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Rapid Overlays for Deck Preservation

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INTRODUCTION

- The number one cause of bridge deterioration is corrosion.
- In 2004 FHWA reported \$10.5 billion spent for repairs.
- Overlays have been used since the 60's to repair, protect and preserve bridge decks.
- Overlays are usually placed on bridge decks to reduce infiltration of water and chloride ions and improve skid resistance, ride quality, and surface appearance.



INTRODUCTION

- The construction of overlays has become increasingly difficult in recent years because of traffic congestion.
- Lanes can not be closed for extended periods because of traffic concerns.



Need for Rapid Overlays

- Contractors are often forced to work at night and on weekends and during cooler weather to accommodate traffic.
- Most of the conventional overlay materials can not be used under these conditions.
- Use of Rapid Overlays is increasing.



Rapid Overlays

- Epoxy: 2 layers of epoxy and broad casted aggregate used by VDOT since 1986
- LMC-VE: Latex-modified concrete prepared with a very early hardening cement used by VDOT since 1997.
- Rosphalt: Polymer-modified asphalt that has negligible permeability first used by VDOT in 2009.



Purpose of Presentation

- Compare the properties and performance of Epoxy, LMC-VE and Rosphalt overlays.
- The presentation covers the VDOT experience as follows:

Epoxy: 26 years

LMC-VE: 15 years

Rosphalt: 3 years



Results

- Construction
- Mixture proportions
- Overlay Properties
- Costs
- Conclusions
- Recommendations



Epoxy Overlays

Two layers of epoxy and broadcasted aggregate placed on a dry, shot blasted surface



Specification for Epoxy Concrete Overlay

VDOT SPECIAL PROVISION FOR EPOXY CONCRETE OVERLAY May 31, 2001

- Viscosity: 7 to 25 poises, ASTM D2393
- Pot life: 15 to 45 minutes, ASTM C881 at 75°F (50 ml sample in paper cup)
- Tensile Elongation: 30 to 70%, ASTM D638
- Minimum compressive Strength at 3 hrs: 1000 psi, ASTM C109
- Minimum Adhesion strength at 24 hrs.: 250 psi at 75°F, VTM-92, ASTM C1583



Specification for Aggregate

Clean, angular grained silica sand or basalt having less than 0.2% moisture having the following gradation:

Per cent by weight passing sieve

No. 4	No.8	No. 16	No. 30
100	30-75	Max. 5	Max. 1



Specification for Surface Preparation

Clean surface by shot blasting and other approved cleaning practices to remove asphalt, oils, dirt, rubber, curing compounds, paint, carbonation, laitance, weak surface mortar, and other detrimental materials that may interfere with the bonding or curing of the overlay.



Surface Preparation by Shot Blasting



Specification for Bond Strength, VTM 92, ASTM 1583

Prior to placing the first course, the Contractor shall determine the bridge deck cleaning method in accordance with VTM-92 to provide a tensile rupture strength greater than or equal to 250 psi or a failure area, at a depth of 1/4 inch or more into the base concrete, greater than 50% of the test area.



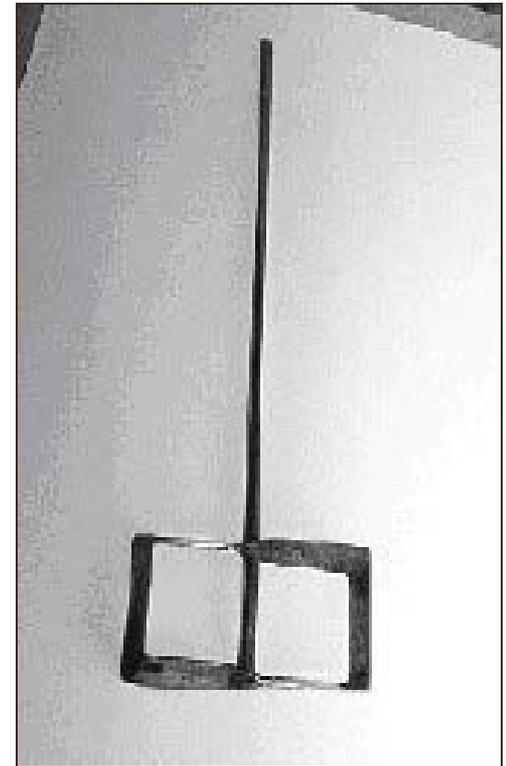
Overlay Tensile Adhesion Test

The cored overlay fails, red needle on load cell indicates failure load.



