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SURTREAT®

Oklahoma Department of Transportation

Demonstration and testing of corrosion abatement and rejuvenation of structural concrete bridge decks on I-40

Surtreat Texas-Gulf Coast

Surtreat personnel, at the suggestion of Oklahoma Department of Transportation staff, performed a visual inspection of several bridges on I-40 near the Oklahoma-Texas border in May, 2002. The purpose was to identify several locations for demonstration of Surtreat formulations under field conditions and to experiment with the delivery of Surtreat formulations through an asphalt overlay. Ultimately, three bridges were selected; two located 4.3 miles east of US 283 and one bridge with concrete deck overlaid with asphalt, located 11.7 miles east of the Texas line. The bridges with exposed concrete decks were selected because of visible spalling of the decks and bent caps. The bridge with asphalt overlay was selected to test the potential for Surtreat to penetrate through the asphalt in concentration to migrate into the concrete. This bridge deck did not have a membrane under the asphalt. The test and demonstration protocol is described later. The goal was to demonstrate abatement of corrosion and reduce permeability of the concrete on the first two bridges under field conditions. The purpose of the third bridge test was to field test penetration of Surtreat through an asphalt overlay to reduce porosity and provide corrosion abatement on the underlying concrete deck.

Summary of Findings

The demonstration and test results show that limited application of Surtreat formulations have cut corrosion rates in half, doubling the service life of the structure,(where treated). Higher application rates and more thorough surface preparation can provide even greater service life extensions. The porosity reductions achieved are important in reducing future penetration of water, chlorides and other elements essential to the corrosion cycle.

The SURTREAT Process

The core technology of SURTREAT is a number of proprietary chemical formulations which when applied to the surface of Portland cement concrete penetrate and combine with the cement paste to:

- Abate and inhibit reinforced steel corrosion in concrete
- Pacify and inhibit penetration of chlorides
- Reduce the cement porosity and inhibit water penetration
- Increase the hardness of the concrete
- Increase the compressive strength of the concrete

SURTREAT'S ability to prevent concrete deterioration goes far beyond any conventional products or methods. Our formulations react with the existing chemistry of the concrete, becoming a permanent part of the structure that cannot be scratched off, worn or otherwise extracted from the surface. SURTREAT also increases the ability of concrete to resist penetration by acids, oils, hydraulic fluids, etc. The SURTREAT system has no affect on skid resistance properties or appearance of the concrete.

Site Descriptions

The test bridges are located on I-40 west of Oklahoma City. The climate is arid and the bridges have been exposed to both sodium chlorides and

magnesium chlorides. The bridge with asphalt overlay is located just east of Erick, 11 miles east of the Texas line The two bridges with concrete decks, (eastbound and westbound) are just east of Sayre.

The Erick bridge was built in 1972. It has a length of 599', width curb to curb 38', (26' treatable) 22,762 sq ft (curb to curb) underside 23,840 sq ft (outside to outside). The concrete deck is 8" thick, with steel beams spanning 34' and concrete bents and columns. The bridge is experiencing corrosion, spalling and delamination. The underside of this bridge was accessed by the ODOT Snooper truck. The asphalt overlay was milled off three years ago, destroying the original membrane. It was then re-topped with asphalt. Core tests performed July 11, 2002 found that the shoulders were not milled and therefore have a membrane in place, limiting the treatable area to the two 13" traffic lanes The asphalt cores, 4" diameter, were tested for penetration rates with good results, using SURTREAT TPS 2 under laboratory conditions.

A test panel was located on the Erick westbound bridge starting 140' west of the east abutment. One 19' panel spanning the two traffic lanes between expansion joints was delineated for treatment.

The eastbound Sayre bridge was built in 1970, with a length of 178' and curb to curb width of 38'. The deck is supposed to have 2" cover over the rebar, however rebar exposed in the traffic lanes varied in depth from ¾" to 2". The deck had numerous spalls, concrete and asphalt patches. The deck is 6764 sq ft curb to curb and the underside is 7369 outside to outside. Three test panels were delineated on this eastbound Sayre bridge measured 99' west of the east end of the parapet wall to an expansion joint. Three 10' curb to curb test panels were delineated for treatment and control.

The westbound Sayre bridge appears to be similar to the eastbound bridge but built in 1980. Dimensions are the same with exception of some difference in steel beam length. The problems are the similar. Three test panels were delineated on the westbound Sayre bridge measured 30' west of the east end of the parapet wall to an expansion joint. Three 10' curb to curb test panels were delineated for treatment and control.

Testing Methods

Several field test methodologies were utilized to develop our data.

