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Technical Report 03-1

Bridge Deck Resurfacing using Rosphalt 50

Interim Report - First Year, December 2004

Transportation Research Division

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Introduction

Most bridge decks in Maine are comprised of Reinforced Portland Cement Concrete (RPCC). Although a durable product, RPCC is permeable and susceptible to chloride penetration leading to corrosion of the steel reinforcement and eventual cracking of the bridge deck.

To delay this from occurring, the deck surface is sealed with latex modified Portland Cement Concrete (PCC) wearing course or a combination of waterproofing membrane and Hot Mix Asphalt (HMA). Each surface treatment has a life expectancy of 15 to 25 years. The latex modified PCC is still vulnerable to chloride penetration but at a much lower rate. The membrane/HMA treatment protects as long as the membrane is intact.

Rosphalt 50 is another product that has been used since 1983 to seal bridge decks. This is a proprietary asphalt additive developed by Royston Laboratories a Division of Chase Corporation in Pittsburgh, PA. It consists of concentrated thermoplastic virgin polymeric materials that, when added to HMA during the mixing process, combines with the asphalt to create an asphalt paving product that seals the RPCC deck and provides a wearing course in one application. Independent Chloride Ion Penetration tests have shown that only negligible chloride ions were transmitted through Rosphalt 50. Additional tests of Rosphalt 50 show that it meets Superpave binder criteria at temperatures of 94˚C to -34˚C. Royston claims the product displays good skid resistance, resists rutting better than Superpave mix, and has a life expectancy of 20 - 25 years. Another characteristic of Rosphalt 50 is that it retains its shape and doesn't soften and flow during prolonged exposure to high temperatures.

This paper will outline the mix design process, bridge deck surface preparation, construction, and initial evaluation of three bridge decks with Rosphalt 50.

Objective

The objective of this project was to overlay three bridges in Maine with Rosphalt 50 to seal the bridge deck and provide a wearing surface. The product will be evaluated over a five-year period for: Skid Resistance, Permeability, Durability and Cost Effectiveness.

Location

Two bridges are located in the town of Howland (Figure 1). Bridge number 6070 is on the southbound lane of Interstate 95 and crosses Seboeis Road. This bridge is 41 meters (136 ft) in length and 14 meters (47 ft) wide with a 2001 AADT of 3980. The wearing surface was in poor condition and needed replacement (Photo 1). Bridge number 6069 is also on the southbound lane of Interstate 95 and crosses the Piscataquis River. This bridge is 163 meters (536 ft) long, 11 meters (36 ft) wide with a 2001 AADT of 3980. The wearing surface on this bridge was also in poor condition (Photo 2).