Mixing the Epoxy

Mixing must be complete so that 1 or 2 parts A and 1 part B make contact and cure properly.



**drywall mud
mixer**



Quality Control

50-ml gel sample is taken from each batch



Spreading Epoxy: two layers of epoxy & broadcasted aggregate 0.25-in thick



Broadcasting Aggregate



Epoxy Overlay in Mission Bay area of San Diego, epoxy and aggregate equipment in adjacent lane



Epoxy Overlay in NY LaGuardia Airport, center truck mixes epoxy, exterior trucks provide aggregate



AASHTO Specifications Washington, DC, 1995

GUIDE SPECIFICATIONS FOR POLYMER CONCRETE BRIDGE DECK OVERLAYS



**AASHTO-AGC-ARTBA
TASK FORCE 34**

Summary for Epoxy Overlays

- Low cost, light weight, deck protection and wearing surface
- Bond strength > 250 psi
- Skid number > 60
- Permeability : <100 coulombs, negligible
- Ready for traffic in 3 hours
- Service life of 15 to 25 years
- Guide specifications for Polymer Overlays, AASHTO, Washington, DC, 1995



LMC-VE Overlays

- Bonded hydraulic cement concrete overlay typically 1.25 to 2.5-in thick
- Similar to conventional LMC Overlays but Constructed with Night or Weekend Lane Closures and special cement



Construction of LMC-VE Overlays Using 8 Hour Lane Closures

- Patching phase
 - Close lane at 9 pm
 - Mill deck surface
 - Patch deck
 - Cure patches
 - Open lane at 5 am
- Overlay Phase
 - Close lane at 9 pm
 - Shot blast surface
 - Wet surface
 - Place overlay
 - Cure overlay 3 hours
 - Open lane at 5 am



Construction of LMC-VE Overlays Using Weekend Lane Closures

- Patching Phase
 - Close lane at 9 pm
 - Mill deck surface
 - Patch deck
 - Cure patches
 - Open lane at 5 am
(may be done during weekend closure)
- Overlay Phase
 - Close lane at 9 pm Friday
 - Shot blast surface
 - Wet surface
 - Place overlay
 - Cure overlay 3 – 24 hours
 - Open lane at 5 am Monday
(may open earlier)



LMC-VE Overlay Construction at Night, 1998



LMC-VE Overlay Curing



LMC, LMC-VE Concrete Specifications

Property	LMC	LMC-VE
Slump, inches	4 - 6	4 - 6
Air, Percent	3 - 7	3 - 7
Lab. Comp. Str. @ 2 hr, psi	-	≥ 2500
Field Comp. Str. @ traffic, psi	≥ 3500	≥ 2500
Lab. Comp. Str. @ 1 day, psi	-	≥ 3500
Lab. Comp. Str. @ 28 days, psi	≥ 3500	-
Lab. Perm. @ 28 days, coulombs	-	-



LMC-VE Cement Specifications

- Cement shall be approximately 1/3 calcium sulfoaluminate and 2/3 dicalcium silicate or other hydraulic cement that will provide a Latex-Modified Concrete that meets the physical requirements for LMC-VE as indicated in this special provision.



Typical Mixture Proportions, lb/yd³

Mixture	LMC	LMC-VE
Cement Type	I/II	VE
Cement	658	658
Fine aggregate	1571	1600
Coarse aggregate	1234	1168
Latex	205	205
Water (w/c \leq 0.40)	137	137
Air, per cent	3 to 7	3 to 7
Slump, in	4 to 6	4 to 6



Average Compressive Strength and Modulus, psi

Age	LMC	LMC-VE
3 hour	-	3660
1 day	1810	5570
7 day	5400	6470
28 day	5990	6980
28 day Modulus	3,290,000	3,140,000



Permeability to Chloride Ion, Coulombs

Age	LMC	LMC-VE
28 day	1500 - 2560	300 - 1400
1 year	200 - 2060	0 - 10
3 year	300 - 710	-
5 year	450 - 500	-
9 year	100 - 400	0 - 60



Drying Shrinkage

Length change (ASTM C157) of LMC-VE specimens at 170 days is approximately 0.02 percent as compared to 0.06 per cent for specimens of LMC.



