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FIELD INSPECTIONS OF HIGH-PERFORMANCE BRIDGE PAINTS

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16. Abstract

Paint inspections were performed on 19 steel bridges. Those structures employed various high-performance sacrificial and barrier paints. Those paints were used singly and in combination. The surface preparation varied for some of those paint systems. The inspections included four girder bridges that had original paint and 15 others, mostly trusses that were repainted. Kentucky Transportation Center personnel also monitored several bridges during repainting operations.

The inspections revealed that the original paint was in excellent condition. Most of the coatings on the repainted bridges were performing well. Some of those bridges have some spot corrosion. Only one of those bridges showed signs of widespread coating failure.

The high-performance coatings were performing well. Most of the corrosion and paint deterioration observed is believed to be related to inadequate surface preparation. Paint inspection provided by the Kentucky Transportation Cabinet is good.

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EXECUTIVE SUMMARY

High-performance paints are sacrificial and barrier paint coatings that have superior durability and corrosion to lead-based paints. High-performance paints are supplanting lead-based paints for most bridge painting applications. Those paints have improved performance characteristics; however, they have drawbacks in that very clean steel surfaces are required and they can only be applied in limited application environments.

The purpose of this study was to conduct visual inspections of a number of experimental Kentucky bridges having high-performance paints to assess their present condition. Those paints had been used by the Department of Highways since 1979. A list of 31 bridges having those systems was supplied by Transportation Cabinet officials. The list was the basis for selecting bridges for inspection.

Bridges having experimental high-performance paints were located throughout the state. The paints included sacrificial and barrier systems applied in various combinations. Also, several surface preparations were employed. Usually, an entire bridge was painted with one experimental paint system and comparisons with other paints were not possible.

Existing paint systems on 19 bridges were inspected. Four of those bridges had original paint. The remainder had been repainted. Those paint systems were from two to seven years old when inspected. All bridges having original paint were girder structures. Most of the repainted bridges were truss structures. In addition to those inspections, Kentucky Transportation Center personnel inspected maintenance painting operations on two bridges.

Inspections of the bridges having original paint revealed the coatings to be in excellent condition. No signs of deterioration were detected.

Most of the repainted bridges were in good condition. Most of those paint systems had a good appearance. The only signs of paint deterioration were fading and chalking. Some of the bridges had spot rusting. Several others had peeling paint. Only one of those paint systems was rated as being in poor condition at the time of inspection. None of the bridges had a massive coating failure.

The rust and peeling problems (which were not extensive) were considered more attributable to inadequate surface preparation than to poor application or an ineffective paint system. Surfaces on truss bridges are difficult to clean and paint. Contaminants may remain after cleaning. Previously corroded steel is very difficult to clean adequately. High-performance paints did not perform well on marginally cleaned steel.

Inspections revealed that most of the high-performance paint systems were performing very well. If the surface is given a near-white metal blast cleaning, high-performance paints will probably provide the desired durability and corrosion protection.

Field inspections of the bridges being painted indicated that Department of Highways paint inspectors are doing a good job of ensuring that the high-performance paints will be properly applied. That is supported by the good appearance of the paint on most of the experimental bridges which were inspected.

The good performance of those paints warrants their increased use on bridges. In the future, those paints should supplant oleoresinous lead-based paints for most applications.

INTRODUCTION

During the last 100 years, oleoresinous paints have been the most common protective coatings for steel bridges. In the last 25 years, several new bridge paint systems have been introduced. They are termed high-performance paints because they have better durability and corrosion resistance than oleoresinous paints. The superior characteristics of the high-performance paints coupled with recent health concerns about pigments in oleoresinous paints have resulted in their increased use.

Oleoresinous paints have good covering characteristics and are relatively insensitive to the quality of the surface to which they are to be applied. Cured oleoresinous coatings are permeable. Moisture may penetrate the coating and contact the underlying steel. For corrosion prevention, those coatings rely on the gradual dissolving of inhibitive ions from the paint pigment. Those ions drift to the steel surface and form a passive layer that prevents corrosion.

Oleoresinous paints most commonly used on bridges are the basic lead silico chromate (BLSC) and zinc chromate paints. They are employed with linseed oil and long-oil alkyd vehicles. The BLSC primers are commonly covered by mid- and topcoats containing colored or aluminum pigments. Typical service lives of those coatings vary from 10 to 15 years. Urban and industrial atmospheres usually contribute to decreased service lives. Rural atmospheres may provide increased service lives.

The corrosion protection offered by high-performance paint systems is based on 1) sacrificial coatings or 2) barrier coatings. Sacrificial coatings employ zinc powder dispersed in the paint as a pigment. Typical organic and inorganic zinc-based paints are permeable. They allow surface moisture to penetrate to the metal surface. In those paints, the zinc corrodes sacrificially in deference to the underlying steel. That provides rust protection even with coating voids such as scratches. Barrier coatings prevent surface moisture from penetrating and contacting the underlying steel surface. Barrier coatings also inhibit penetration by corrodant ions and oxygen further suppressing corrosion processes.

High-performance paints are more sensitive to application factors than oleoresinous paints. They must be applied to very clean surfaces. They are also relatively intolerant to deviations from ideal application conditions (i.e. humidity and temperature), coating thickness, and proper curing for multiple coats. When properly applied, they offer service lives ranging from 20 to 30 years.

