Research Report
KTC-09-02/KH59-07-1F

KENTUCKY TRANSPORTATION CENTER

EXPERIMENTAL PAINTING OF THE I-64 RIVERSIDE PARKWAY IN LOUISVILLE, KY

UNIVERSITY OF KENTUCKY
College of Engineering

OUR MISSION

We provide services to the transportation community
through research, technology transfer and education.
We create and participate in partnerships
to promote safe and effective
transportation systems.

OUR VALUES

Teamwork
Listening and communicating along with
courtesy and respect for others.

Honesty and Ethical Behavior
Delivering the highest quality
products and services.

Continuous Improvement
In all that we do.

Research Report
KTC-09-02/KH59-07-1F
Experimental Painting of the I-64 Riverside Parkway in Louisville, KY

By

Rick Younce
Transportation Technician

Theodore Hopwood II
Associate Engineer III, Research

And

Sudhir Palle
Associate Engineer II, Research

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

In cooperation with
Kentucky Transportation Cabinet
Commonwealth of Kentucky

February 2009

<table>
<tr><td>1. Report No.

KTC-09-02/KH59-07-1F</td><td colspan="2">2.Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="3" rowspan="2">4. Title and Subtitle
Experimental Painting of the I-64 Riverside Parkway in Louisville, Ky</td><td colspan="2">5. Report Date
February 2009</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="3">7. Author(s) Rick Younce, Theodore Hopwood and Sudhir Palle</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="3" rowspan="2">9. Performing Organization Name and Address
Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, KY 40506-0043</td><td colspan="2">10. Work Unit No. (TRAIS)</td></tr>
<tr><td colspan="2">11. Contractor Grant No.
KHIT 59</td></tr>
<tr><td colspan="3" rowspan="2">12. Sponsoring Agency Name and Address
Kentucky Transportation Cabinet
State Office Building
Frankfort, KY 40622</td><td colspan="2">13. Type of Report and Period Covered
Final</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code</td></tr>
<tr><td colspan="5">15. Supplementary Notes
Prepared in cooperation with the Kentucky Transportation Cabinet, Federal Highway Administration, and U.S. Department of Transportation. Study Title: Disposal of Bridge Paint Debris</td></tr>
<tr><td colspan="5">16. Abstract

The Kentucky Transportation Cabinet conducted a large-scale zone maintenance painting operation on 13 elevated steel bridges along the I-64 Riverside Parkway in Louisville, KY in 2007. That work included abrasive blast-cleaning and painting of steel underlying open deck joints on 3.2 miles of steel structures. The painting was performed by spray application of one coat of a calcium sulfonate alkyd coating. The painting covered an area of 237,060 ft^2 of steel cleaned and painted at a unit cost of
$15.82/$ft^2$.

The project incorporated a high level of containment as the existing coating possessed lead-based paints and the project was located in a densely populated area. The project was successfully completed in 4 months. Follow-on inspections conducted at 2 and 14 months respectively indicated that almost all of the zone painting was in good condition and performing satisfactorily.</td></tr>
<tr><td colspan="3">17. Key Words
Blast-cleaning, Bridges, Calcium-Sulfonate Alkyds, Coatings, Deck Joints, Painting, Steel, Structures, Zone Painting</td><td colspan="2">18. Distribution Statement
Unlimited with the approval of the Kentucky Transportation Cabinet</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td colspan="2">20. Security Classif. (of this page)
Unclassified</td><td>21. No. of Pages
39</td><td>22. Price</td></tr>
</table>

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

EXECUTIVE SUMMARY

The Kentucky Transportation Cabinet (KYTC) let a large-scale rehabilitation project on the I-64 Riverside Parkway in Louisville in the spring of 2007. A portion of the work included zone painting of steel on the superstructures at locations where significant corrosion had occurred (primarily at locations under open deck joints) since the bridge was last painted by overcoating in 1997-98.

While zone painting had not been employed by KYTC in the past, it will probably be used more widely in the future along with spot painting to extend the service lives of protective coatings on steel bridges. The I-64 zone painting work employed experimental special notes for cleaning and coatings application developed by the KYTC Division of Maintenance. Those notes provided for abrasive blasting of the underlying steel at joint areas followed by the application of a single coat of calcium-sulfonate alkyd paint colored light beige to match the existing paint.

Gohmann Asphalt and Construction, Inc., the lone bidder, was awarded the total contract for $61,596,000.00. The cost for experimental cleaning and painting of the expansion joints and a cross-frame retrofit was $3,750,000. KYTC officials estimated that 237,060 ft^2 of steel were to be cleaned and painted at a resulting unit cost of $15.82/$ft^2$. The Kentucky Transportation Center (KTC) was contracted to monitor the experimental spot painting work under Kentucky Highway Investigative Task 59 Experimental Painting on the Riverside Parkway.

The painting contractors used a high level of containment around the areas that were blast-cleaned and coated due to the presence of lead in the existing coating and to the dense population in the urban areas surrounding the project. The coatings work was successfully completed in six months (beginning in June 2007) without any major difficulties.