Bond Strength, psi

Age	LMC	LMC-VE
1-6 months	114 - 260	153 - 276
3- 5 years	200 - 310	-
9-10 years	246 - 296	176 - 301

Test results are primarily for failures in the concrete deck below the bond interface.



LMC-VE Overlay on I64 Over Rivanna River, 2006



User Costs

- Road user cost calculations for I64 over Rivanna River for LMC-VE and LMC Overlay options were computed by Michael Fontaine of VTRC.
- Costs are based on the methodology described in the Texas Transportation Institute Urban Mobility Report (Schrank and Lomax, 2007, TTI).
- The report provides default values for time and vehicle occupancy.
- Assumptions include one of two lanes closed at Mile Marker 136, 16 % trucks, and maximum queue of 3.6 miles between 6 and 7 pm, 2006 dollars.



User Costs, I64 over Rivanna River

Option	LMC		LMC-VE		LMC-VE	
Closure	2 Weeks		2 Weekends +Mon		4 Weekends	
Days, \$	Days	Cost, \$	Days	Cost, \$	Days	Cost, \$
Weekday	10	648,730	2	129,746	0	0
Saturday	2	3,854	2	3,854	4	7,708
Sunday	2	2,656	2	2,656	4	5,312
Total	14	655,240	6	136,256	8	13,020
Savings	-	0	-	518,984	-	642,220

Construction cost= \$750,000 for 5,000 yd² overlay.



Summary for LMC-VE Overlays

- Low cost, deck protection & wearing surface
- Bond strength > 250 psi
- Skid number > 60
- Permeability : <1500 coulombs @ 28 days, low; negligible after a year
- Ready for traffic in 3 hours
- Service life of 25 to 30 years or more
- VDOT Special Provision for LMC-VE Overlays



Rosphalt Overlays

- Polymer modified asphalt overlay typically 1.25 to 2.5-in thick constructed with a Rosphalt admixture
- VDOT experience based on 2 bridges:
 - I 85 NBL (2009)
 - Rte 3 Norris Bridge Span 22 (2010)



I85 NBL (looking south) has saw cut and sealed joint in the Rosphalt between the abutment and the approach slab.



The underside of I85 NBL deck (looking south) is in good condition and free of leaking cracks and no full depth patching was done.



