FINAL REPORT

EVALUATION OF HIGH PERFORMANCE CONCRETE OVERLAYS PLACED ON ROUTE 60 OVER LYNNHAVEN INLET IN VIRGINIA

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(A Cooperative Organization Sponsored Jointly by the
Virginia Department of Transportation and
the University of Virginia)

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Charlottesville, Virginia

August 2000
VTRC 01-R1

ABSTRACT

Sixteen high performance concrete overlays were placed on two 28-span bridges on Route 60 over Lynnhaven Inlet in Virginia Beach, Virginia, in the spring of 1996. The construction was funded with 20 percent Virginia Department of Transportation maintenance funds and 80 percent special ISTEA Section 6005 federal funds specifically allocated to demonstrate overlay technologies. ISTEA funds were also used to evaluate the installation and condition of the overlays and to prepare an interim report and this final report.

The installation included a total of 16 overlays: 13 concrete mixtures that included a variety of combinations of silica fume, fly ash, slag, latex, corrosion-inhibiting admixtures, a shrinkage-reducing admixture, and fibers; an overlay with a thickness of only 0.75 in (19 mm); and spans with and without topical treatments of two corrosion inhibitors.

With the exception of one of the systems, the overlays were required to have a minimum thickness of 1.25 in (32 mm). Another system had a variable thickness ranging from 1.25 to 0.75 in (32 to 19 mm) to provide good ride quality.

All the overlays have performed well with the exception of most of the areas adjacent to joints. Many of these areas were replaced by the original contractor and replaced again by the city of Virginia Beach.

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INTRODUCTION

Sixteen high performance concrete overlays were placed on two 28-span bridges on Rte. 60 over Lynnhaven Inlet, Virginia Beach, Virginia, in the spring of 1996. The construction was funded with 20 percent Virginia Department of Transportation maintenance funds and 80 percent special ISTEA Section 6005 federal funds specifically allocated to demonstrate overlay technologies. ISTEA funds were also used to evaluate the installation and initial condition of the overlays and to prepare this report.

A site location map for the two bridges is shown in Figure 1. Initially, the westbound bridge (WBL) was overlaid while traffic used the eastbound bridge (EBL). Then, traffic was detoured to the WBL while the EBL was overlayed.

The installation included 13 different concrete mixtures, an overlay with a thickness of only 0.75 in (19 mm), and spans with and without topical treatments of two corrosion inhibitors for a total of 16 different overlays. The overlay types are identified in Figure 1 as follows: 7% silica fume (SF); 5% SF and 35% slag (S); 5% SF and 15% class F fly ash (FA); 15% latex-modified concrete (LMC); 13% SF and 15% FA;, 13% SF and 15% FA placed 0.75 in (19 mm) thick; 7% SF and Rheocrete corrosion-inhibiting admixture (CIA) (RCI); 7% SF, Armatec CIA (ACI), and ACI topical treatment (A); 7% SF and ACI; 7% SF, Darex CIA (DCI), and Postrite (P) topical treatment; 7% SF and DCI; 40% S; 7% SF and shrinkage-reducing admixture (CQI); 7% SF and polyolefin fibers (POF); 7% SF and steel fibers (STF); and 7% SF and polypropylene fibers (PPF). With the exception of system F, overlays were required to have a minimum thickness of 1.25 in (32 mm). In addition, system E had a variable thickness that ranged from 1.25 to 0.75 in (32 to 19 mm) to provide good ride quality.

PURPOSE AND SCOPE

The objective of this research was to demonstrate and evaluate bridge deck overlays placed using ISTEA section 6005 funds.

