

EVALUATION OF SILICA FUME HIGH DENSITY THIN BONDED OVERLAYS

Interim Report February 2001

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SI (METRIC) CONVERSION FACTORS

EVALUATION OF SILICA FUME HIGH DENSITY THIN BONDED OVERLAYS

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INTRODUCTION

In September 1999, the Oklahoma Department of Transportation (ODOT) placed silica fume modified PCC overlays on two bridges on I-35 in Carter County. The first year of testing was completed in October 2000.

ODOT has been exploring ways to stop or slow chloride-induced corrosion of uncoated reinforcing steel in bridge decks. One method widely used to prevent chloride intrusion is placement of thin, low permeability PCC overlays on the existing decks. Silica fume is a commonly used PCC additive where high density and low permeability is desired. Added benefits of overlays are improved smoothness and friction characteristics. Other agencies have reported that silica fume modified PCC overlays have demonstrated success in reducing chloride intrusion and restoring driving surfaces of bridge decks(2).

INVESTIGATION

Various researchers have expressed concern that the difficulty of curing silica fume mixes might lead to cracking, which in turn, can be a cause of delamination(1). Cracking of the overlay was measured and mapped. The following observations regarding cracking were made.

The south bound bridge has a longitudinal construction joint which travels the length of the project. The joint is located on the inside half of the outside (west) lane. A crack formed over this joint which has a maximum width of 6 mm ($^{1}/_{4}$ inch). All other cracks were randomly spaced over approximately 10 percent of the bridge deck of the southbound bridge. These are "hairline" cracks size in accordance with SHRP-3-338 manual, a fracture that is very narrow in width, less than 3mm ($^{1}/_{8}$ inch).

1

The north bound bridge also had a construction joint in the corresponding location (inside half of the outside, or east, lane). Maximum width of the crack over this joint was 3 mm ($\frac{1}{8}$ inch). Hairline cracks were randomly located over approximately 25 percent of the northbound bridge. Crack maps of each of the two bridges are included in Appendix A.

All four lanes of the two bridge decks were chain-dragged tested to detect the presence of delamination or debonding. Deck areas where the deck has a horizontal fracture plane give a hollow sound when a chain is dragged on their surface. Generally, it is not possible to distinguish between delamination and debonding using manual sounding techniques (3). The longitudual construction joints on both bridges gave the hollow sound during chain drag testing. These were the only locations, on either bridge, where delamination or debonding was indicated. No debonding was noted at these locations during the testing done after completion of the overlays (September 1998), indicating that any delamination or debonding present has occurred since then.

Half-cell testing (ASTM C - 876 - 80) was done on both bridges to detect electrical potentials associated with corrosion. Locations where the individual half-cell potentials were measured, and the amounts of the readings, are shown in Appendix A. Half-cell readings are divided into three classes, based on the measured potential. These are listed below:

Class	Potential(v)
Class "A"	250 to350
• Class "B".	-360 to400
Class "C"	410 and more negative.

Seven percent of the readings on the southbound bridge and 2.9 percent of the readings done on the northbound bridge were in the Class "A" range. No readings were classified as Class "B" or "C".

Smoothness of the bridge was measured with an Ames 4000 - B profilograph and a K. J. Law T-6400 Lightweight Profilometer. Each lane of each bridge deck was measured with each of the instruments. Measurements from both the profilograph and the profilometer are listed in Appendix B. On the southbound bridge, the profile index for the outside lane was 25.71 in/mi. and 17.41 in/mi. for the inside lane. The average profile index (both lanes) was 21.56 in/mi. The northbound bridge had a profile index of 20.00 in/mi in the outside lane and 7.92 in/mi in the inside lane. The average of both lanes on this bridge was 13.96 in/mi.

Skid trailer measurements were also taken. The skid trailer was able to get one measurement for each lane of each bridge. Skid trailer measurements are expressed as skid numbers (SN). Measured values were 43, 52, 42, 46. Skid data sheets are included in Appendix B.