Rosphalt Overlay on the Norris Bridge looking eastbound towards White Stone

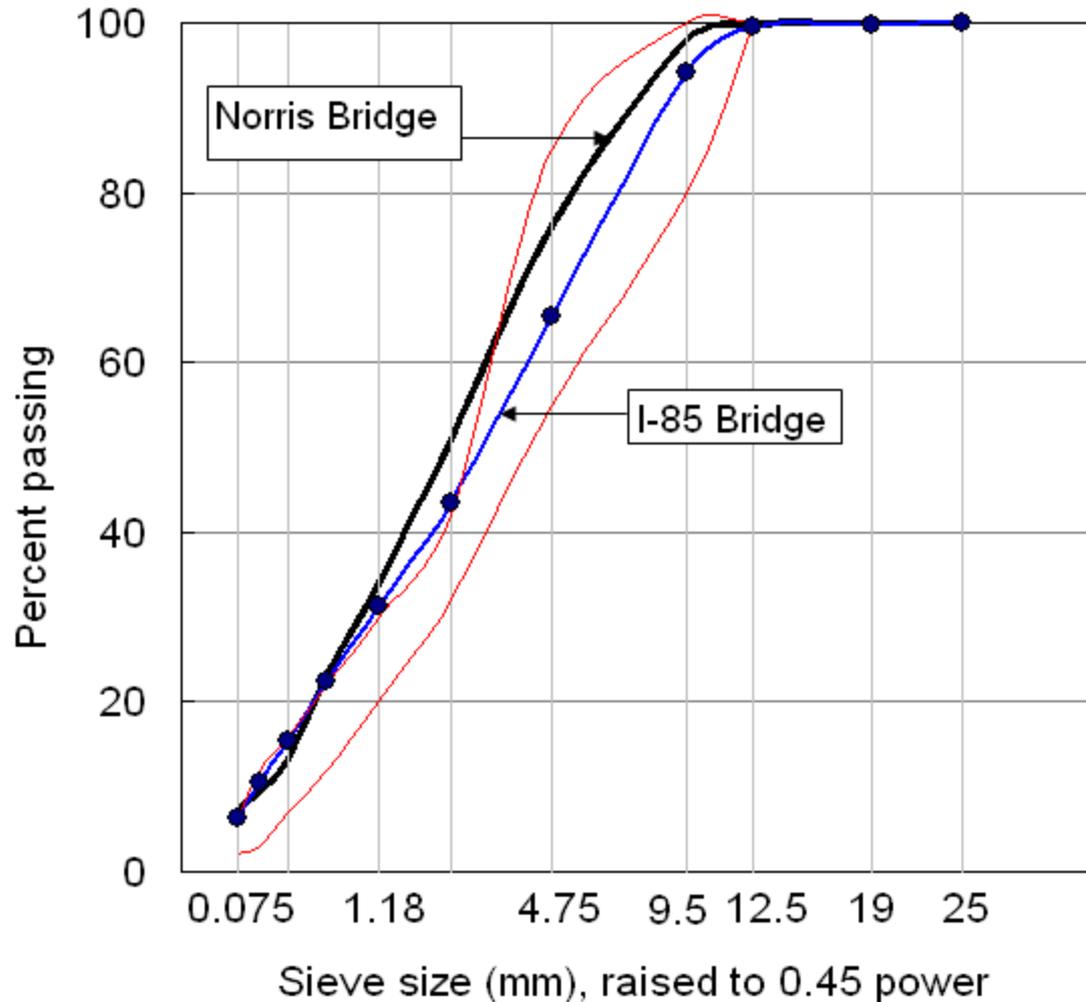


Specification for Rosphalt Overlays

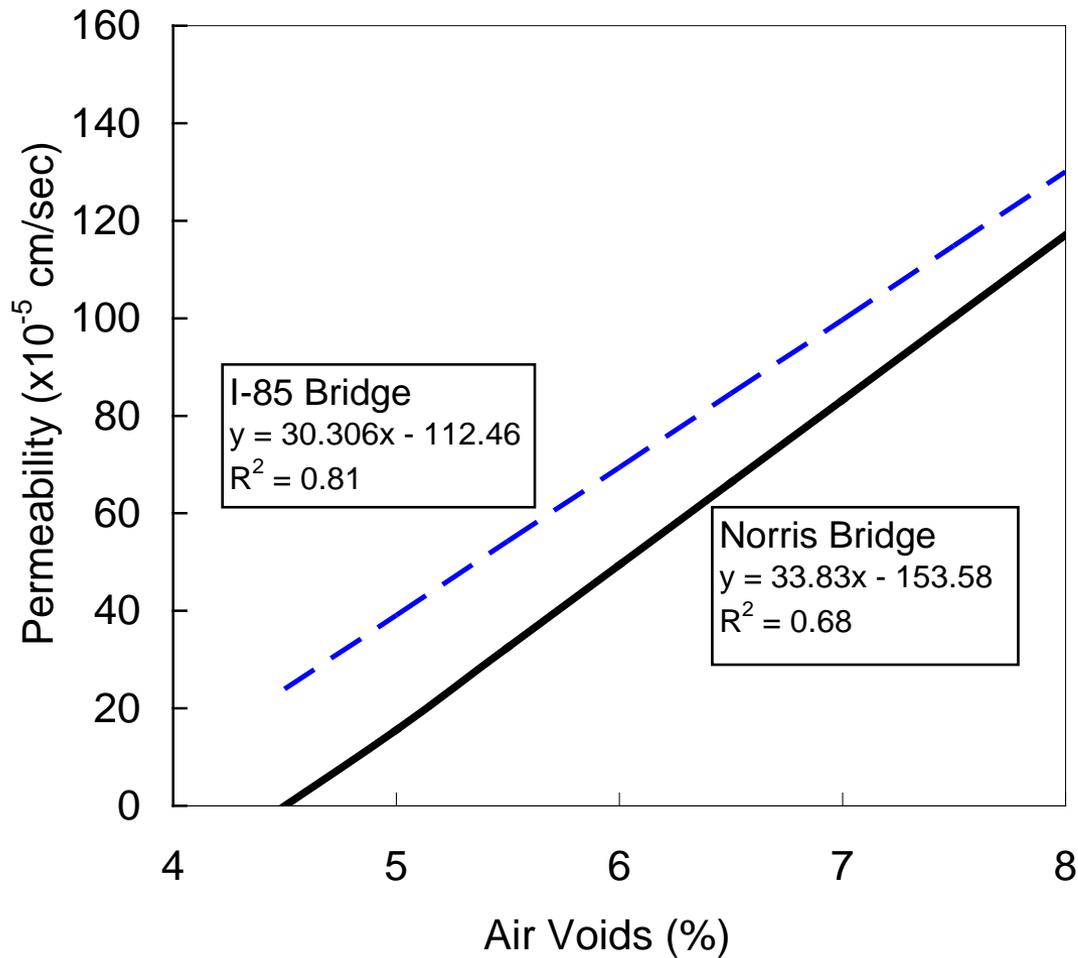
- Supplier has generic specification
- VDOT made minor revisions to specification
- Specification requirements for permeability, fatigue resistance and rutting resistance