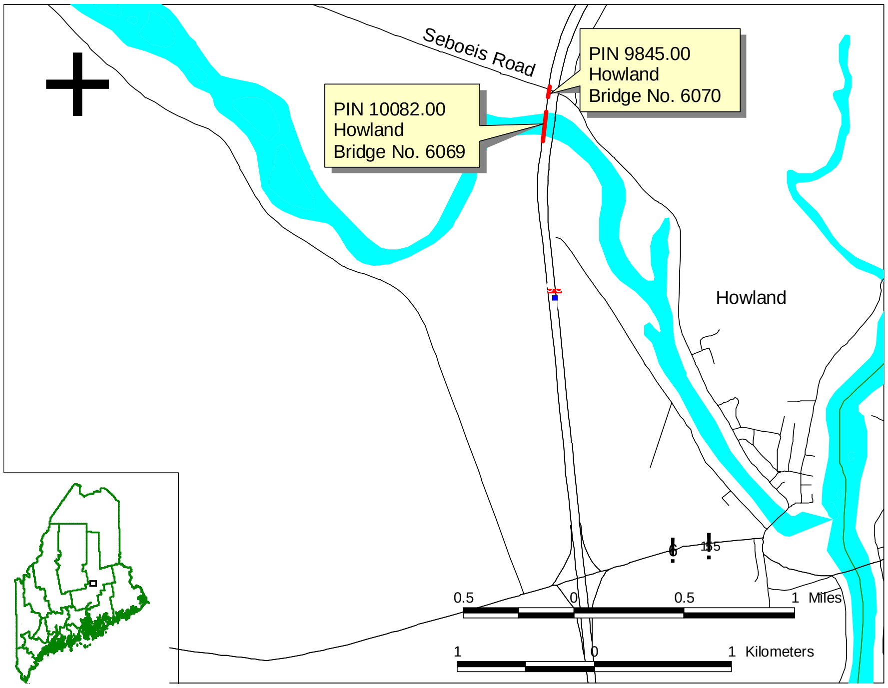

Figure 1. Bridge #6069 and 6070 location map

Photo 1. Bridge #6070 wearing surface

Photo 2. Bridge #6069 wearing surface

The third bridge is located between the cities of Bangor and Brewer (Figure 2). Bridge number 1558 is 476 meters (1563 ft) long, 33 meters (108 ft) wide, has a 2001 AADT of 13503, and carries Interstate 395 traffic over the Penobscot River.

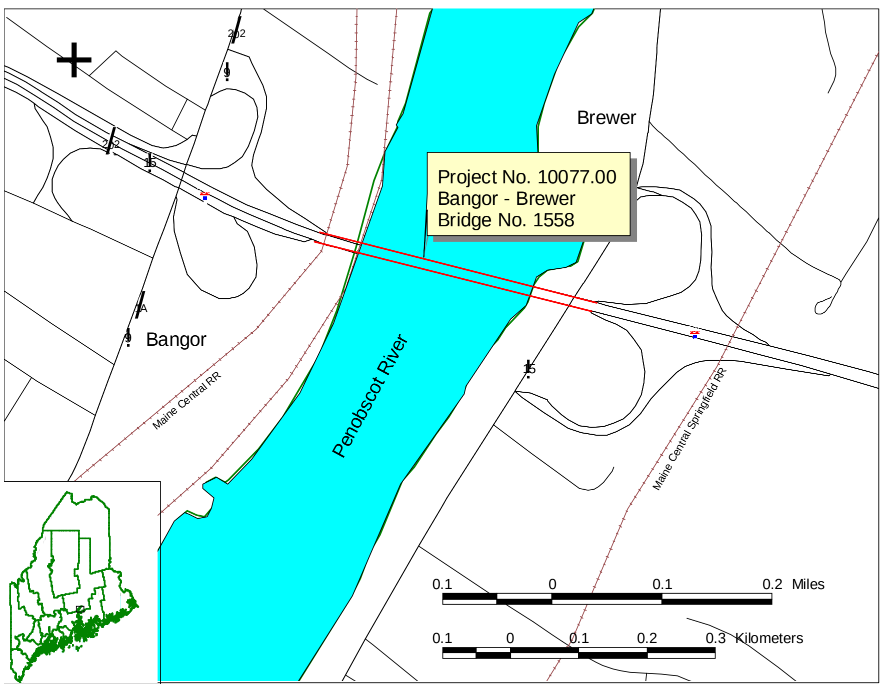

Figure 2. Bridge #1558 location map

Although the wearing surface was in fair condition, there were areas of shoving that have been repaired over the past five years (Photos 3 & 4). The problem areas are located on the accelerating lane of each entrance ramp and decelerating lane of each exit ramp.

Photo 3. Bridge # 1558 patch area on entrance ramp

Photo 4. Bridge # 1558 patch area on exit ramp

Scope

Two construction procedures were used for this project. One procedure involved milling the bituminous pavement and leaving the bridge deck membrane intact prior to resurfacing. The other consisted of removing the deck membrane and existing bituminous pavement prior to resurfacing.