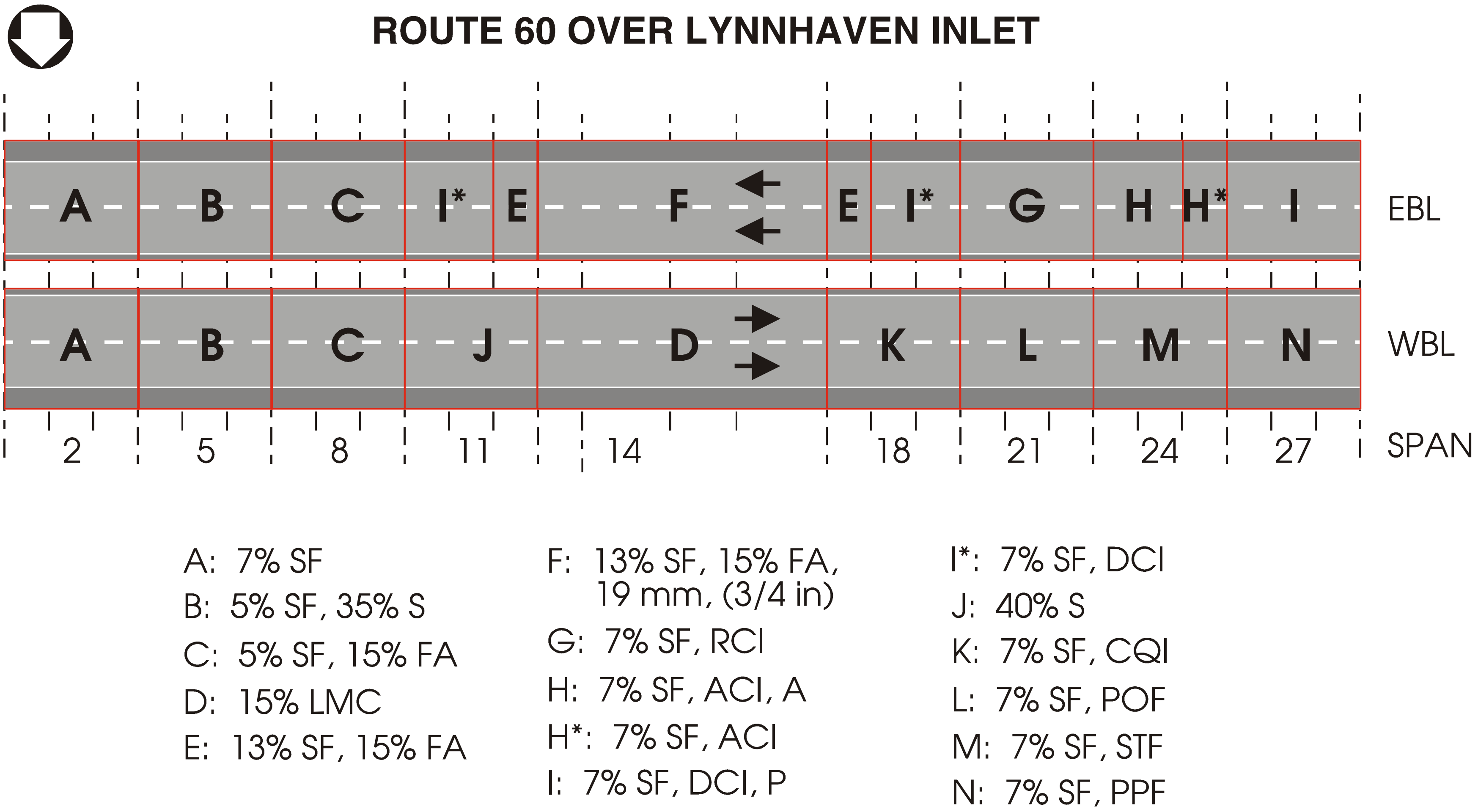

Figure 1. Plan View for Overlays on Two 28-Span Bridges on Rte. 60 Over Lynnhaven Inlet

METHODOLOGY

The objective was to be accomplished by completing the following tasks using the outside travel lane of at least one deck span with each of the 16 overlays:

1. Evaluate conditions of each deck prior to placement of the overlays.
2. Document the specifications used for each installation.
3. Document the installation of each overlay.
4. Evaluate the initial condition of each overlay.
5. Evaluate the condition of each overlay annually.
6. Evaluate the final condition of each overlay in 1999.
7. Prepare a final report for the Federal Highway Administration.

This report covers Tasks 6 and 7. Tasks 1 through 5 are were covered in the interim report.[1] Where available, information for more than one span and for the inside lane is included in the evaluation of each overlay.

Evaluations of the overlays were based on an assessment of how well they are bonded to the deck, how well they are protecting the deck from the infiltration of chloride ion and corrosion, how well they are providing a skid-resistant surface, and their cost-effectiveness.