A post-completion walk through inspection from ground level was conducted by KTC researchers in January of 2008. It revealed that most areas had been satisfactorily completed. Minor rust or rust staining of the zone painted areas was detected on a few beam flanges and rockers. No other deficiencies were detected. A follow-on KTC inspection was conducted on the project in April 2009. At that time, the color matching of the zone painted calcium-sulfonate alkyd with the existing polyurethane paint was found to be inconsistent at several locations. Chloride measurements at beam ends under deck joints indicated low levels which were not expected to be problematic.

The painting project appears to be in good condition and it is performing satisfactorily. It should provide a decade or more of service in protecting the structural steel. The service life of the zone painting project will be determined in large part by the performance of the closed deck joints installed along the project.

BACKGROUND

The I-64 Riverside Parkway was constructed in the 1970s. At that time, the steel on the elevated deck-girder bridges was painted using a lead alkyd primer with two aluminum-pigmented alkyd topcoats. That paint served until the mid-1990s when the steel was overcoated with an aluminum pigmented moisture cure polyurethane spot primer and full intermediate coats and a topcoat of two-component aliphatic polyurethane (light beige color).

The overcoating project has performed very well except for locations directly under open deck joints (i.e. finger dams and sliding plate joints). Debris from the roadway spilled into troughs intended to protect the structural steel from rain water and deicing salts from the roadway. That debris clogged the troughs and caused water/chlorides to spill onto the structural steel under the joints resulting in extensive corrosion and rust staining in the joint areas (Figures 1 & 2). Initial efforts to conduct zone painting with multi-coat systems were thwarted due to high anticipated costs associated with the use of multi-coat zinc based systems. Increasing corrosion damage and rust staining diminished the appearance of the Parkway especially in areas where public parks and walkways ran under the Parkway on its east end.

Eventually, an opportunity arose to remediate the coating under the joint areas when the Kentucky Transportation Cabinet (KYTC) officials decided to conduct a large-scale rehabilitation along the project. The work ran along the Parkway between Preston Street and the Shawnee Expressway in downtown Louisville. It involved paving the roadway and bridge decks with an overlay of impermeable asphalt and repairing bridge joints along the Parkway. As part of that work, the troublesome open joint/trough systems were to be replaced with closed joints (strip seals) and other leaking closed joints along the project were to be replaced as well. As most of the overcoating system on the structural steel was in very good condition away from the open joints, KYTC officials chose to use zone painting on structural steel in the distressed joint areas rather than to completely repaint the structures.

Thirteen elevated steel structures on the Riverside Expressway (I-64) between mile points 1.3 and 5.00 were included in the project. The project bridge numbers and their locations were as follows:

- B00142 – 2nd St. to Preston St./Bridge/Ramps
- B00292 – 2nd St. to 7th St. Bridge
- B00293 – 7th St. to 13th St. Bridge
- B00285 – 13th St. to 17th St. Bridge
- B00298 – I-64 WB Ramp to 9th St.
- B00299 – 9th St. Ramp to I-64 EB
- B00300 – 9th St. Ramp to I-64 WB
- B00301 – Main St. Ramp to I-64 EB

- B00302 – I-64 EB Ramp to 9th St.
- B00281 – I-64 EB Ramp to 22nd St.
- B00282 – I-64 over 22nd St. & Northern Parkway
- B00283 – I-64 over K&IT RR and 27th St.
- B00284 – I-64 over Southern RR

In April 2007, KYTC awarded rehabilitation project IM 64-2(157) to Gohmann Asphalt and Construction, Inc. of Clarksville, IN for $61,596,000.00. For the zone painting portion of the work, the contractor was to clean and paint the structural steel 1) beneath and adjacent to the expansion joints and 2) on a cross-frame retrofit being performed on the elevated steel structure between 2nd Street to 7th Street (B00292). The cost of cleaning and painting of the expansion joints and cross-frame retrofit was $3,750,000. Approximately 237,060 ft^2 of steel were to be cleaned and painted yielding a unit cost of $15.83/ ft^2. Though this project involved painting limited areas, the number of those to be painted on each structure and the number of structures equated to the area of a large multi-lane overpass bridge. The need to set up and break down painting operations at each deck joint undoubtedly resulted in the high unit cost for the zone painting work.

The Kentucky Transportation Center was contracted to monitor the experimental zone painting work under Kentucky Highway Investigative Task 59 “Experimental Painting on the Riverside Parkway”. This report addresses the zone paint work performed under that study.

SPECIAL NOTES

The contract for this project included experimental special notes for developed for the paint work and related items. Those included:

- Bidding or Subcontractor Prequalification and Staffing,
- Surface Preparation and Paint Application,
- Surface Preparation Residue Management,
- Paint,
- Quality Control,
- Environmental and Worker Safety Regulations,
- Pre-Bid Conference,
- Payment,
- Controlling and Maintaining Traffic

In addition to the special notes the contract required that all work be done in accordance with the Kentucky Transportation Cabinet, Department of Highways, and Standard Specifications for Road and Bridge Construction.

The primary special notes about the paint and factors related to its application are discussed below.