The ODOT interstate maintenance yard for the area containing the two bridges used 5:1 sand to salt mixture for deicing bridge and highway surfaces. Thirty light applications of sand/salt mixture has been placed on each bridge since completion of the silica fume modified overlay. The mixture was applied at a rate of less than 20 lb per square yard.

CONCLUSION

One year of test data has been summarized in this report. Regarding chloride ion transport through concrete, the presence of interconnected pores, cracks, hairline cracks, and aggregate particles will affect the ability of the chloride ions to migrate into the concrete(4).

Hairline cracking was the major distress found on the bridge decks. The 1999 half-cell readings on the southbound bridge had 2.9 percent in the Class "A" category. By 2000, Class "A" readings had increased to 7.0 percent. Locations with hairline cracking and relatively high half-cell readings tend to occur in the same general areas, indicating that chloride intrusion through the hairline cracking is the likely cause of the higher readings.

The ride quality decreased slightly, skid test results show an adequate amount of friction

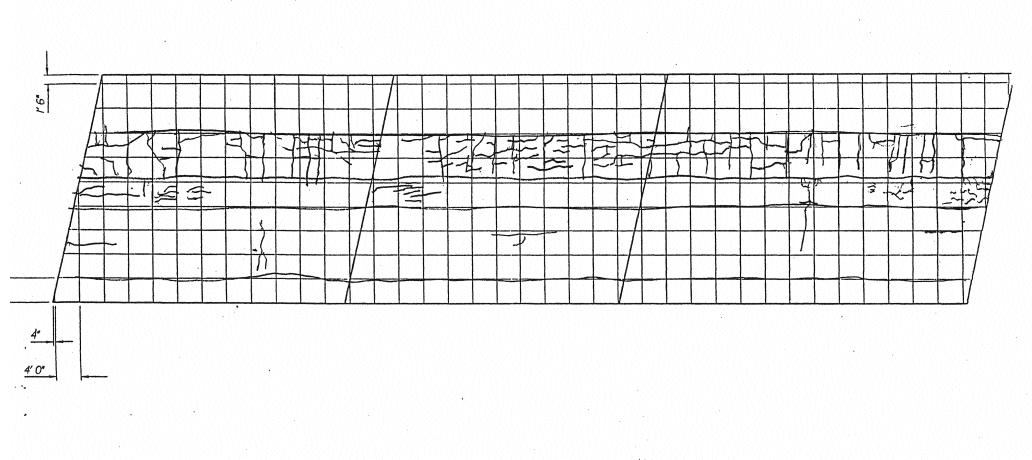
characteristics. Carter county had a mild winter during the last evaluation period (less freeze-thaw cycle then the rest of Oklahoma). Results of half-cell testing indicates that both bridges are in good condition, based on reinforcing steel corrosion activity. Overall, the two silica fume modified PCC overlays are in good condition and performing well.

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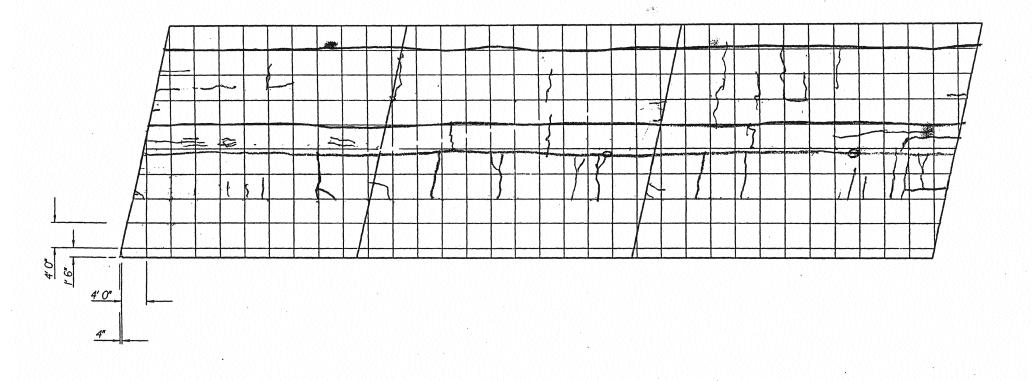
APPENDIX A CRACK MAPS

