasion Loss One-hour Soak Six-day Soak	50 g/ft^2 (538 g/m^2) Maximum 75 g/ft^2 (807 g/m^2) Maximum
ISSA TB-147	Lateral Displacement	5% Maximum
ISSA TB-144	Classification Compatibility	11 Grade Points Minimum (AAA, BAA)
ISSA TB-113	Mix Time @ 77° F (25° C)	Controllable to 120 Seconds Minimum


EMERGENCY
EYEWASH
PULL


TB 100
W.T.A.T.


TB 139
Cohesion Test


TB 109
Excess Asphalt
TB 147
Lateral Displacement


TB 144
Classification Compatibility

CHAPTER FOUR, CONTRACTING PROCEDURES

- Contracting Types
- Micro surfacing Programs and their Impact on Competition
- Training and Certification Programs for Contractors and Inspectors
- Warranties
- Micro surfacing Contract Provisions

Contracting Types

- LOW BID; required by state and local legislation
- Unit Price
- IDIQ; Pre priced without knowledge of exact location or quantities

TABLE 22
SUMMARY OF SURVEY GENERAL CONTRACTING INFORMATION

Question	U.S.	Canada	Total
Change in Annual Microsurfacing Program Volume?			
Virtually the Same Amount	5	3	8
Fluctuates ±20% Each Year	6	1	7
Fluctuates ±50% Each Year	1	1	2
Rarely Know How Much Each Year	9	1	10
No Knowledge	7	2	9
Typical Number of Bidders?			
1 to 3	25	7	32
4 to 6	2	1	3
7 to 9	1	0	1
Adequate Number of Qualified Bidders?			
Yes	12	2	14
No	14	6	20
No Opinion	2	0	2
Prequalified List of Eligible Bidders?			
Yes	11	0	11
No	14	8	22
Do Not Know	3	0	3
Required Training/Certification of Contractor Personnel?			
Yes	1	1	2
No	19	7	26
Do Not Know	8	0	8
Required Training/Certification of Agency Personnel?			
Yes	5	1	6
No	20	6	26
Do Not Know	3	1	4

TABLE 23
SUMMARY OF WARRANTIES REPORTED IN THE SURVEY

Agency (state or province)	Warranty Length	Nature of Microsurfacing Warranty	Microsurfacing Performance Rating from Survey
Indiana	3 years	Friction, raveling, rutting	Fair
Louisiana	1 year	Materials and workmanship	Good
New Hampshire	1 year	Surface defects	Excellent
Nevada	2 years	Standard construction warranty	Good
New York	1 year	Delamination, snowplow damage, flushing, and raveling > 2.0 SY	Good
Ohio	2 years	See Table 24 for details	Good
Oklahoma	1 year	Standard construction warranty	Fair
Texas	2 years	Rutting, flushing, and raveling	Fair
Alberta	1 year	Adhesion (raveling)	Good
British Columbia	1 year	Standard construction warranty	Good
Manitoba	2 years	Performance specification includes warranty provision	Excellent
Nova Scotia	2 years	Standard construction warranty	Good
Ontario	2 years	Flushing, raveling	Good
Quebec	1 year	Standard construction warranty	Good
Saskatchewan	1 year	Standard construction warranty	Good

TABLE 24
SUMMARY OF OHIO DOT MICROSURFACING WARRANTY SPECIFICATION

Distress Type	Threshold Level (per 500 SF of surface area)	Description
Bleeding/ Flushing	300 SF (28 SM)	Excess asphalt binder that creates a shiny, reflective condition that becomes tacky to the touch at higher temperatures.
Surface Loss	120 SF (11 SM)	Loss of surface interlock by traffic wear, debonding, or delamination.
Raveling	300 SF (28 SM)	"Moderate" level raveling as defined in the Strategic Highway Research Program (SHRP) "Distress Identification Manual for the Long-Term Pavement Performance Project" (SHRP-P-338).
Rutting	0.25 in. (6.5 mm) continuous in any segment	Measure the wheel path with a 4 ft (1.2 m) straight edge. Only applies during the first 120 days after the Form C-85 is issued.
Maintenance Bond	2 years	75% of the amount bid for the microsurfacing pay item.

Source: Ohio DOT (2008).

Why Warranties ?

- QA/QC Transferred to Contractors
- Agency Staff Reduction
- National Initiative from Method Specifications to Performance Specifications

Micro surfacing Contract Provisions

- Seasonal Considerations; Temperature Specifications, Air and Surface
- Contract Payment Provisions;

  Area or Weight?