CONTAINMENT

Containment requirements employed by KYTC for each bridge maintenance painting projects are customized to project circumstances (existing coatings, type of surface preparation, type of coatings application (and coating materials), along with the sensitivity of the environment. The containment requirements imposed on the contractor were the same for all project paint sites (joints and cross members).

The contractor was to totally enclose all cleaning and painting operations during all phases of work. The containment was to meet the criteria for SSPC Guide 6/NACE NO. 3, "Commercial Blast Cleaning" Standard – Containment Classification Class 2A (i.e. using flexible containment materials). The containment was to use negative air pressure meeting the requirements of Type H2 (e.g. the walls flexible containment would become concave when the negative pressure was applied). To achieve negative pressure painting contractors normally used vacuum trucks with HEPA filter systems to draw lead-contaminated air from abrasive blasting from the containment structures through large ducts. To ensure emission control, the contractors were to visually inspect the exterior areas around the containment using Method A – Visible Emissions of SSPC Guide 6.

Those stringent conditions were imposed due to: 1) the presence of lead in the existing paint, 2) the tendency for abrasive blasting to create fine, airborne particles of paint debris and 3) the proximity of people, businesses, schools and houses to the project. The proper use of containment was considered as important as any other engineering factor on the project. While the coating specified for this project rarely caused overspray damage, contractors spraying the material had the option of leaving the containment in place during coatings application to minimize the possibility of overspray damage to vehicles and building in close proximity to the work.

CLEANING AND SURFACE PREPARATION

The cleaning and surface preparation specifications did not vary from those normally used on full painting projects employing abrasive blasting or overcoating.

Prior to painting all visible oil, grease, and other surface contaminants had to be removed from steel substrates using only solvents or detergents acceptable to the coating manufacturer and KYTC.

Prior to surface preparation at the joint areas, stratified rust had to be removed from all structural steel beneath and adjacent to the joints. All structural steel within five feet each side of all bridge expansion joints were to be abrasively blasted to SSPC-SP 14/NACE NO. 8 "Industrial Blast Cleaning" Standard as per SSPC-VIS 1. For cross-frame retrofit locations at B00292, all damaged coating areas two feet on each side of cross frame retrofit locations were to be cleaned to an SSPC-SP3 condition per SSPC-VIS 3. Needle guns were not permitted to be used for any surface preparation. Contractors were given the option of using expendable or recyclable grit for abrasive blasting. Most painting contractors possess equipment to use recyclable steel grit and favor using it due to the reduction in paint residue compared to the use of expendable abrasives. On this project, both painting subcontractors used recyclable steel grit.

Compressed air used for abrasive blasting was to be checked for contamination from moisture or oil using the blotter test (ASTM D 4285).

PAINTING SPECIFICATIONS

Painting of the expansion joints and cross members was to employ a single coat of calcium sulfonate alkyd paint from the KYTC List of Approved Materials maintained by the Division of Maintenance. Calcium sulfonate alkyds had performed well when properly applied (i.e. with sufficient coating thickness). The coating relied on the affinity of calcium sulfonate for steel and the high pH of the paint to suppress corrosion reactions. The coating was also selected for its ability to be applied successfully over a wide range of film builds (i.e. coating wet and dry film thicknesses). It was likely that the contactors would encounter irregular substrates due to past corrosion damage and it was unlikely that they would be able to maintain specific film builds in those areas.

The color was selected to match the existing beige used on the 1997-98 overcoating project; I-65 Kennedy Bridge at the east end of the project and the approach ramps to the I-65 Kennedy Bridge. It was to be a beige originally corresponding to Federal Color Standard # 36521, however, the Special Notes specified the color by referring to the CIE Laboratories Color Scale of: Light-to-Dark (L*=75.10), Red-to-Green (a*=1.90) and Blue-to-Yellow (b*=8.81). This digital form of defining colors is based upon a universal standard for quantitative color measurement (1).

Watson Coatings *8300 Armor-Shield Calcium Sulfonate Alkyd* was employed on the project. The coating was applied by spraying at 17 – 25 wet mils. That would provide a resulting dry film build of 10 – 15 dry mils. Batches/shipments of the coating were to be sampled on arrival at the job site. Before the coating could be used on the project, the samples were to be tested by the Division of Materials for conformance with previous qualification samples submitted by Watson Coatings and characterized by the Division of Materials/performance tested by KTC.

OTHER COATINGS-RELATED SPECIAL NOTES

Several other special notes pertained to work performed by the painting subcontractors. Those primarily related to workmanship, inspection and disposal of industrial wastes and surface preparation debris. They conformed to standard Special Notes applied to full painting projects.