A modified version of VTM 92 was used to provide an indication of how well the overlays are bonded to the base concrete. Typically, three cores 2.25 in (5.7 mm) in diameter and approximately 4 in (102 mm) long were tested for each overlay. The cores were drilled through the overlay and base concrete and taken to the laboratory for testing. In the laboratory, the cores were saw cut parallel with and approximately 1 in (25 mm) above and below the plane of the bond interface. The machined surfaces of two pipe caps were bonded to the saw cut surfaces of each core with an epoxy. Two hooks were connected to the threaded pipe caps, and the hooks and core were pulled in tension using a universal testing machine. Cores were loaded at the rate of 1,200 lb/min (5.3 kN), and the failure load and failure location were recorded.

Failures can occur in the base concrete, the bond interface, the overlay, the epoxy used to bond the caps to the core, and a combination of these locations. A 100% failure in the bond interface provides a true indication of bond strength. Failures at other locations indicate that the bond strength is greater than the failure load. However, for practical purposes, failures in the base concrete or overlay provide an indication of the degree to which the overlay is anchored and are considered as indicating bond strength. When a failure occurs in the epoxy, the result may be discarded if it is lower than the average of the other results or included if it is the same or higher. An epoxy failure should be a rare occurrence.

Bond strength test results may be qualified as follows:

≥ 300 psi (2.1 MPa), excellent
250 to 299 psi (1.7 to 2.1 MPa), very good
200 to 249 psi (1.4 to 1.7), good

100 to 199 psi (0.7 to 1.4 MPa), fair
0 to 99 psi (0 to 0.7 MPa), poor.

A chain drag of the deck is used to indicate areas that are delaminated (0 bond strength). A survey of the deck for spalled and patched areas provides an indication of bond strengths that were not high enough to prevent failure because of stress caused by shrinkage, traffic, temperature change, moisture, and freeze-thaw action.

Protection against the infiltration of chloride ion is evaluated based on deck surveys and mapping of cracks and tests of two or three cores for permeability to chloride ion (AASHTO T277). Permeability test results are based on tests of the top 2 in (51 mm) of cores 4 in (102 mm) in diameter and are typically the average of tests on two or three cores. Results are expressed as follows:

>4000, high
2000-4000, moderate
1000-2000, low
100-1000, very low
<100, negligible.

Protection against corrosion is indicated by electrical half-cell potential measurements (ASTM C 876). Readings are typically taken on a 5-ft (1.5 mm) grid and are interpreted as follows:

0 to –0.19 V_{cse}, 90% probability of no corrosion
-0.20 to –0.35 V_{cse}, uncertain as to corrosion
more negative than –0.35 V_{cse}, 90% probability of corrosion.

Protection against corrosion is also indicated by the chloride ion content at the level of the reinforcing steel. Contents of 1.3 lb/yd^3 (0.77 kg/m^3) or greater are sufficient to cause corrosion. Samples are typically taken and analyzed in accordance with AASHTO T 260. Most state departments of transportation use 2 lb/yd^3 (1.2 kg/m^3) as the threshold for decisions.

Skid resistance is typically measured with a skid test trailer that is pulled at 40 mph (64 km/h). Tests are done with a treaded tire (ASTM E501) or a bald tire (ASTM E524). Results are reported based on the average of three tests. The treaded tire provides a good indication of microtexture, and the bald tire, macrotexture. State departments of transportation do not publish standards for numbers, but asphalt and concrete pavements and bridge decks typically have numbers between 30 and 50. Cost-effectiveness is typically based on life cycle costs. Unfortunately, it is difficult to get representative costs for demonstration projects because of the unique nature and small size of typical projects. Relative comparisons of the costs of traffic control, construction, materials, and mobilization for various overlay systems can provide an indication of relative cost-effectiveness.

RESULTS OF EVALUATION OF CONDITIONS AFTER INSTALLATION

Cracks

Prior to placement of the overlays, with the exception of the center spans, which are on steel beams, the decks were free of cracks and patches. Span 14 in the WBL had 322 ft (98 m) of transverse cracks, and span 14 in the EBL had 69 ft (21 m).