- Capo-Test for strength estimation of compressive strength near to surface
- GWT for measurement of water permeation at a constant pressure
- GalvaPulse to measure corrosion rate in rebar
- Acid reactivity using 20% HCl
- Rainbow Dye spray indicator for pH and carbonation indicator

Erick Bridge Testing and Treatment

The westbound Erick bridge was treated on August 1 with TPS 2 at a rate of 60 sq. ft. per gallon. This rate was determined in laboratory testing of core samples prior to the field application. Four treatments of TPS 2 were applied on ½ hour intervals to allow penetration through the asphalt topcoat. The TPS treatments were followed by four applications of water on ½ hour intervals. The panel was flushed with water prior to opening the lane to traffic.

Several sections of parapet wall, which exhibited spalling, were treated adjacent to the test panel. In addition, a section of the bridge deck underside was tested and then treated with three applications of TPS 2 and two applications of TPS 12. (The treated site is located on the north side of the outside beam, at the east end of the bridge)

Asphalt penetration results

In November, an ODOT crew removed asphalt cover (1x2) in treated area and (1x1) in untreated area of the slow lane. Powder samples taken at 0-1" for chloride tests and Rainbow dye pH tests showed 12-13 pH in both areas. some signs of TPS II effect showed on the aggregate in rainbow dye test of the treated area. acid reactivity tests were similar in both areas. Weather conditions prohibited performance of GWT permeability tests. Based on the limited findings, the asphalt penetration test was inconclusive. SURTREAT has a vacuum injection system available for deeper penetration of product. We will pursue testing this new technology to determine its applicability to asphalt penetration. Obviously, impervious membranes would preclude any penetration. At the same time, corrosion testing was done on several areas of the Erick bridge. Corrosion tests, shown below, demonstrate dramatic improvements with the minimum rates being cut in half and the maximums reduced by a factor of 1.6 thus extending the service life.

(Because of the difference in temperature and humidity conditions during testing in August and November, we calculated a compensation factor to provide a relatively conservative comparison of the test data. Corrosion activity diminishes as temperatures fall.)

Erick Bridge Corrosion Rate Measurements

Before treatment (August 2002-12 measurements

Measurement	Corrosion Current $\mu A/Cm^2$	Corrosion Rate $\mu M/yr$
Minimum	2.6	30
Average	5.1	59
Maximum	8.4	97

Before treatment-Temperature adjusted for 10° centigrade differential at times of testing

Measurement	***Corrosion Current $\mu A/Cm^2$***	***Corrosion Rate $\mu M/yr$***
Minimum	***1.3***	***15***
Average	***2.5***	***29.5***
Maximum	***4.2***	***48.5***

After treatment with TPS II and TPS XII (November 2002-11 measurements)

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.65**	**7.5**
Average	**1.16**	**13.5**
Maximum	**2.6**	**30.2**

Sayre Bridges Testing and Treatment

Prior to treatment in late July, several tests were performed to provide baseline information. Treatment protocols utilized in the test panels are SURTREAT TPS formulations 2, 4, and 12. In addition, a test panel was left untreated on each bridge to provide for any additional baseline information. Both Sayre bridges were tested for water permeability using Germann GWT equipment. A Capo Pull-out test was performed on the Eastbound bridge and corrosion measurements were taken on both bridges using the GalvaPulse system.

Demonstration Protocol

On July 30, the westbound Sayre bridge was treated on panel 1 with TPS 12, applied at a rate of 150 sq. ft. per gallon followed by several water mistings to maintain moist pavement for 1 hour following treatment. On July 31, the same panel was treated with three applications of TPS 2, totaling of 100 sq. ft. per gallon and misting with water between treatments. All pavement was flushed with clean water and allowed to dry before opening to traffic. Westbbound test panel 2 was treated July 30 with three applications of TPS 2 totaling 100 sq. ft. per gallon, followed immediately with water misting and then flushing before opening to traffic.

The Eastbound Sayre bridge test panel 1 was treated on July 30 with TPS 2 at a total rate of 150 sq. ft. per gallon, using 2 applications followed by one application of TPS 4 at a rate of 250 sq. ft. per gallon, followed with water misting and then flushing with water to remove any surface residual. Eastbound test panel 2 was treated with TPS 12 on July 30 and 31 at a rate of 150 sq. ft. per gallon, followed by misting and flushing.

A bend cap, (on the east end of the bridge), which was severally spalled, with exposed rebar, was treated with TPS 2 at a rate of 100 sq. ft. per gallon.