The painting project employed a QC-QA quality system with the contract/painting subcontractor responsible for quality control (QC) and KYTC inspectors for quality assurance (QA). The quality system incorporated Control Point inspections requiring both QC and QA inspections at various stages of work. No paint was to be applied until the prepared substrates had been inspected and approved by the resident engineer. Paint could only be applied to clean dry surfaces. Any defects on the newly painted surfaces were to be repaired. In addition to that, each painting subcontractor was required to prepare and paint a test patch in accordance with the specifications. The test patch had to be approved by KYTC officials and was retained throughout the duration of the project as a reference should disputes arise about the quality of work at other locations. The variation of color of the applied paint was to conform to the values specified in the Special Notes (see Painting Specifications above) within 1.5 ΔE as determined by a spectrophotometer utilizing at D65 illuminant at 45^o illumination and 0^o viewing using a 2^o observer. The variation in color (measured versus specified) is calculated by the formula:

$$\Delta E = (\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2})^{1/2} \qquad (1)$$

Where:
ΔE = Total color difference,
ΔL^* = Difference between measured and specified light-to-dark standard,
Δa^* = Difference between measured and specified red-to-green standard and
Δb^* = Difference between measured and specified blue-to-yellow standard.

Typically, normal observers can distinguish color variations > ΔE = 1.0. A color variation of ΔE > 1.5 would be readily observed from a location distant from the bridge.

Industrial waste disposal/surface preparation debris recycling was also included in the special notes. Industrial wastes/surface preparation debris was to be collected and stored in secured enclosures until disposal/recycling. The contractor/painting subcontractors were to have a “competent person for lead abatement” as required by OSHA 1926.62 with formal training as well as practical experience. Recycling of the surface preparation debris was to be done at the Doe Run Company facility at Boss, MO.

PROJECT OVERVIEW

Gohmann Asphalt and Construction, Inc. subcontracted the cleaning and painting of the expansion joints and the cross frame retrofits to Bridges R Us Painting Company Inc. of Campbell, OH and Eagle Painting & Maintenance Co. Inc. of Lansing, IL.

Eagle Painting & Maintenance Co. painted the expansion joints on bridges B00142, B00281, B00282, and B00284. They also painted several joints on bridges B00283, B00292, B00300, and B00302 and were responsible for painting the cross-frame retrofit on bridge B00292. A paint test patch was performed by the contractor on July 13, 2007 on bridge B00142. The subcontractor and KYTC agreed on the quality of the surface preparation and coating application based upon the completed test patch. The subcontractor was then allowed to proceed with the cleaning and painting of the expansion joints and the general contractor supervised the progress of work performed by both painting subcontractors.

Bridges R Us Painting Co., Inc. successfully prepared a paint test patch on July 23, 2007 on bridge B00300. Thereafter, that firm cleaned and painted the expansion joints of its assigned bridges (B00285, B00293, B00298, B00299, and B00301). It also painted several joints on B00283, B00292, B00300 and B00302.

In performing the work, the subcontractors usually prepared bulkheads to separate the portions of a structure that were to be cleaned from the rest of the steel to prevent damage from the blasting abrasive (Figure 3). After preliminary solvent/detergent cleaning and removal of any stratified rust (typically performed by hammering), containment enclosures were placed around the joint areas to contain airborne debris generated by abrasive blasting (Figure 4).

Once the containment enclosure was completed, negative pressure was created using vacuum systems connected to the enclosures by large ducts (Figure 5). The negative pressure could be observed in the flexible containment by the concave shape created in the containment walls (Figure 6). The painting subcontractors used a variety of containment designs both elevated and draped to ground level (Figures 7 – 9). The provision to use flexible containment gave the painting subcontractors sufficient latitude to employ a variety of innovative and low-cost enclosures.

Both painting subcontractors elected to use recyclable steel grit abrasive to limit the amount of hazardous waste generated due to the presence of lead paint residue from the original steel coating. That entailed the use of large trailer-mounted recycling units (Figure 10). Those units contained vacuums that were connected to hoses. Workers used the hoses to pick up surface preparation debris and grit from a ground tarp or bottom lining of the containment enclosures. That material would go through several screening procedures to separate the lead paint residue and rust along with the spent steel grit from the grit that was reusable. All surface preparation debris and related wastes from the air vacuum units would be separated and stored for recycling (Figure 11).

The abrasive blasting operation prepared the steel substrate for coating application (Figures 12 & 13). The SSPC SP-14 “Industrial Blast Cleaning” was not a high-grade of surface preparation, but was employed to keep the coatings costs to a reasonable level. In some cases, inadequate surface preparation was detected and the painting subcontractor had redo his work (Figure 14).

After the surface preparation (abrasive blasting at the joints and power tool cleaning at the cross-frame retrofit) was accepted, the painting subcontractor applied the calcium sulfonate alkyd, typically by spraying (Figure 15 & 16). Some new steel was present at the joint locations under the deck as part of the new closed joint installations. That steel was also painted with the calcium sulfonate after blast cleaning (Figure 17). The coating application was occasionally subject to common coatings issues including excessive film build and misses (Figures 18 & 19). At some locations the new paint highlighted existing section loss on the corrosion-damaged steel (Figure 20).

Upon completion of the work on a bridge, the subcontractors would shift to the next one leaving a crew behind to complete any required touch-up work at the joints including work that was detected during final QA inspections (Figures 21 & 22).

The subcontractors finished cleaning and painting and KYTC accepted all painting work by November 19, 2007. KTC inspections during the project revealed that the completed zone painting varied in color conformity with the existing paint (Figures 23 & 24).