Table 1 shows the data obtained in 1999. Many of the overlays have minor cracking that can be attributed to shrinkage. The most cracking was observed for overlay system F on span 14 of the EBL. Although much of the 148 ft (45.34 m) of cracking can be attributed to reflective cracking since 69 ft (21 m) of cracking was observed prior to placement of the overlay,

Table 1. Cracks, Delaminations, Spalls, and Patches In 1999

	WBL					EBL				
				Patches (ft^2)					Patches (ft^2)	
Span	Cracks (ft)	Delaminations (ft^2)	Spalling (ft^2)	Inside	Outside	Cracks (ft)	Delaminations (ft^2)	Spalling (ft^2)	Inside	Outside
1	2.0	0.0	0.0	16.3	16.3	66.5	8.0	3.6	2.9	4.0
2	3.0	0.9	0.0	27.0	27.0	0.0	0.0	0.5	0.0	0.0
3	0.5	0.3	0.0	33.0	33.0	1.3	0.0	0.5	8.8	2.5
4	0.0	0.0	0.0	35.8	35.8	16.0	12.0	5.3	15.8	3.0
5	1.5	1.5	0.5	40.1	40.1	1.7	1.5	7.2	13.3	8.0
6	38.5	0.0	0.0	53.1	53.1	0.3	0.0	0.0	0.0	0.0
7	7.0	4.0	4.0	10.8	9.2	4.3	0.0	0.0	11.0	25.0
8	6.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	5.0	19.5
9	3.5	1.5	0.0	16.3	0.7	0.8	0.0	0.0	13.0	0.0
10	8.5	0.0	0.0	32.5	35.0	3.7	4.5	0.0	9.0	13.0
11	3.5	3.0	0.0	36.8	52.0	3.7	5.0	0.0	14.0	12.0
12	8.5	0.1	0.0	17.0	32.5	0.0	0.5	1.3	11.9	11.0
13	18.0	0.4	0.0	21.1	20.5	0.0	0.0	0.0	41.3	20.2
14	3.5	0.0	0.0	7.6	7.6	148.8	0.0	0.2	40.5	28.0
15	2.3	0.0	0.0	0.0	0.0	2.3	0.0	0.0	2.4	12.4
16	3.5	1.5	0.0	6.5	6.5	0.0	0.0	0.0	0.0	0.0
17	0.5	1.5	0.0	13.0	13.0	2.5	0.0	2.5	4.4	17.8
18	1.3	0.0	0.0	0.0	0.0	7.0	3.0	8.0	19.5	0.0
19	4.5	0.7	0.0	0.0	1.9	2.5	0.0	5.0	0.0	3.3
20	5.7	0.0	0.0	3.5	3.0	2.5	0.0	0.2	23.7	21.8
21	7.0	0.0	0.0	23.6	21.6	3.3	1.5	0.8	44.3	45.2
22	3.0	3.4	0.0	19.5	21.5	5.3	0.0	0.0	73.6	44.1
23	6.5	1.6	0.0	0.5	0.8	7.0	0.0	0.0	27.4	17.1
24	0.5	1.5	0.0	0.0	0.0	2.0	0.0	0.0	58.8	39.2
25	0.0	0.0	0.0	0.0	0.0	8.0	0.5	0.0	29.2	32.5
26	0.0	0.0	0.0	0.0	0.0	3.0	0.0	0.0	22.2	17.1
27	0.0	0.0	0.0	0.0	0.0	5.3	5.3	1.0	23.3	11.3
28	0.0	0.0	0.0	0.0	0.0	3.5	2.0	0.0	8.2	13.8

1 ft = 0.305 m.
1 ft^2 = 0.093 m^2.

additional cracking has occurred because of shrinkage. Overlay system F is thin and has the highest binder content and, therefore, would be expected to crack the most. The second worst cracking occurred on span 1 of the EBL, and the cracks can be attributed to the shrinkage of the 7% SF overlay. On the positive side, only 3.5 ft (1.07 m) of cracking was observed on span 14 of the WBL. Prior to placement of the overlay, 332 ft (98 m) of cracking was recorded. Evidently, the LMC overlay used on span 14 was able to bridge the 322 ft (98 m) of cracking observed prior to placement. This overlay has the lowest modules of elasticity of the overlay systems used and would be expected to have the most crack-bridging capability.

Delaminations

The overlay delaminated on each side of many of the joints on the WBL because the joints were not properly prepared. No filler material was placed in the joint, and the finisher placed a notch in the surface of the freshly placed overlay to control contraction cracking. Unfortunately, when the spans expanded, the overlay delaminated within 2 ft (0.6 m) on each side of the joint because no expansion material was in the joint area. The overlay in the vicinity of most joints had to be removed, formed properly, and placed again.