  Method or Performance Specification?
- Incentive / Disincentive and Quality Price Adjustment Clauses

Pay Item Unit of Measure

TABLE 26
SUMMARY OF MICROSURFACING UNITS OF MEASURE AND THEIR RATIONALE

Pay Item Unit of Measure	Reduces the Cost		Fairest to the Contractor		Easier to Accurately Estimate		Do Not Know Why We Use Them	
Binder	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Units of Area (SY/SM)	1	0	3	2	4	3	3	0
Units of Weight (ton/tonne/MG)	2	0	4	0	4	2	2	0
Aggregate	U.S.	Canada	U.S.	Canada	U.S.	Canada	U.S.	Canada
Units of Area (SY/SM)	2	0	2	1	4	4	3	0
Units of Weight (ton/tonne/MG)	1	0	7	0	7	2	1	0

CHAPTER FIVE, CONSTRUCTION PRACTICES

- Surface Preparation; clean , pavement marking removal, crack seal, asphalt patching, tack coat.
- Types of Applications

  Full Lane Width Surface Course

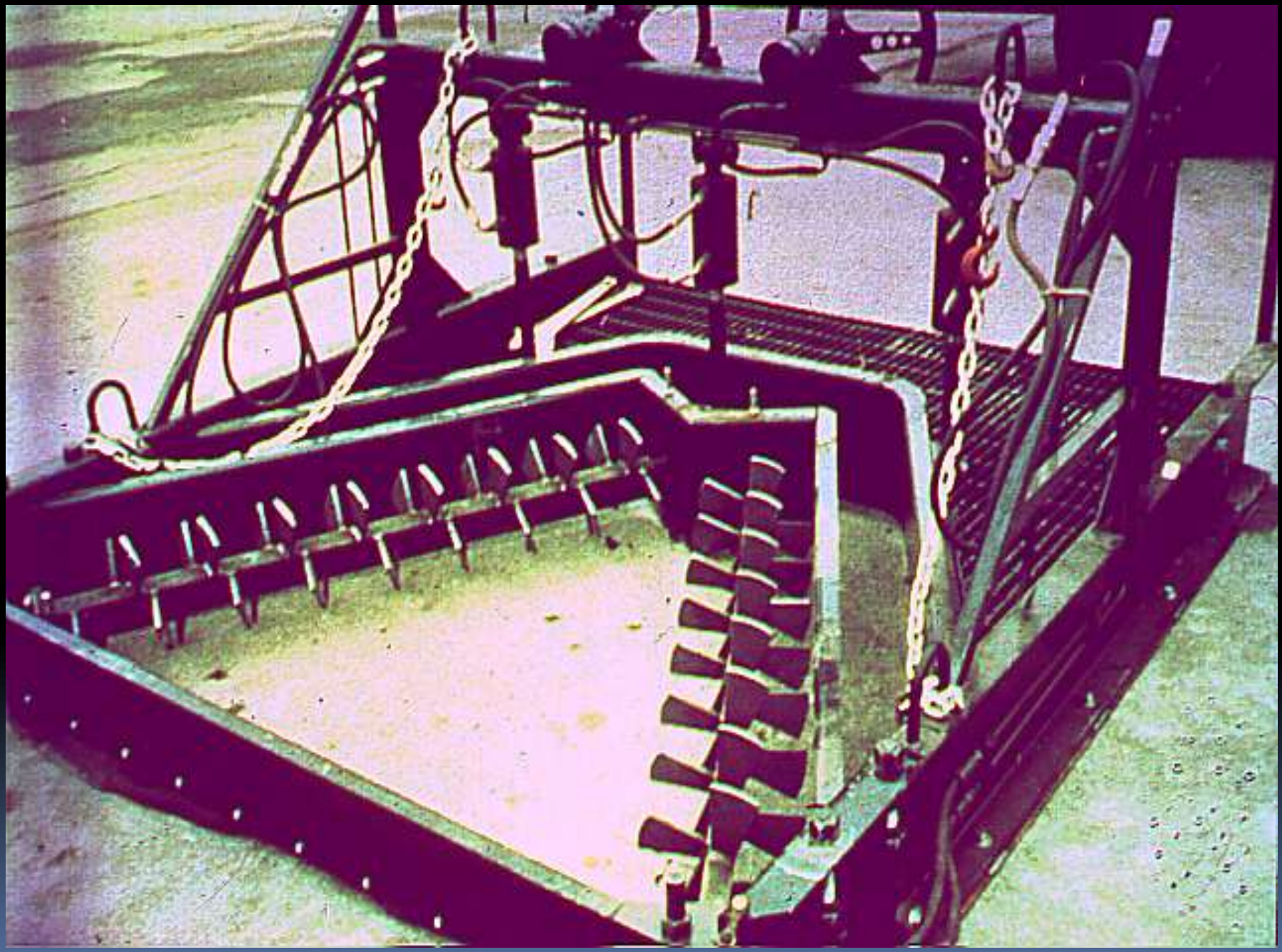
  Scratch Coat

  Rut Filling

Asphalt Preparation

Rut fill Application

- Over ½ inch
- Use multiple applications when rut depth is greater than 1 inch
- Rut filling box
- Traffic after each application
- Over crown 1/8 to 1/4 inch
- Requires surface course



REPROFILING RUTTED WHEELPATHS WITH MICRO-SURFACING

For each inch of applied micro-surface mix
add 1/8" to 1/4" crown to each rutfill
to compensate for return traffic compaction.

Original Pavement Cross Section

Ruts in Wheelpaths

RUTS 1/2" & OVER MUST USE THE RUT BOX

Scratch Course

- Less than ½ inch
- Steel screed
- Requires surface course
- 10 - 20 lbs./yd^2

RUTS LESS THAN 1/2"
MAY BE FILLED WITH SCRATCH COURSE.

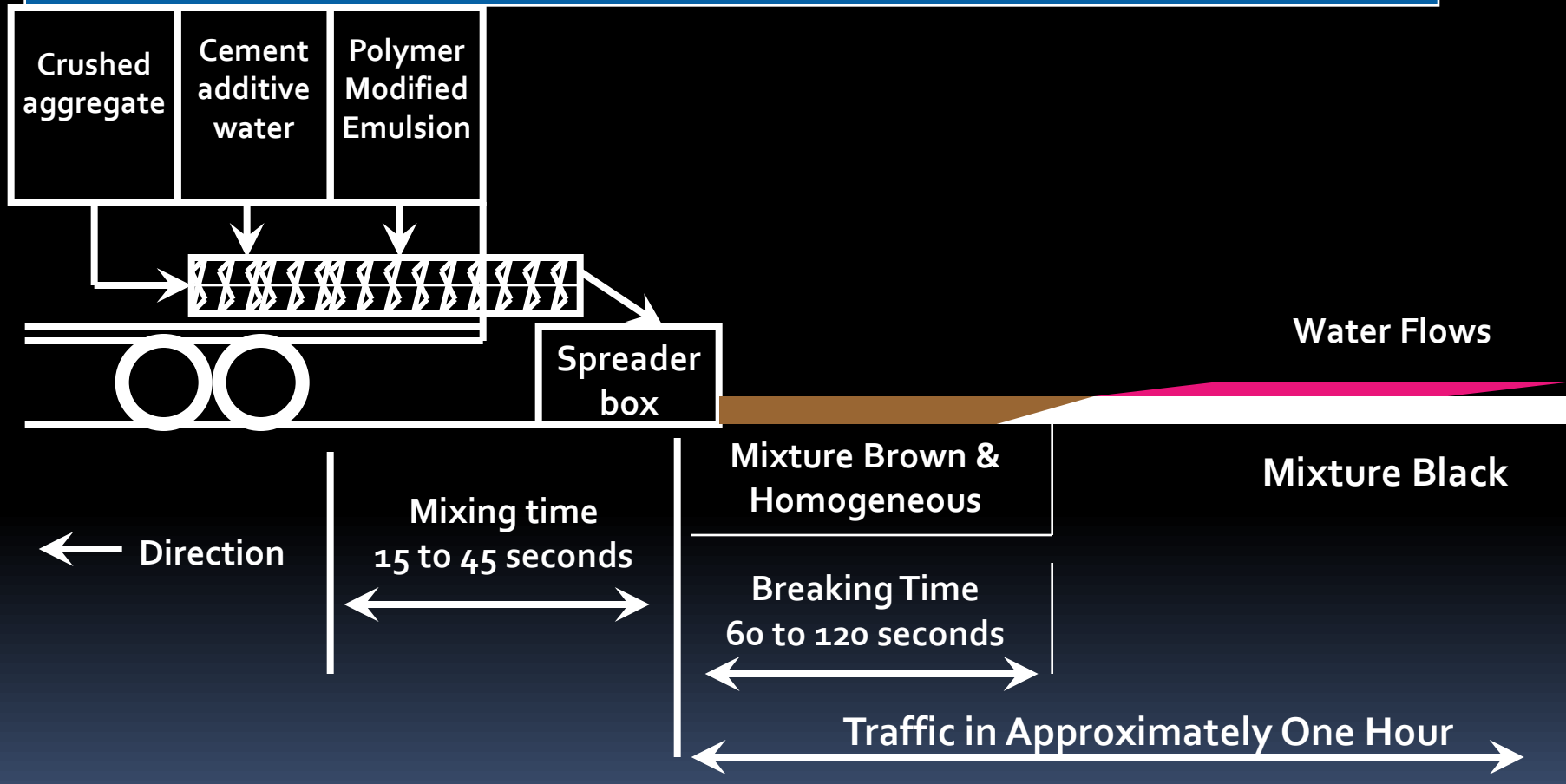
THE SCRATCH COAT IS GENERALLY
6" LESS THAN THE WIDTH OF THE LANE.