KTC PROJECT INSPECTION AND FIELD TESTING

KTC researcher conducted several follow-on inspections of the project after it was completed. A post-completion walk through inspection of the entire project was performed from ground level in January 2008. In April 2009, KTC researchers measured color conformity of the existing and new coatings at several locations along the project and measure soluble salt (chloride) contamination at substrate level and on the surface of the new coating.

PROJECT INSPECTION

The January 2008 walk-through inspection revealed that most areas had been satisfactorily completed. Color variations between the existing and the new coatings were observed at many locations along the project. At most joints, the new coating had been applied for a distance at least 5 feet from the joints (Figures 25 & 26). Minor rust or rust staining was also observed on some of the flanges and rockers (Figures 27 – 29). No other deficiencies were encountered during this inspection.

This inspection revealed that the project was in overall good condition and most of the work conformed to the project special notes. The calcium sulfonate alkyd coating had not experienced significant soiling (a major concern with that coating due to its extended time-of-wetness). While the coating was flat, compared to the existing high-gloss polyurethane topcoat, the two coating systems had a similar sheen due to weathering of the polyurethane. The only observable variation between the existing and new coatings related to color.

FIELD TESTING

In April 2009, KTC took color readings at 10 locations of both the existing polyurethane system and calcium sulfonate alkyd system at/near the joints. In part this study was to investigate the color discrepancies between the two systems at several locations along riverside parkway.

The beige color used on the original overcoating project was referenced to the previously mentioned Federal color number. The paint manufacturer was asked to supply a slightly darker paint than was supplied by one manufacturer for that project over approximately three years from 1997 – 99. The Division of Materials began color testing about halfway through that project. The existing paint weathered about 10 years prior to the zone painting project. On the latter project, the calcium sulfonate alkyd supplier initially provided some paint that did not meet the color specification. That was discovered and corrected shortly after the project began. However, the initial off-color paint was applied on several structures. Apparently, it was a reasonable match with the existing paint and was accepted by KYTC. KTC researchers observed the color variance during the January 2008 inspection and wanted to determine how significant the colors of the existing and zone painting varied based upon spectral analysis.

Typically, three readings were taken on the exterior web face that is exposed to weathering elements (e.g. sunlight and rain) and about the same number of readings was taken at sheltered locations on the interior of the bridge (Figure 30). The readings were used with L*, a*, b* values from the Federal Standard for beige to compute ΔE (total color difference) values. For the most part, the colors of both systems varied significantly from the specified standard color (Table 1). On the exterior surfaces, the calcium sulfonate varied from the standard by 2.41 to 7.43 ΔE. On the interior surfaces, the calcium sulfonate varied from the standard by 2.49 to 13.81 ΔE. On the exterior surfaces, the polyurethane topcoat varied from the standard by 1.15 to 6.78 ΔE. On the interior surfaces, the polyurethane topcoat varied from the standard by 5.46 to 14.67 ΔE.

The greater variance of both coatings on the interior surfaces versus the exterior ones is hard to explain. A second comparison involved computing ΔE values between the calcium sulfonate coatings on the exterior versus the interior and the polyurethane between the exterior and interior (Table 2). The calcium sulfonate showed significant exterior to interior variance at only 3 of the 10 test locations. At the other locations, the ΔE values were at or below 1.0. The polyurethane topcoat showed significant exterior to interior variance at 5 of the 10 test locations. This was probably due to its service life of over 10 years with the higher likelihood of chalking/weathering on exterior surfaces. The calcium sulfonate and polyurethane exterior ΔE values were greater than 2.0 at 7 of 10 sites. The calcium sulfonate and polyurethane interior ΔE values were greater than 2.0 at 6 of 10 sites though the magnitudes of the ΔE values were generally less.

Surface soluble salt contamination tests were performed at the same locations as color readings using CHLOR*TEST and Bresle tests to find any retained chlorides in the structure (Table 3). These tests were conducted at beam ends under deck joints to ensure the highest probability that any surface soluble salts/chlorides would be detected (Figure 30). Typically, two tests would be performed at each location using each test method. One set of tests would be conducted on the surface of the paint and the second would be performed at the substrate after the calcium sulfonate alkyd coating had been removed by light grinding using a 3M abrasive pad (Figures 31 – 34). For the latter test, the objective of the preliminary surface testing was to remove most of the surface paint down to the abrasively blasted steel substrate. If any surface chlorides remained prior to painting, it was anticipated that they would still be present and detectable. At each test location the new closed joints were in very good condition and there were no signs of joint leakage (Figure 35). It was likely that any chlorides detected on the surface of the paint were due to aerosols generated by traffic driving on wet roadways above the deck girders.