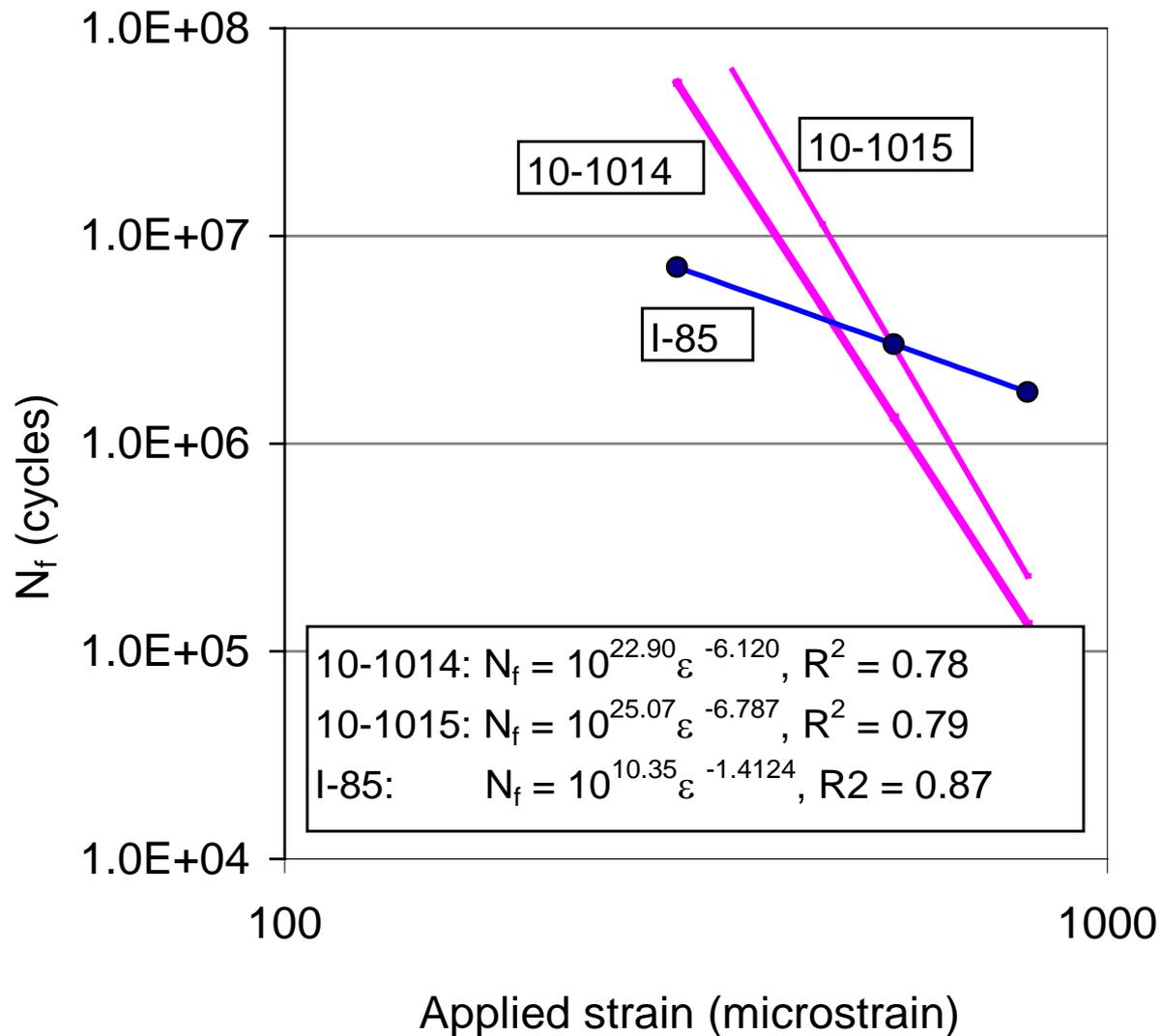
Gradation for Rosphalt mixtures: Norris Bridge mixtures appear finer than I-85 Bridge mixtures. JMF gradation requirement limits are shown with thin red lines.