Bridge number 6069 and 6070 had the deck membrane replaced in 1990 and 1988 respectively. Bridge inspectors determined that the membrane was still intact and protecting the deck from chloride intrusion. Because of this, bituminous pavement was removed to within 6 mm (0.25 in) of the bridge deck leaving the deck membrane intact. The surface was brushed clean and tack coated with Royston's 754 Adhesive Tac Coat. All vertical faces that will be in contact with Rosphalt 50 were tacked with Royston's 120-29 Edge Sealer. Both bridges were paved with 50 mm (2 inches) of Rosphalt 50 rubberized asphalt paving mix.

Bridge number 1558 had a number of areas that have been repaired the past 10 years due to either deck membrane failure or pavement failure. It was determined to remove the bituminous pavement and deck membrane prior to resurfacing. After milling, the bridge deck was cleaned and tacked with Royston's 754 Tac Coat. Royston's 120-29 Edge Sealer was applied on all vertical surfaces and the bridge was surfaced with 75 mm (3 inches) of Rosphalt 50 in two lifts.

Rosphalt 50 seals the deck without applying a new deck membrane and reduces the amount of time to resurface the bridge, which reduces the amount of traffic control necessary to resurface the deck.

Materials

Materials used for this project include:

9.5 mm Nominal Maximum Aggregate Size Superpave mix with Rosphalt 50 additive
Royston 120-29 Edge Sealer
Royston 754 Tac-Coat

The bid item for Rosphalt 50 High Performance Rubberized Asphalt included application and placement of all materials listed above.

Cost Comparison

Resurfacing using 50 mm (2 inches) of bituminous pavement (Bridge # 6069 and 6070)

Resurface Only (estimated costs)		
Bituminous Tack Coat		\$0.61 / m^2 (\$0.51 yd^2)
9.5 NMAS Superpave		\$7.06 / m^2 (\$5.90 yd^2)
	Total	\$7.67 / m^2 (\$6.41 yd^2)

Resurface plus Waterproofing Membrane (estimated costs)		
Waterproofing Membrane		\$20.86 / m^2 (\$17.44 yd^2)
Bituminous Tack Coat		\$0.61 / m^2 (\$0.51 yd^2)
9.5 NMAS Superpave		\$7.06 / m^2 (\$5.90 yd^2)
	Total	\$28.53 / m^2 (\$23.85 yd^2)

Resurfacing using 50 mm (2 inches) of bituminous pavement (Bridge # 6069 and 6070) continued

Resurface plus High Performance Waterproofing Membrane (estimated costs)		
High Performance Waterproofing Membrane		\$32.69 / m^2 (\$27.34 yd^2)
Bituminous Tack Coat		\$0.61 / m^2 (\$0.51 yd^2)
9.5 NMAS Superpave		\$7.06 / m^2 (\$5.90 yd^2)
	Total	\$40.36 / m^2 (\$33.75 yd^2)

Resurface using Rosphalt 50 (bid price)

Rosphalt 50 (Includes Royston 754 Tac-Coat and Edge Sealer 120-29) \$38.16 / m^2 (\$31.91 yd^2)

Resurfacing using 75 mm (3 inches) of bituminous pavement (Bridge #1558)

Resurface Only (estimated costs)

Bituminous Tack Coat		\$0.61 / m^2 (\$0.51 yd^2)
9.5 NMAS Superpave		\$10.62 / m^2 (\$8.88 yd^2)
	Total	\$11.32 / m^2 (\$9.39 yd^2)

Resurface plus Waterproofing Membrane (estimated costs)

Waterproofing Membrane		\$20.86 / m^2 (\$17.44 yd^2)
Bituminous Tack Coat		\$0.61 / m^2 (\$0.51 yd^2)
9.5 NMAS Superpave		\$10.62 / m^2 (\$8.88 yd^2)
	Total	\$32.09 / m^2 (\$26.83 yd^2)

Resurface plus High Performance Waterproofing Membrane (estimated costs)