The overlay delaminated on each side of most of the joints on the EBL because the form material was not compressible and because it was not removed in a timely fashion. The overlay was recast one or more times in the vicinity of most joints on both bridges because incorrect forming and form removal techniques were used. The 7% SF mixture (A) was used for the overlay repairs. A silicone joint material was placed in each joint following the saw cutting operation.

Delaminations in 1999 are shown in Table 1. Between 1996 and 1999, areas of delamination adjacent to the joints ranged from 0 to 48 ft^2 (4.5 m^2). A chain drag of the overlays in 1999 revealed no delaminations except adjacent to the joints.

Spalls

No spalls were noted other than adjacent to the joints.

Patches

Considerable patching occurred on both bridges between 1996 and 1999. The patching was necessary because of delaminations within 2 ft (0.6 m) of each side of most of the joints. Most of the patching was done by the contractor that placed the overlays. The delaminations occurred because the old concrete was not removed below the reinforcement so that the overlay material was anchored around the reinforcement. In addition, the contractor failed to place forms over the joints in the WBL and failed to remove the joint material in a timely fashion on the EBL. The lack of joints and the presence of incompressible joint material caused considerable shear stress on the overlay adjacent to the joints. Patching was not required other than adjacent to the joints.

Skid Tests

The results of the skid tests conducted in December 1996 and November 1999 with a skid trailer are shown in Table 2. The tests were conducted on the outside lane of the overlays. All the overlay concretes provide excellent skid resistance. Saw-cut grooves 0.13 in (3.2 mm) wide, 0.13 in deep, spaced 0.75 in (19 mm) apart yielded the excellent skid numbers.

Table 2. Skid Test Results in 1996 and 1999

Overlay Type	1996 WBL Bald Tire	1999 WBL Bald Tire	1996 WBL Treaded Tire	1999 WBL Treaded Tire	Overlay Type	1996 EBL Bald Tire	1999 EBL Bald Tire	1996 EBL Treaded Tire	1999 EBL Treaded Tire
A	48	51	47	51	I	45	47	46	46
B	49	51	50	50	H	33	47	34	47
C	48	52	47	51	G	38	49	39	49
J	54	54	53	53	I*	43	48	43	47
D	42	53	43	54	F	37	46	39	47
K	39	51	42	51	I*	38	48	42	48
L	36	48	38	48	C	37	49	42	50
M	41	50	43	50	B	41	49	43	50
N	40	48	39	47	A	46	51	44	50

Electrical half-cell potential results (ASTM C876).

Electrical half-cell potentials were measured (ASTM C 876) on a 4-ft (1.2-m) grid over the outside shoulder and travel lane prior to placement of the overlays and in November 1999. The data reported in Table 3 as the percentage of readings in each range show a 90% or greater probability that corrosion is occurring (potentials more negative than –0.35) in small areas of eight spans prior to the overlays being placed and a small area of span 14 after the overlays were placed. For the majority of the spans, there is a 90% or greater probability that corrosion is not occurring (potentials less negative than –0.20) prior to and after the overlays were placed.

Tensile Bond Strength

Table 4 shows the results of the tensile adhesion tests conducted on the outside travel in accordance with a modified version of ACI 503R and VTM 92. The modifications were that cores were removed from the deck and saw cut in the laboratory to provide a specimen 4 in (102 mm) high with 2 in (51 mm) on each side of the bond line, a pipe cap was bonded to both sawn surfaces, and the specimen was subjected to tension using a universal testing machine in the laboratory. The bond strengths were fair to good. The majority of the failures were at the bond interface and in the base concrete close to the bond interface, which indicates that surface preparation could have been better. The initial test results for the spans that received topical

Table 3. Electrical Half-Cell Potentials Prior to Overlay Applications and in November 1999 (ASTM C 876)