The test results indicated that some small concentrations of chlorides were present on the surfaces of the paint under deck joints. The CHLOR*TEST results showed soluble salt (chloride) concentrations from 0 – 60 $\mu g/cm^2$ and the Bresle tests indicated conductivities from 0-59 $\mu s/cm^2$. At most locations, the chloride concentrations (or conductivity indications thereof) were low. At the steel substrates the soluble salt concentrations were generally lower (0 – 30 $\mu g/cm^2$ for the CHLOR*TEST and 0-35 $\mu s/cm^2$ for the Bresle test). Some of the test values are above those normally considered acceptable for abrasively blasted substrates prior to painting (acceptable limits usually specified <10 – 20 $\mu g/cm^2$ for CHLOR*TEST or <30 $\mu s/cm^2$ for the Bresle test). It is interesting to note that small rust pits were encountered at several substrate test locations that provided higher soluble salt/chloride surface test values (Figure 36).

CONCLUSIONS

The contractor officially completed the entire project on November 30, 2007. It was completed generally in accordance with the specifications. The paint work was performed without incident which is notable as the work was conducted in a highly congested urban setting.

The KTC follow-on inspection found the paint work to be in overall good condition. At a few sites, mostly edges of flanges or floor beams, rust-back was occurring either due to high soluble salts remaining on the steel prior to painting or to inadequate film build during coating application. This problem has been observed on other maintenance painting projects. KTC researchers did not investigate the coating thickness of the new paint as that is normally part of the QC-QA process. Some staining was observed from leakage at longitudinal joints-but that probably is unavoidable (or difficult to remedy). At a few locations, it appeared that the painting subcontractors had not blasted/repainted the steel five feet from the joint. However, at all locations, the painting subcontractors had blast cleaned and repainted all corroded steel and distressed existing paint within five feet of all joints inspected.

The color readings taken at various locations along the project show that on some bridges there is a clear distinction between the two coating systems, a fact this is readily confirmed by cursory visual inspections. No clear reason could be divined from the testing to explain the large color differences of both the calcium sulfonate alkyd and the polyurethane topcoat from the values specified in the special notes. KYTC did not require the contractor to correct the coating color based upon the workmanship provision in the special notes. Subjectively, KTC researchers did not find the color differences between the existing polyurethane topcoat and the new calcium sulfonate to be a critical issue.

The soluble salt/chloride tests indicate that some of the substrates were still chloride contaminated when painted and though the soluble salt/chloride levels are fairly low, they may prove problematic in the future. The higher readings on the surface of the paint (60 $\mu g/cm^2$ and $\geq$ 30 $\mu s/cm^2$) indicated that chlorides could probably accumulate on the steel surfaces in sufficient quantity to promote steel corrosion in the future if not removed (despite the presence of a protective coating).

During the field testing, KTC researchers observed ragged parting lines that were created when the painting subcontractors conducted abrasive blasting operations and removed the existing paint five feet from the joints (Figure 37). While the painting subcontractors lapped all of those edges with new paint, there is some concern about eventual failure of the existing polyurethane topcoat at those locations. It probably would have been desirable to feather those edges with power tools prior to applying the new paint.

The zone painting work achieved its desired purpose and remedied a persistent corrosion problem. While the aesthetics of the zone painting work is not perfect, it is a definite improvement over the rampant corrosion/rust staining that it replaced. The durability of the zone coating will be tied to the performance of the new closed deck joints. If they are properly maintained and promptly replaced when they begin to leak, the zone painting will provide a decade or more of good service. If those joints are not well maintained, the zone painting will begin fail shortly after the closed joints begin to leak.

RECOMMENDATIONS

The following recommendations pertain to this and future coatings projects:

1. Expand the use of zone and spot painting to extend the performance of existing coatings on steel bridges.
2. Investigate the testing for soluble salts prior to painting.
3. Consider striping edges of girders, beams, and stiffeners with coatings prior to overall painting to eliminate thin spots and prevent early edge/corner rust-back.
4. Maintain the condition/function of closed deck joints and seek to replace open deck joints where practical.
5. Wash bridge steel located below decks on an annual basis to remove chlorides.

REFERENCES

1. http://en.wikipedia.org/wiki/Lab_color_space

TABLES

Table 1. Color variations (ΔE) calculated versus L*, a*, b* values for beige (Federal Standard No. 36521 – L*=75.10, a*=1.90 and b*=8.81) from spectrophotometer readings at various test locations along the project.

Test Location	ΔE Calcium Sulfonate Exterior	ΔE Polyurethane Exterior	ΔE Calcium Sulfonate Interior	ΔE Polyurethane Interior
3rd Street Exit Ramp	2.41	3.37	4.51	4.53
9th Street Intersection On Ramp EB	2.98	5.93	4.03	7.18
9th Street Intersection On Ramp WB	2.71	5.19	3.04	5.15
9th Street Intersection Off Ramp from EB	2.65	5.34	2.49	5.46
22nd Street Mainline EB East Side	6.17	1.15	6.27	6.54
22nd Street Mainline WB East Side	6.44	5.60	6.60	4.97
22rd Street EB Off Ramp East End South	6.73	6.60	13.81	9.50
22rd Street EB Off Ramp North Side East	7.43	6.78	13.02	14.67
Mainline Over Northwestern Street EB	5.75	2.79	5.71	6.52
Mainline Over Northwestern Street WB	5.98	1.32	6.03	7.42

Table 2. Color variations for spectrophotometer readings from various test locations along the project.