High Performance Waterproofing Membrane		\$32.69 / m^2 (\$27.33 yd^2)
Bituminous Tack Coat		\$0.61 / m^2 (\$0.51 yd^2)
9.5 NMAS Superpave		\$10.62 / m^2 (\$8.88 yd^2)
	Total	\$43.92 / m^2 (\$32.72 yd^2)

Resurface using Rosphalt 50 (bid price)

Rosphalt 50 (Includes Royston 754 Tac-Coat and Edge Sealer 120-29) \$57.39 / m^2 (\$47.99 yd^2)

Formula to determine cost of mix:

Mix Quantity × mix cost ÷ bridge deck area

Where:

Actual Mix Quantity used:
- Bridge #6069 = 211 Mg (233 ton)
- Bridge #6070 = 70 Mg (77 ton)
- Bridge #1558 = 2790 Mg (3075 ton)

Mix Cost:
- Actual cost of Rosphalt 50 = \$322.43 / Mg (292.50 / ton)
- Estimated cost of 9.5 mm NMAS Superpave = \$59.67 / Mg (\$54.13 / ton)

Area of bridge deck:
- Bridge #6069 = 1781 m^2 (2130 yd^2)
- Bridge #6070 = 593 m^2 (709 yd^2)
- Bridge #1558 = 15674 m^2 (18746 yd^2)

The estimated costs for 9.5 mm NMAS Superpave, Waterproofing Membrane, and High Performance Waterproofing Membrane are based on the average unit cost of each item over the past three years.

The estimated cost for Tack Coat is the average unit cost per liter (\$3.07) at an application rate of 0.20 L/m^2.

The costs above do not include traffic control costs. It took ten days of paving to resurface all three bridge decks with Rosphalt 50. It was estimated that it would take fifteen to seventeen days to apply a waterproofing membrane and resurface with Superpave.

Using Rosphalt 50 to resurface bridge number 6069 and 6070 is less costly than resurfacing with a high performance waterproofing membrane but significantly more than resurfacing with or without a conventional waterproofing membrane.

When the thickness of Rosphalt 50 is increased by 25 mm, as is the case for bridge # 1558, the price of resurfacing is significantly higher than all other bridge deck treatments.

Construction

Construction information such as mix design, construction procedures and photos, and verification test results will not be included in this report. Construction details can be reviewed in Technical Report 03-1, "Bridge Deck Resurfacing using Rosphalt 50", Construction Report, January 2003.

Evaluation

Visual observations, frictional resistance tests, and bituminous core densities were utilized to evaluate the effectiveness of Rosphalt 50 as a concrete bridge deck wearing surface. Cores were extracted from the concrete deck and tested for chloride content. Test results will be used as a base line to monitor the effectiveness of Rosphalt 50 as a bridge deck sealant. In five years another set of cores, next to the first set, will be cut and tested comparing chloride content.

Visual Observations

Bridge No. 6070 over the Sebois Road in the town of Howland was inspected on October 6, 2003. The wearing surface was in very good condition with no visible cracks. Construction joints are very well knit with no separation. Photo 5 contains a portion of the centerline joint. Rosphalt 50 treated HMA is well sealed around drains and curbing. Rut depth measurements averaged 1.4 mm (0.05 in) in the travel lane.

Bridge No. 6069 over the Piscataquis River in the town of Howland was inspected on October 6, 2004. The overall condition of the wearing surface is very good and the average travel lane rut depth is 0.25 mm (0.01 in). Material around drains and curbing is well sealed. The centerline joint is well knit and difficult to see in areas.

Bridge No. 1558 over the Penobscot River in the city of Bangor was inspected on October 7, 2003. The wearing surface looks very good with minimal rutting, less than 12 mm (0.25 in) in depth. All joints are very tight and difficult to see in some areas. The 3 meter square (12 foot square) patch area in the west bound travel lane that was referenced in the construction report is in good condition and matched well with the surrounding mat. One of the reasons for utilizing Rosphalt 50 on this bridge was to reduce surface mix shoving at the exit ramps. After one year of traffic, Rosphalt 50 has effectively eliminated shoving in these areas. Mix around curbing and scuppers are well sealed but the mix around scuppers looks very coarse possibly due to less than adequate compaction effort in these areas during construction. Approximately two dozen defective areas were observed in both lanes of the bridge. These defects are concentrated orbs of Rosphalt 50 polymer that range in diameter from 50 to 200 mm (2 to 8 in). The defect in Photo 6 is 125 mm (6 in) in diameter. All defects inspected are intact and are not separating from the mat and don't appear to reduce the sealing capabilities of Rosphalt 50.