CRACK MAP OF SOUTH BOUND BRIDGE



5B

CRACK MAP OF NORTH BOUND BRIDGE



NB

APPENDIX B HALF CELL TESTING

Oklahoma Department of Transportation

Research and Development Division

Date October 6,2000

To Wilson Brewer

From Bryan W. Cooper

Subject Half Cell testing and deck analysis on Silica Fume bridge project in Carter County Item No. 2132

I have analyzed the results of the half-cell testing that was conducted on October 3, 2000. I have concluded from the results of this testing that there is very little corrosion in the reinforcing steel of these particular bridge decks.

Half-cell test readings are divided into three classes. They are Class "A", Class "B", and Class "C". The classification of these readings are specified within these following ranges:

Class "A": .250 - .350

Class "B": .360 - .400

Class "C": .410 and greater

A plan view of these bridge decks has been provided and displays the grid layout that was used in this testing and the readings that were gathered at each point.

The results of this analysis shows that there was only 2.9% Class "A" readings on the Northbound bridge and no Class "B" or "C" data. The testing on the Southbound bridge indicated 7.0% of Class "A" readings and no Class "B" or "C" indications, Class "C" being the most critical. The 1999 results indicated 2.6% for the Northbound and 4.2% for the Southbound.

It is my belief that your crack mapping results will indicate that the cracking in the southbound bridge, is a major contributor to the increase of the percentage of Class "A" readings on this bridge.

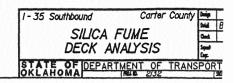
The results seem to indicate that we still have two bridges in good shape in reference to the corrosion of the reinforcing steel.

Cc: Gary Williams

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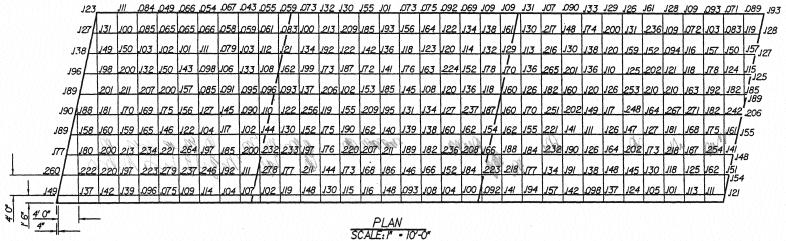


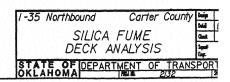
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REVINO. ENGINE

APPENDIX C PROFILE RESULTS

Oklahoma Department of Transportation

Materials and Research Division

Date October 31, 2000

To Gary Williams

From Bryan K. Hurst Brt

Subject 2000 Silica Fume Overlay Bridge Profiles Item 2132

> On Wednesday, October 25, 2000, profilograph and KJ-Law Profilometer testing was performed on the Silica Fume Overlay Bridges on I-35 near Ardmore, Ok. The two southbound lanes were tested first that morning and the two northbound lanes were tested that afternoon. New software has been installed on the KJ-Law Profilometer since the 1999 testing on these bridges, and with it comes a change in the filter wavelength setting from 300 to 100. This setting slightly changes roughness results making them appear smoother. The 1999 results were amended with the new software and were included in the "1999 Silica Fume Overlay Bridge Field Report."