		Prior to Overlay, - V_{CSE}			November 1999, -V_{CSE}		
Span	**Direction**	**<.20**	**0.2-0.35**	**>0.35**	**<.20**	**0.2-0.35**	**>0.35**
2	WBL	96.9	3.1	0.00	100.0	0.0	0.0
	EBL	81.3	14.3	4.4	100.0	0.0	0.0
5	WBL	100.0	0.0	0.0	98.1	1.9	0.0
	EBL	98.9	1.1	0.0	100.0	0.0	0.0
8	WBL	91.8	7.1	1.0	98.1	1.9	0.0
	EBL	96.7	3.3	0.0	100.0	0.0	0.0
11	WBL	98.0	2.0	0.0	98.1	1.9	0.0
	EBL	75.8	19.8	4.4	92.3	7.7	0.0
14	WBL	86.2	11.7	2.1	43.3	54.8	1.9
	EBL	44.0	43.4	12.6	90.4	9.6	0.0
18	WBL	96.9	3.1	0.0	100.0	0.0	0.0
	EBL	81.3	15.4	3.3	96.2	3.8	0.0
21	WBL	99.0	1.0	0.0	96.2	3.8	0.0
	EBL	86.8	11.0	2.2	100.0	0.0	0.0
24	WBL	94.9	4.1	1.0	100.0	0.0	0.0
	EBL	100.00	0.00	0.00	100.00	0.00	0.00
27	WBL	98.2	1.8	0.0	100.0	0.0	0.0
	EBL	93.4	6.6	0.0	100.0	0.0	0.0

applications of corrosion inhibitors (spans 24 and 27 of the EBL) were the lowest for the spans evaluated. Tests in 1999 showed these spans to have bond strengths similar to those of many of the other spans. In general, bond strengths did not change over the 3-year evaluation period and continued to be between 200 and 320 psi (1.4 and 2.2 MPa) in 1999. Values over 200 psi (1.4 MPa) are good, over 250 psi (1.7 MPa) are very good, and over 300 psi (2.1 MPa) are excellent.

Permeability Test Results

Table 5 shows the results of permeability tests (AASHTO T 277) conducted on cores 4 in (102 mm) in diameter removed from the outside lane of the decks and tested at an age of 6 to 7 months (November 1996) and 42 to 43 months (November 1999). Tests were conducted on the top 2 in (51 mm) of two cores from each span with the exception that only one core was tested from the EBL in 1996. The STF on span 24 of the WBL could not be tested because the steel fibers cause a short circuit. The test results were in the low (1000 to 2000) to very low range (100 to 1000), indicating that all of the overlays are providing good protection. Systems in the low range were the 7% SF in the WBL, 40% S, POF, PPF, and DCI. In general, the permeabilities have not changed over the 3-year evaluation period.

Table 4. Tensile Bond Strengths

Span	WBL, 10 mo					EBL, 6 wk				
	Overlay Thickness, in	Bond Strength, psi	Failure Area, %			Overlay Thickness, in	Bond Strength, psi	Failure Area, %		
			Overlay	Bond	Base			Overlay	Bond	Base
2	1.6	305	3	29	68	1.5	230	3	40	57
5	1.6	325	3	32	65	1.6	210	5	38	57
8	1.6	265	0	0	100	1.6	240	2	30	68
11	1.4	260	20	33	47	1.7	230	3	34	63
14	1.7	260	0	25	75	1.1	240	0	35	65
18	1.6	280	10	40	50	1.5	275	5	40	55
21	1.6	265	18	58	24	1.5	220	3	17	80
24	1.9	290	20	27	53	1.7	135	0	28	72
25	-	-	-	-	-	2.0	215	2	27	71
27	1.5	315	0	17	83	1.5	145	0	57	43

Span	WBL, 11/99					EBL, 11/99				
	Overlay Thickness, in[1]	Bond Strength, psi[1]	Failure Area, %			Overlay Thickness, in[190]	Bond Strength, psi[1]	Failure Area, %		
			Overlay[1]	Bond[1]	Base[1]			Overlay[1]	Bond[1]	Base[1]
2	1.6	275	37	28	35	1.7	255	0	40	60
5	1.3	300	0	0	100	1.7	260	8	33	58
8	1.5	280	3	7	90	1.8[2]	260[2]	5[2]	28[2]	67[2]
11	1.5	300	27	23	50	1.9	290	8	18	73
14	1.6	310	3	27	70	1.2	305	2	0	98
18	1.5	245[4]	6[3]	35[3]	59[3]	1.9	265	12	10	78
21	1.5	220	35	38	27	1.4	205	5	28	67
24	1.8	250	20	8	72	1.5	200	3	32	65
25	-	-	-	-	-	1.8[4]	200[4]	0[4]	0[4]	100[4]
27	1.5	320	33	0	67	1.4	255	17	58	25

[1] Average of 3 cores, except as noted.
[2] Average of 4 cores.
[3] Average of 5 cores.
[4] Average of 2 cores.
1 in = 25.4 mm, 1 psi = 6.89 kPa.