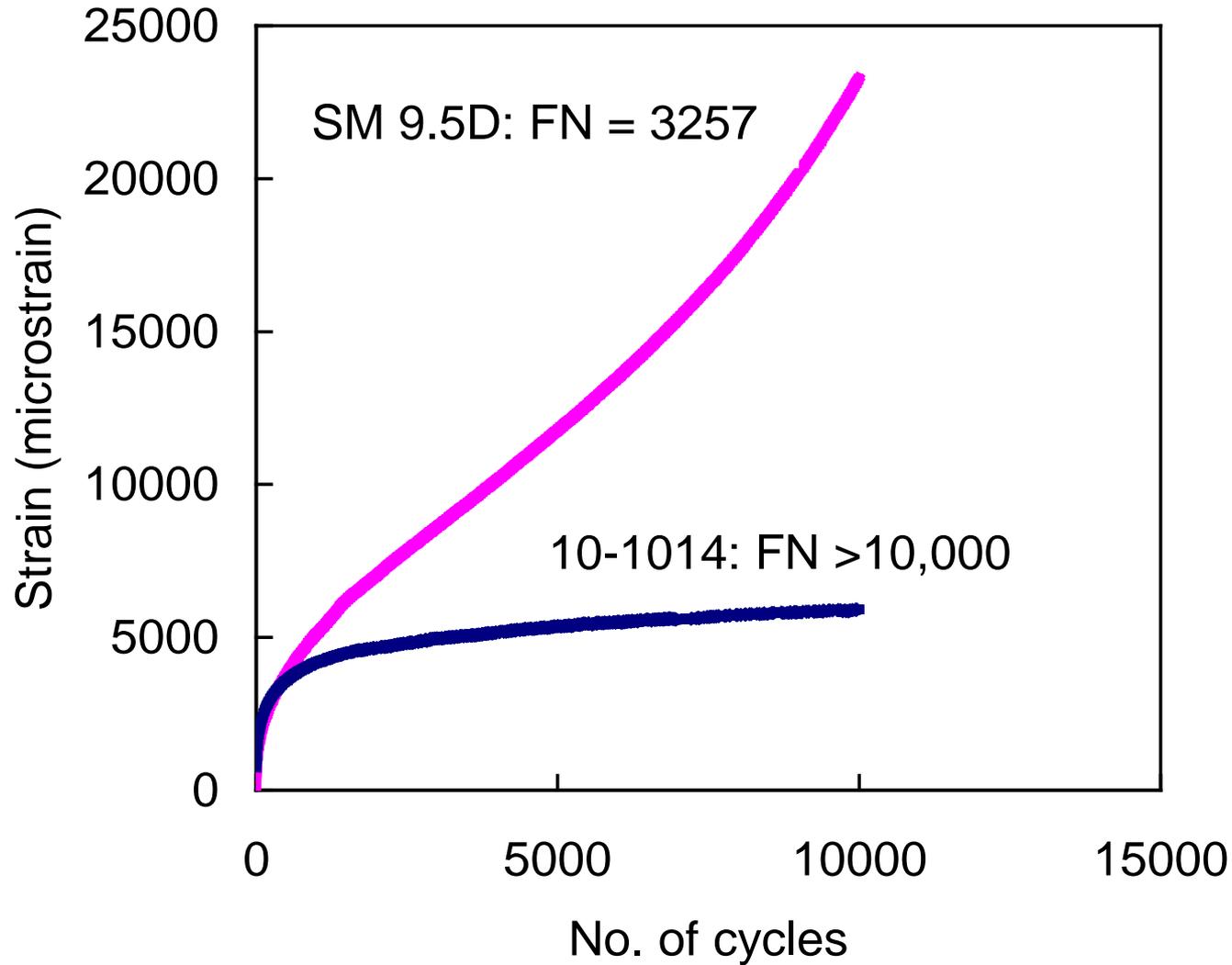
Permeability versus Air Voids for laboratory-compacted Rosphalt Mixtures



Fatigue curves for Rosphalt mixtures.