> Roughness figures were obtained from both the Ames Profilograph and the KJ-Law Profilometer, for 2000. The table below contains the project results for the 1999 testing and the results from the 2000 testing:

LOCATION]	ROUGHN	NESS / IN	CHES PE	R MILE		
		19	99			20	000	
	Ames Pr	ofilograph		-Law lometer	Ames Pro	filograph		Law ometer
	TOTAL PROJECT	BRIDGE DECK	TOTAL PROJECT	BRIDGE DECK	TOTAL PROJECT	BRIDGE DECK	TOTAL PROJECT	BRIDGE DECK
SOUTHBOUND RT. LN. / LWP	20.43	27.14	25.27	32.93	31.90	25.71	21.83	31.91
SOUTHBOUND LT. LN. / RWP	12.49	17.5	11.79	18.44	10.00	17,14	8.61	16.31
NORTHBOUND RT. LN. / LWP	6.33	19.58	7.5	N/A	10.52	20.00	12.15	18.15
NORTHBOUND LT. LN. / RWP	5.21	7.92	6.02	7.57	6.13	7.92	5.00	4.76

APPENDIX D SKID TEST DATA

				SKID DATA SI	HEET		Pa	ge _/	of <u>4</u>
SITE: LANE: DATE: TIME: DRIVER: OPERATOR:		NBOL	9/2000	Carter					
	Right	86.9 84.8	49.1	15:29:00	510036069	EVENI Bridg			1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
Left Wheel	N =	2 M 1 M	= 47	.2 SD = .8 SD =	3.11 H 0.00 H 3.37 H	= 4	19.4 12.8 19.4	L =	45.0 42.8 42.8

SKID TEST DISCLAIMER

This test is conducted solely for the purpose of generating input data for priority programming of maintenance and construction projects. Tests are performed by field personnel not trained nor expert in scientific testing procedure. While every effort is made to conduct tests accurately, tests are not subject to rigorous scientific control. The test results are calculated as the product of a mechanical test wherein a skid trailer tire interfaces with the road surface providing an approximate value which may be converted to a coefficient of friction only for that portion of the road surface actually in contact with the tire of the test trailer. The calculated coefficient of friction has value only as to the surface actually tested and no attempt should be made to use this test as a means of evaluation of untested surface areas or for correlation of this test with tests of other tested surface areas.

					SKID DATA S				aye _	<u> </u>	of_4
SITE: LANE: DATE: TIME: DRIVER: OPERATO	R:		NBIL	9/2000	Carter						
REF POST	SN	WHEEL	SN PEAK	AIR TEMP		CYCLE NUMBER	EVEN	1T			
20.253	46.1	Right	100.5	49.1	15:32:06	510036074 510036075 510036076	5 Bric	lge	Ç A		
			1 M	= 46	.1 SD =	1.16 0.00 3.99	Н =		L	=	46.1
							•				

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			5	SKID DATA SI	HEET		Page	3	of_ <u>4</u>
SITE: LANE: DATE: TIME: DRIVER: OPERATOR:		SBOL	9/2000	Carter					
REF POST SN	WHEEL	SN PEAK		TEST TIME	CYCLE NUMBER	EVENT			
20.410 50.7 20.357 43.4 20.316 41.0	Right	91.1	48.2	15:26:41	510036066	Bridge	l. Maria		
Left Wheel Right Wheel Total	N = N = N =	1 M	= 43	.4 SD =	6.88 H 0.00 H 5.07 H	= 43.	4 L	=	43.4
· · · · · · · · · · · · · · · · · · ·									

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			SKID DATA SI	HEET	Page _	4 of 4
SITE: LANE: DATE: TIME: DRIVER: OPERATOR:	SE 11					
REF POST SN		AIR K TEMP		CYCLE NUMBER EV	/ENT	
20.393 51.5 20.352 52.2 20.315 50.5	Right 81	.0 48.2	15:30:43	510036072 Br	idge	· · · · · · · · · · · · · · · · · · ·
Left Wheel Right Wheel Total		M = 52		0.76 H 0.00 H 0.89 H		= 50.5 = 52.2 = 50.5
Tests are performed	by field personnel	purpose of gene not trained nor	expert in scientific	AIMER r priority programming of testing procedure. While ults are calculated as the	e every effort is made	to conduct tests

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