Location / Color Readings Comparison (ΔE)	Calcium Sulfonate Exterior vs. Interior	Polyurethane Exterior vs. Interior	Calcium Sulfonate Exterior vs. Polyurethane Exterior	Calcium Sulfonate Interior vs. Polyurethane Interior
3rd Street Exit Ramp	2.91	1.33	2.02	0.85
9th Street Intersection On Ramp EB	1.11	1.76	4.01	4.00
9th Street Intersection On Ramp WB	0.59	0.76	2.71	2.35
9th Street Intersection Off Ramp from EB	0.26	1.06	3.26	3.09
22nd Street Mainline EB East Side	0.47	6.42	5.71	1.58
22nd Street Mainline WB East Side	0.51	2.76	1.67	2.05
22rd Street EB Off Ramp East End South	7.57	3.06	1.11	4.32
22rd Street EB Off Ramp North Side East	6.09	1.96	1.06	1.96
Mainline Over Northwestern Street EB	1.32	3.74	3.11	1.30
Mainline Over Northwestern Street WB	0.91	6.33	4.75	2.60

Table 3. Chloride Readings taken at various locations along the project

Location / Chloride Analysis	Test Location	CHLOR* TEST On Paint (μg/cm²)	CHLOR* TEST After Paint Removal (μg/cm²)	Bresle Test On Paint (μs/cm²)	Bresle Test After Paint Removal (μs/cm²)
3rd Street Exit Ramp	Fascia Girder Bearing Seat	0	3	0	0
	Inside fascia	0	15	0	0
9th Street Intersection On Ramp EB	Fascia Girder East Side	0	0	0	0
	Fascia Girder West Side		3	24	18
9th Street Intersection On Ramp WB	East Fascia	5	0	23	19
	West Fascia	15	10		
9th Street Intersection Off Ramp from EB	East Fascia	7	10		
	West Fascia		5		
22nd Street Mainline EB East Side	East Fascia	15	10	32	27
22nd Street Mainline WB East Side			30	59	22
22rd Street EB Off Ramp East End South		60	10	27	35
22rd Street EB Off Ramp North Side East		20	12	30	28
Mainline Over Northwestern Street EB			20	27	31
Mainline Over Northwestern Street WB		60	25	30	15

FIGURES

Figure 1. Corrosion on underlying structural steel under open deck joint (1999).

Figure 2. Debris build-up on lower flange due to presence of open deck joint (1999) .

Figure 3. Bulkheads installed adjacent to a joint prior to cleaning and painting.

Figure 4. Crew installing containment enclosure at a joint area prior to cleaning and painting operations.

Figure 5. Vacuum system for applying negative pressure to containment enclosure and for collecting airborne fines. Unit is connected to two enclosures by large ducts.

Figure 6. Typical containment by Eagle Painting during blasting operations at the Riverfront Park. Note the concave shape of the containment walls (negative pressure).

Figure 7. Elevated containment enclosure at bridge B00299 the 9th Street Interchange to I-64 eastbound (Bridges 'R Us).

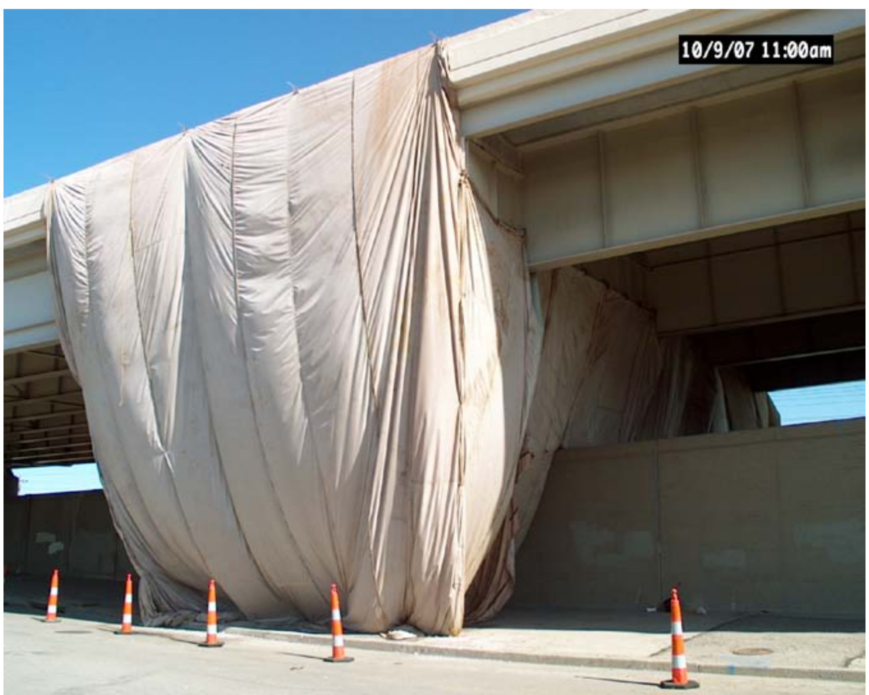

Figure 8. Grounded containment enclosure splitting a retaining wall at bridge B00282 on I-64 between 22nd Street & Northern Parkway (Eagle Painting).