Table 5. Post Installation Rapid Permeability Test Data

Span	WBL, 96 Overlay Thick., in	WBL, 96 Perm., Coulombs	WBL, 99 Overlay Thick., in	WBL, 99 Perm., Coulombs	EBL, 96 Overlay Thick., in	EBL, 96 Perm., Coulombs	EBL, 99 Overlay Thick., in	EBL, 99 Perm., Coulombs
2	1.7	1082	1.8	1459	1.6	527	1.6	518
5	1.4	522	1.4	587	1.5	422	1.7	497
8	1.6	349	1.7	362	1.3	369	1.6	300
11	1.4	1309	1.5	1887	1.9	1418	1.9	1090
14	1.6	703	1.7	333	1.2	193	1.2	230
18	1.5	581	1.5	702	1.7	1614	1.9	2347
21	1.6	1249	1.5	1660	1.7	1031	1.4	823
24	-	-	1.8	-	1.7	393	1.6	419
25	-	-	-	-	-	327	-	-
27	1.4	923	1.4	1458	1.5	1695	1.4	1395

1 in = 25.4 mm.

Cost of Overlay

The contractor bid $1,200/yd^3 ($1,569/m^3) for all overlay systems. Therefore, it was not possible to get an indication of relative cost from this project. The cost was approximately 50% greater than VDOT typically pays for LMC and SF concrete overlays probably because of the experimental nature of the project. Based on the relative cost of the ingredients, the researchers believe that the overlays would rank as follows from highest to lowest cost:

1. 7% SF and STF, 7% SF and POF
2. 7% SF and PPF, LMC, 7% SF and CQI
3. 7% SF and DCI, 7% SF and RCI, 7% SF and ACI
4. 13% SF and 15% FA
5. 7% SF
6. 5% SF and 35% Slag, 5% SF and 15% FA
7. 40% S.

The majority of the cost of an overlay is for labor, equipment, mobilization, and traffic control. The material is often less than 10% of the cost, and, therefore, differences in material costs are minor when the total cost of the overlay is considered.

CONCLUSIONS

Estimate of Remaining Service Life of Overlays

Data obtained during the evaluation indicate the overlays have many properties that are similar to those of overlays that have lasted 20 years. Some areas adjacent to the joints may have to be patched in less than 20 years because of the less-than-satisfactory construction practices.

Evaluation of Cost-Effectiveness

The concretes differ slightly with respect to cost because of the differences between the cost of the ingredients and the equipment and procedures required for the installation. The contractor bid for the same for all overlays, and, therefore, comparative costs for the different systems could not be determined for this project.

Because of the relatively higher costs of the ingredients, the overlays with steel fibers, polyolefin fibers, and latex would be slightly more expensive, and the overlays with 40% S, 5% SF and 35% slag, and 5% SF and 15% FA would cost the least.

Assessment of Project's Objectives Using Section 6005(E)7

In the spirit of the ISTEA funding, this project demonstrated the viability of high performance concrete overlays and identified areas for improvement.

Other Conclusions

1. High performance concrete overlays that have low permeability to chloride ion and high bond strength can be constructed with a variety of combinations of silica fume, fly ash, slag, latex, corrosion-inhibiting admixtures, a shrinkage-reducing admixture, and fibers.

2. Joints in overlays must be properly formed and the forms removed in a timely fashion to prevent damage to the bond interface of the overlay adjacent to the joint and subsequent spalling in a short time.

3. Removal of concrete to a depth below the top reinforcement adjacent to joints and placement of the overlay concrete around the reinforcement will reduce the incidence of spalling adjacent to joints caused by improper forming and form removal.

RECOMMENDATION

High performance concrete overlays as described in this report should be used to extend the life of bridge decks.

ACKNOWLEDGMENTS

This research and 80% of the construction was done with ISTEA 6005 thin bonded overlay funds provide by the Federal Highway Administration. Thanks to Vasant Mistry and Roger Larson of the Federal Highway Administration for administering the funds.

REFERENCE

1. Sprinkel, M. M., and Ozyildirim, C. *Evaluation of the Installation and Initial Condition of High Performance Concrete Overlays Placed on Rte 60 Over Lynnhaven Inlet in Virginia*. VTRC 99-IR4. Virginia Transportation Research Council, Charlottesville, 1999.