BERGKAMP
MIX PAVERS
04/28/2009

CHAPTER SIX, MICROSURFACING EQUIPMENT PRACTICES

- Continuous Mixing Machines
- Truck Mounted Mixing Machines
- Calibration of Mixing Machines
- Test Strips
- Rolling

Micro-Surfacing Application




WATER
EMULSION

What is calibration?

- Process of measuring by weight
  - Actual output of:
  - Aggregate
  - Emulsion
  - Fines (dependent on machine make)
- Correlated to revolutions of the aggregate belt
- Recorded by a counter


08.29.2007 11:21


Intermountain
Slurry Seal
08.29.2007 11:44

Why do we calibrate?

- Allow the machine to be set such that the ratios of aggregate, emulsion and fines stay fixed at a predetermined level.
- Ensure quality control of the system for the contractor and buying agency

CHAPTER SEVEN, QC/QA and PERFORMANCE MEASURES

- Quality Management

  Manage Design

  Manage Construction

TABLE 33
SURVEY RESULTS ON FIELD QC/QA PRACTICES

Quality Management System	U.S.	Canada	Specification Content Analysis
Inspection Responsibility?			
Agency	28	6	18
Consultant	0	1	0
Contractor	0	1	0
Use of Independent Lab to Verify Job Mix Formula?			
Yes	3	0	0
No	21	8	18
Do not know	4	0	0
Field Sampling/Testing?			
Yes	20	5	10
No	5	3	8
Do not know	3	0	0
Field Testing Responsibility			
Agency	15	3	15
Consultant	5	0	0
Contractor	0	2	0
Not specified	0	0	3
Source of Field Acceptance Tests?			
Source/pit	2	2	10
Stockpile	15	4	6
While transferring to nurse units	1	0	0
Before entering the mixing machine	1	1	0
Do not know/not specified	3	1	4

TABLE 37
IMPACT OF PROJECT FACTORS ON MICROSURFACING QUALITY

Rated Impact (1 = highest rated factor)	U.S. Ranking	Canadian Ranking
Contractor Experience	1	2
Selecting the Right Project	2	1
Construction Procedure	3	3
Preconstruction Road Preparation	4	7
Better Aggregates	5	5
Better Binder	6	6
Design Method	7	4
QC/QA Program	8	8

TABLE 39
PUBLIC COMPLAINT SUMMARY

Public Complaints	U.S.	Canada	Total
No Complaints	5	3	8
Road Noise	8	1	9
Appearance	5	3	8
Loose Stone	1	1	2
Vehicle Ride	1	0	1
Do Not Know	8	0	8

TABLE 38
REASONS FOR MICROSURFACING FAILURE

Cause of Failure	U.S.	Canada	Total
Improper application rate	5	5	10
Dirty or dusty aggregate/gradation issues	4	4	8
Wrong road—poor project selection	6	2	8
Improper ambient and/or surface temperatures	3	3	6
Improper binder viscosity	3	3	6
Improper binder temperature	3	3	6
Improper surface preparation	3	2	5
Weather	2	2	4
Field construction procedures	1	0	1
Snow plow damage	1	0	1

TABLE 40
SUMMARY OF SERVICE LIFE FACTORS

Service Life Factors	U.S.	Canada	Total
Underlying Pavement Structure	14	6	20
Original Substrate Surface Quality	12	4	16
Traffic Volume	5	0	5
Cold Climate Considerations (freeze/thaw cycles, snowplowing, etc.)	5	2	7
Maintenance Funding	2	1	3
Friction Loss	3	0	3
Construction Quality	0	1	1
Do Not Know	2	0	2