Rutting resistance of Rosphalt mixtures using FN test



Summary of Asphalt Mixture Properties

Bridge	I85 SBL	I85 NBL	Rte 3 EBL	Rte 3 WBL
Asphalt, per cent	-	7.5	9.5	8.5
Rut, FN (cycles) (AASHTO TP79)	-	-	>10,000	-
Fatigue, Endurance Limit (AASHTO T 321)	-	95	360	360
Perm x 10 ⁻⁵ cm/sec (VTM 120)	358*	416*	0**	0**
Voids, per cent	6.8	6.9	2.9	4.4
Density Cores	-	-	97.7%	97.4%
SN B Tire	44	41	29	38



Low Bid Cost of the Rosphalt Overlay

- I85 NBL: Rosphalt @ \$1125/ton = \$121/yd² (2-in thick) (Reduced payment for high permeability @ \$843.75/ton = \$90.75/yd²)
- Rte 3: Rosphalt @ \$2000/ton = \$218/yd² (2-in thick) (total project cost = \$490/yd²)
- Based on these costs Rosphalt is a very expensive method for placing a wearing and protection system on a bridge deck



Estimated total cost for Norris Bridge (overlay + miscellaneous + traffic control) using the indicated unit costs for the overlay systems were as follows:

- Rosphalt @ \$490/ton = \$6,335,260
- LMC-VE @ \$111/yd² (2 to 2.5-in) and \$126/yd² (3 to 3.5-in) = \$9,541,950
- The analysis also estimated user costs for the 2 options which were as follows: Rosphalt = \$30,580 and LMC-VE = \$68,170



Summary for Rosphalt Overlays

- Expensive deck protection & wearing surface
- Skid number ≥ 29
- Permeability : negligible when voids $< 4\%$
- Ready for traffic in approximately 3 hours
- Service life of 15 years or more based on literature
- VDOT and Manufacturer Special Provisions for Rosphalt Overlays



Comparative costs 2006-2010, \$/yd²

Overlay	Rosphalt	LMC-VE	Epoxy
Overlay	121 to 218	90	30
Misc.	32	32	16
Traffic	13	28	13
Total	166 to 263	150	59



CONCLUSIONS

- Epoxy, LMC-VE and Rosphalt overlays can be placed rapidly.
- Epoxy and Rosphalt overlays have negligible permeability initially and LMC-VE overlays have negligible permeability after a year.
- The specified low permeability for the Rosphalt on I85 was not achieved because the specified density was not achieved. Mixes must be used that can be compacted with static rollers.
- The Rosphalt on the Norris Bridge is more fatigue and rut resistant than typical SM-9.5 mixes and should last longer.



CONCLUSIONS Cont.

- Epoxy and LMC-VE overlays have high skid numbers.
- Epoxy and LMC-VE overlays are economical, particularly when user costs are considered. Rosphalt can be an economical alternative at \$590 per ton (2-in thick).
- Based on the first two projects in Virginia, Rosphalt is too expensive to be considered as a competitive overlay system.



RECOMMENDATIONS

- DOT s should continue to use epoxy and LMC-VE overlays to extend bridge deck life.
- DOTs should consider using Rosphalt overlays when reasonable prices can be obtained.



References

1. Sprinkel, M. M., 1999, “Very-Early-Strength Latex-Modified Concrete Overlay,” Transportation Research Record, Transportation Research Board, Washington, D.C.
2. Sprinkel et. al, 1993, *Rapid Concrete Bridge Deck Protection, Repair, and Rehabilitation*, SHRP-S-344, Washington D.C.
3. Sprinkel, M. M. and A. K. Apeageyi, 2011, Evaluation of the Instalation and Initial Condition of Rosphalt Overlays on Bridge Decks, VCTIR, Charlottesville, Virginia (in Publication).





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QUESTIONS ?

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