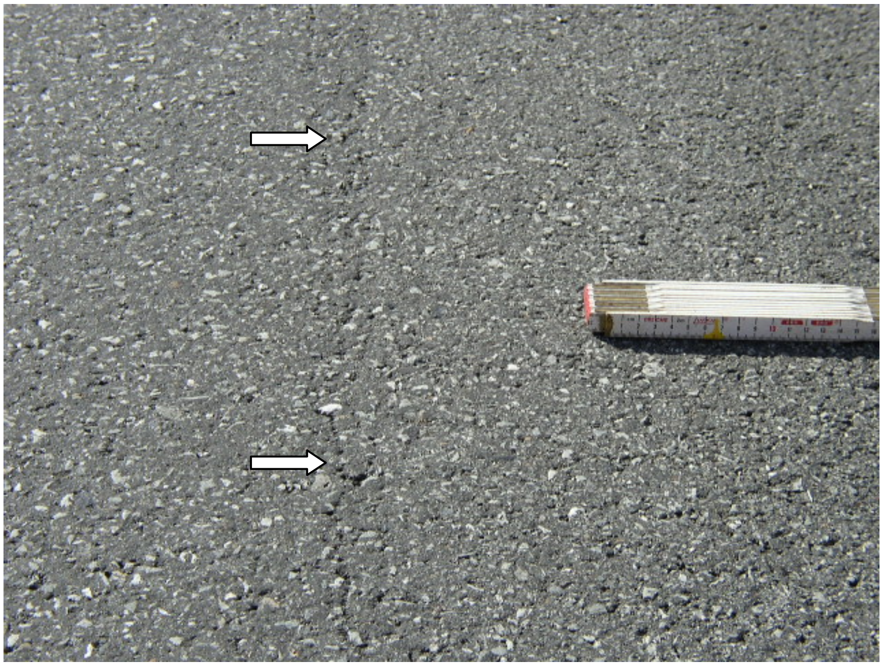

Photo 5. Bridge # 6070 centerline joint

Photo 6. Surface defect on Bridge # 1558

Frictional Resistance

Frictional resistance measurements were collected on September 23, 2003. Frictional resistance has increased on all bridge decks this year. Average frictional numbers (FN) for Bridge number 6070 and 6069 in Howland increased 16 and 10 percent respectively, bridge number 1558 increased 20 percent. Frictional resistance is normally low shortly after construction then increases as traffic abrades asphalt from surface aggregates then decreases slightly as exposed aggregates are polished and surface voids are filled with vehicle deposits. Table 1 contains a summary of frictional readings from 2002 and 2003. Mean

FN are nearly identical for Bridge number 6070 and 6069 at 60.3 and 60.5 respectively and Bridge number 1558 has an average FN of 51.2. Frictional resistance is well above the minimum mean FN of 35.

Left lane Frictional Numbers are between 11 and 25 percent higher than the right lane on all bridge decks. This is typical of two lane roadways, reduced traffic in the left lane equates to less abrasion and vehicle deposits.