Sayre Bridge Tests Summary

The demonstration and test results show that limited application of Surtreat formulations have cut corrosion rates in half, doubling the service life of the structure,(where treated). Higher application rates and more thorough surface preparation can provide even greater service life extensions. The porosity reductions achieved are important in reducing future penetration of water, chlorides and other elements essential to the corrosion cycle.

Sayre Westbound deck

Concrete pH—Carbonation Depth
At a depth of 0-1 inch pH was measured at 12 using indicator dye. The carbonation front measured by indicator dye was at a depth of 0.125 prior to treatment. After treatment, indicator dye test at the 0-1inch level measured a pH of 12-13,

CAPO PULLOUT TEST MEASUREMENTS
Before treatment August 2002

28 Kn	4300 psi

After treatment withTPS II at 100 sf/gal November 2002

32 Kn	4900 psi
2nd location At 15 Kn concrete shattered	Test failure due to compression ring jamming

GWT Water Permeability Test Measurements
Before treatment August 2002

Atmospheres of pressure	Units of water	Absorption time in sec	Flux rate mm/sec$^{x10^{-3}}$	Permeability in mm/sec
1.8	10	297	0.88	0.05

After treatment with TPS II at 100 sf/gal November 2002

Atmospheres of pressure	Units of water	Absorption time in sec	Flux rate mm/sec$^{x10^{-3}}$	Permeability in mm/sec
1.8	10	478	0.55	0.03

Permeability reduced by a factor of 1.6

Sayre Eastbound Deck

GWT Water Permeability Test Measurements
Before treatment August 2002

Atmospheres of pressure	Units of water	Absorption time in sec	Flux rate mm/sec$^{x10^{-3}}$	Permeability in mm/sec
2.0	10	60	4.3	.32

After treatment with TPS II at 100 sf/gal November 2002

Atmospheres of pressure	Units of water	Absorption time in sec	Flux rate mm/sec$^{x10^{-3}}$	Permeability in mm/sec
2.0	10	266	1.0	.0.07

Permeability reduced by a factor of 4.4

These tests demonstrate the potential for reduction in permeability-ranging from a factor of 1.6 to 4.4. Combined with compressive strength increase of 600 psi, this reduction in permeability will substantially reduce penetration of chlorides, oils, acids and water which degrade the concrete and fuel corrosion of the rebar.

Sayre Westbound Deck Corrosion Rate Measurements

Before treatment August 2002 (36 measurements)

Measurement	Corrosion Current $\mu A/Cm^2$	Corrosion Rate $\mu M/yr$
Minimum	1.4	16
Average	3.4	39
Maximum	13.0	151

Before treatment-Temperature adjusted for 20° centigrade differential at times of testing

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.35**	**4.2**
Average	**0.85**	**10.0**
Maximum	**3.25**	**37.7**

After treatment with TPS II at 100 sf/gal and TPS XII at 150ssf/gal November 2002 (15 measurements)

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.10**	**1.16**
Average	**0.15**	**1.7**
Maximum	**0.24**	**2.8**

After treatment with TPS II at 100 sf/gal November 2002 (10 measurements)

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.05**	**0.58**
Average	**0.15**	**1.74**
Maximum	**0.34**	**3.94**

Sayre Eastbound Deck

Before treatment August 2002 (36 measurements)

Measurement	Corrosion Current $\mu A/Cm^2$	Corrosion Rate $\mu M/yr$
Minimum	0.6	7
Average	5.9	68
Maximum	40	464

Before treatment-Temperature adjusted for 10° centigrade differential at time of testing

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.3**	**3.5**
Average	**2.95**	**34**
Maximum	**20**	**232**

After treatment with TPS II at 150 sf/gal and TPS VI at 250sf/gal November 2002 (40 measurements)

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.10**	**1.16**
Average	**2.0**	**23**
Maximum	**9**	**107**

Sayre Eastbound bent cap Corrosion Rate Measurements

Before treatment August 2002 (12 measurements)

Measurement	Corrosion Current $\mu A/Cm^2$	Corrosion Rate $\mu M/yr$
Minimum	5.9	68
Average	9.2	107
Maximum	19	220

Before treatment-Temperature adjusted for 10° centigrade differential at times of testing

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**2.95**	**34**
Average	**4.6**	**53**
Maximum	***9.5***	***110***

After treatment with TPS II-3 applications, and TPS XII-1application November 2002 (17 measurements)

Measurement	**Corrosion Current $\mu A/Cm^2$**	**Corrosion Rate $\mu M/yr$**
Minimum	**0.16**	**1.8**
Average	**0.23**	**2.6**
Maximum	**0.28**	**3.2**

For more information on the demonstration and test results or details on SURTREAT formulations, contact:

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