Figure 9. Containment enclosure being installed at I-64 bridge abutment on B00285 (Bridges 'R Us).

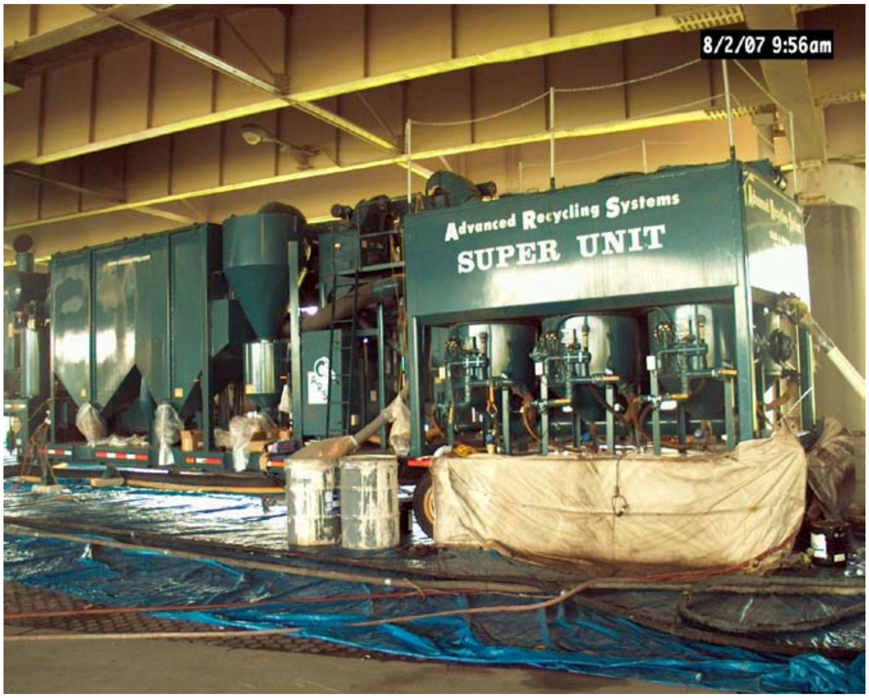

Figure 10. Typical steel grit recycling unit mounted on a trailer Note the steel drums used to collect the surface preparation debris.

Figure 11. Steel drums containing leaded surface preparation debris are stored in a fenced-in area for eventual disposal by recycling.

Figure 12. Properly blast-cleaned rocker at abutment ready for painting.

Figure 13. Blast-cleaned area at expansion joint ready for painting. Note the blast finish on the hanger and beam ends has visible traces of lead paint and mill scale.

Figure 14. Improperly blast-cleaned bolts with excessive rust residue that had to be re-blasted prior to painting.

Figure 15. Area near joint that has been blasted and partially painted near a bulkhead.

Figure 16. Area near cross-frame repair that has been power tool cleaned and partially painted on bridge B00292.

Figure 17. Coating on added steel under decks that is part of the new closed deck joints.

Figure 18. Areas on the bottom of cross bracing and a flange that have excessive paint build-up.

Figure 19. A missed spot on the backside of a fastener detected after painting.

Figure 20. Corrosion damage to a floor beam highlighted by application of the new coating.

Figure 21. Inspector examining completed coating at joint.

Figure 22. Worker using a brush to touch-up the coating on a bearing rocker.

Figure 23. An area approximately five feet from joint that was cleaned and painted by Eagle Painting. Note the color difference between the existing and new paint.

Figure 24. An expansion joint that was cleaned and painted by Bridges R Us. Note the similarity in color between the existing and new paint.

Figure 25. Zone painted floor beam and girders in good condition (January 2008).

Figure 26. Overall view of zone painted area in good condition (January 2008)

Figure 27. Rust-back at edge of a lower flange on a floor beam at an expansion joint (January 2008).

Figure 28. Zone painted area showing rust-back on edge of lower flange of a girder (January 2008).

Figure 29. Rust-back and staining due to leakage from longitudinal deck joint (January 2008).

Figure 30. Conducting soluble salt test on steel on deck joint (April 2009).

Figure 31. Removing paint to conduct soluble salt test at steel substrate (April 2009).

Figure 32. Extracting de-ionized water solution from Bresle patch on surface of coating (April 2009).

Figure 33. Using a conductivity meter on extracted de-ionized water solution from Bresle patch to measure soluble salts (April 2009).

Figure 34. Using a CHLOR*TEST sleeve/test solution to extract soluble salts from a steel substrate (April 2009).

Figure 35. Closed deck joint in good condition (April 2009).

Figure 36. Rust formation in pit at steel substrate (April 2009).

Figure 37. Ragged edge between existing paint on right and new paint on left (April 2009).

For more information or a complete publication list, contact us at:

KENTUCKY TRANSPORTATION CENTER

176 Raymond Building
University of Kentucky
Lexington, Kentucky 40506-0281

(859) 257-4513
(859) 257-1815 (FAX)
1-800-432-0719
www.ktc.uky.edu
ktc@engr.uky.edu