CHAPTER EIGHT, CASE STUDIES

TABLE 41
CASE STUDY PROGRAM SUMMARY

Case Study	Agency/Location	Reason for Inclusion	Remarks
Microsurfacing as a pavement preservation treatment	Maine DOT Caribou, Maine	Specific use for pavement preservation; long-term performance in an area with heavy snowplowing	Demonstrates microsurfacing performance in cold, snowy climate; answers concerns that it is not appropriate on roads with heavy snowplowing
Use of microsurfacing as a preventive maintenance treatment to improve safety	York Region Ontario, Canada	Focus on safety; specific use for preventive maintenance	Demonstrates a use for microsurfacing that does not focus on pavement distress
Long-term comparative performance of microsurfacing on asphalt and concrete pavements	Oklahoma DOT Tulsa and Oklahoma City, Oklahoma	Used for filling deep ruts and treating alligator cracking on high-volume interstate; 9-year record	Very comprehensive look at the treatment in a variety of situations
Microsurfacing on a high traffic-interstate highway	Georgia DOT Atlanta, Georgia	Heavy urban traffic volume; road noise evaluation	Agency survey response indicated they do not use microsurfacing
Microsurfacing on Jointed plain concrete pavement	Kansas DOT Cowley County, Kansas	Evaluation of ride quality improvement; use of microsurfacing on a concrete surface	Ride quality is of prime importance on concrete pavements; comparison is with a hot-mix overlay
Microsurfacing using a softer binder	Minnesota DOT Albertville, Minnesota	Evaluation of cracking and rut filling performance	Provides an alternative for situations where cracking is the primary issue

CHAPTER NINE, CONCLUSIONS

- Microsurfacing is best suited to address rutting, raveling, oxidation, bleeding, and loss of surface friction. Microsurfacing is not appropriate for structurally deficient pavements. This makes project selection the most important step in the microsurfacing design process with regard to impact on the final performance of the microsurfacing itself.
- Microsurfacing can be expected to provide an average service life of 7 years if the underlying road is in good condition.

- Microsurfacing is a pavement preservation and maintenance tool with very few technical or operational limitations.
  - Microsurfacing was shown to be effective for all levels of traffic, as well as useful in both urban and rural settings.
  - Microsurfacing was shown to be effective on both asphalt and concrete pavements.
  - Microsurfacing can be effectively used in locations where the work is to be done at night or in cool weather, as well as where stresses resulting from stopping and snow plowing are present.

- Most agencies do not prequalify microsurfacing bidders. This may be because the pool of competent and qualified contractors is inherently shallow. Contractor experience was also cited as the most important microsurfacing quality factor. Therefore, the FHWA's Pavement Preservation Expert Task Group initiative to develop a certification program at the national level is needed.
- Requiring warranties for microsurfacing projects is not problematic because the contractor normally furnishes the job mix formula.

Pavement preservation success depends on identifying candidate roadways before they need reactive maintenance. The survey found very little information regarding trigger points for invoking microsurfacing to extend the underlying pavement's life and preserve its structural integrity. Thus, research is needed to determine measurable values of distress that can be used in an agency's pavement preservation program. Additionally, microsurfacing success demands that the road be structurally sound. Therefore, research may also include consolidating agency pavement management system trigger values and furnishing guidance as to appropriate microsurfacing timing.

Microsurfacing is one of the few pavement preservation and maintenance treatments that can restore the transverse geometry of a rutted road. Because U.S. agencies use it primarily as a surface course, they are not maximizing the potential benefits of microsurfacing when they do not use it as the primary tool to fill ruts as their Canadian counterparts do.

Public highway agencies in Australia and New Zealand have long been using performance contracting techniques to procure pavement maintenance and preservation services. These contracts are based on objective key performance measures such as skid number, pavement macrotexture, and other criteria. The suggested research would evaluate the current programs used in those and other countries, such as the United Kingdom, South Africa, Portugal, and Spain; and develop a set of key performance measures that could be used in microsurfacing projects being procured on a performance basis.

- The lack of rigorous field tests based on a rational quantification of measurable microsurfacing properties leads to a suggestion for research to develop a series of field tests that allow an inspector to test the microsurfacing mix after it has been laid, as well as tests to identify when the mix has cured to a sufficient degree to open it to traffic without fear of damaging it.

HIGH PERFORMANCE SLURRY SYSTEMS

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