Table 1. Frictional Resistance Summary

	Howland Bridge # 6070		Howland Bridge # 6069		Bangor Bridge #1558	
Year	2002	2003	2002	2003	2002	2003
Number of Tests	4	4	9	8	29	29
High FN	46	67	47	65	49	60
Low FN	40	55	35	55	36	43
Average FN	43.0	60.3	41.8	60.5	43.1	51.2
Standard Deviation	2.58	6.18	3.99	3.66	3.76	5.69

Density and Chloride Content

On September 6 and 7, 2003, six cores were cut on each bridge to a depth of 150 mm (6 in) to measure HMA density and chloride content of the concrete deck. Sample locations include the shoulder, wheel paths, between wheel paths, and near centerline. Table 2 – 4 contains a summary of core locations and test results. Density results for core number H10, H11, and H12 are not available; HMA core samples were misplaced prior to testing.

Royston mix design specifications stated that compaction of the mix should be ≥ 96% of theoretical compaction. Test results determined by AASHTO T166 METHOD-A reveal that cores from the wheel path and between wheel paths on Bridge No. 6070 and 1558 passed while all remaining tests in the shoulder and on Bridge No. 6069 failed. This supports the observation during construction that compaction of the shoulders was not adequate to properly achieve minimum density.

Chloride content is measured at a depth of 0 to 13 mm (0 to 0.5 in) and 13 to 38 mm (0.5 to 1.5 in) below the concrete surface. Chloride content was determined using test procedure AASHTO T260. To measure the concrete deck sealing capabilities of Rosphalt 50, another set of cores will be extracted within 150mm (6 in) of the 2003 samples and chloride content will be compared.

Table 2. Bridge No. 6070, Density and Chloride Content Test Summary, South Bound Travel Lane

	Core Location (m)		HMA	Chloride Content (%)		
Core No.	Station	Offset	Density (%)	0 – 13 mm	13 – 38 mm	Comment
H1	0+003	6.1 rt	92.5	0.019	0.0083	Sampled near drain
H2	0+007	2.6 rt	96.4	0.0047	0.0024	Right wheel path
H3	0+011	1.1 rt	96.9	0.027	0.018	Left wheel path
H4	0+023	5.3 rt	92.4	0.041	0.031	In the shoulder
H5	0+027	2.1 rt	97.1	0.035	0.039	Between wheel path
H6	0+032	0.4 rt	93.5	0.025	0.019	Near centerline

Table 3. Bridge No. 6069, Density and Chloride Content Test Summary, South Bound Travel Lane

	Core Location (m)		HMA	Chloride Content (%)		
Core No.	Station	Offset	Density (%)	0 – 13 mm	13 – 38 mm	Comment
H7	0+031	4.3 rt	92.1	0.032	0.032	Sampled near drain
H8	0+036	2.5 rt	95.5	0.0094	0.0024	Right wheel path
H9	0+040	1.2 rt	95.3	0.012	0.0071	Left wheel path
H10	0+046	4.3 rt	NA	0.015	0.0035	In the shoulder
H11	0+050	1.8 rt	NA	0.014	0.0024	Between wheel path
H12	0+055	0.2 rt	NA	0.041	0.019	Near centerline

Table 4. Bridge No. 1558, Density and Chloride Content Test Summary, East Bound Exit Lane

	Core Location (m)		HMA	Chloride Content (%)		
Core No.	Station	Offset	Density (%)	0 – 13 mm	13 – 38 mm	Comment
B1	0+094	19.0 rt	94.5	0.027	0.0094	Near wedge joint
B2	0+096	16.5 rt	97.4	0.025	0.018	Right wheel path
B3	0+102	14.7 rt	96.1	0.016	0.011	Left wheel path
B4	0+220	19.3 rt	92.2	0.024	0.014	Near scupper drain
B5	0+222	15.7 rt	95.8	0.021	0.018	Between wheel path
B6	0+224	13.8 rt	94.7	0.013	0.0035	Near centerline

Summary

Rosphalt 50 has been performing as expected after one year of exposure to traffic and the environment. Frictional resistance has increased to within normal readings. Rutting is minimal and Rosphalt 50 has eliminated shoving at exit ramps on the Bangor I-395 Bridge. Defective areas (concentrated asphalt spots) on the I-395 Bridge are a concern and will be monitored closely for ravel or separation from the mat.

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Additional Documentation:

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