The two types of high-performance paints may be used together as composite paint systems. Those systems offer extended performance and enhanced appearance. Sacrificial coatings must be used as primers because the zinc powder must be in intimate contact with the steel surface. Most barrier coatings have better surface appearance than inorganic zinc paints. They may be pigmented to provide the desired color for topcoats. Barrier coatings may increase the lives of zinc-based primers by reducing contact with moisture and corrodants. That prevents excessive depletion of zinc powder in the primer. Zinc primers limit the spread of corrosion at voids in barrier coatings . The most common combination paint systems employ an inorganic zinc primer having one or more vinyl (barrier) topcoats.

High-performance paints have lower life-cycle costs than oleoresinous paints due to their extended service lives. A recent publication noted that the life-cycle cost of a typical oleoresinous paint system was \$ 0.12 per ft^2 per year (over a 10-year life). That is compared to \$ 0.044 per ft^2 per year (over a 30-year life) for a sacrificial primer having two coats of barrier-type paint (1).

Current Kentucky Transportation Cabinet paint specifications incorporate several oleoresinous and high-performance paint systems. The oleoresinous paints include BLSC primers having alkyd mid- and topcoats. The high-performance paint systems are comprised of inorganic zinc or epoxy mastic primers. Those are used with epoxy mastic or vinyl mid- and topcoats (2). The Transportation Cabinet paint specifications contain both composition and performance requirements. Sample testing is required. The Division of Materials specifies those tests. Paints which meet specification requirements are included on a list of approved products and the primer and topcoat paints must be from the same manufacturer.

FIELD INSPECTIONS

The purpose of this study was to determine the performance of experimental high-performance bridge paints and coatings. Those coatings were first used by Transportation Cabinet in 1979 when an inorganic zinc/vinyl system was placed on the US 62 bridge over the Ohio River at Maysville.

In 1986, the Transportation Cabinet furnished Kentucky Transportation Center personnel with a list of experimental bridges that employed high-performance paints (3). Those coatings were used on nine new bridges and 22 existing bridges.

The new bridges were given a near-white blast cleaning prior to painting. The existing bridges had various surface-preparation treatments. Several of those bridges were spot-blast cleaned, though most were given a near-white blast cleaning. The paint systems used for the new girder bridges were 1- or 2-component inorganic zinc primers with vinyl topcoats. The maintenance paint systems ranged from inorganic zinc primers with epoxy mid coats, and vinyl or alkyd topcoats. Aluminized epoxy mastics and a sulfonated wax were also used as single-system coatings.

Due to the limited scope of this study, paint inspections were performed along with inspections of other bridge components. Those components were investigated as a separate subtask. Bridges having high-performance paint systems were widely disbursed throughout the state. A total of 17 of the listed bridges were inspected. In addition, the US 231 bridge over the Ohio River at Owensboro and the US 25 bridge over I 75 in Scott County were inspected during painting. Inspections were conducted between March 1986 to November 1987.

The intent of the study was to appraise the short-term performance of new paints. Kentucky Transportation Center inspections were limited to visual examinations of the structures. Those inspections included qualitative assessments of paint condition on various portions of the bridges. No attempt was made to measure coating thicknesses and retention, or to evaluate the coatings in a quantitative manner. A video camcorder was used to record the paint condition. During videotaping, Kentucky Transportation Center personnel provided commentary of what was being viewed and their impression of the performance of a paint system.

Bridge paint coatings inspected by Kentucky Transportation Center personnel are listed in Tables 1 and 2. Those coatings ranged in age from new to seven years old when inspected. Four of the bridges, all continuous girder structures, were painted during construction. Most repainted bridges were truss or combination truss/stringer bridges. A majority of those were multiple-span structures.

INSPECTION RESULTS

Summaries of the inspection results are presented in Tables 3 and 4.

Construction Painted Bridges

Four construction painted bridges were inspected. The paint coatings ranged from two to five years in age when inspected. The paint condition on all of those bridges was excellent (Figure 1). The paint on each bridge appeared to have been very well applied. The only problem noted was variance in surface sheen which appeared to be the result of overspray settling on wet paint. That imparted a slightly mottled surface appearance.

Maintenance Repainting Operations

Maintenance repainting operations on the US 231 and US 25 bridges were monitored during the blast-cleaning and paint-application processes. Those operations were performed concurrently on adjacent portions of both bridges.

The workmanship was very good on both structures. Painting crews thoroughly removed the old paint by dry abrasive blasting. Department of Highways inspectors closely monitored the work. Blast cleaning did not exceed the painting operations by more than a few hours. That allowed the freshly exposed steel to be coated with primer by the end of each work day thereby preventing flash rusting. On the US 231 bridge, the paint contractor was limited to 8 hours working access each day. Six hours were allocated to blast cleaning. The remaining 2 hours were used for primer application.

The US 231 bridge was a large truss structure having girder and deck truss approach spans. The Department of Highways paint inspector was accustomed to working at heights. He inspected the paint operations thoroughly. The inspector normally was stationed in another district, but the Tranportation Cabinet temporarily moved him to painting projects that involved large structures.

Department of Highways personnel were equipped with **Testex** gages to measure the roughness of blast cleaned surfaces. **KTA** gages were used to measure the thickness of the dry paint film. The inspectors also employed sling psychometers and surface temperature gages to ensure that paints were applied under the proper climatic conditions.

Painting of the US 231 bridge was routine. A problem was encountered in the application of the coating on the US 25 bridge. A calcium sulfonated wax, **Valvoline Tectyl 185**, was employed as a single-system, high-build coating on that bridge. The paint operation required blast-cleaning on portions of those girders adjacent to areas that had been recently painted. Blast-cleaning created a large amount of airborne debris. The debris carried to the freshly painted areas. It bonded to the **Tectyl** imparting a discolored surface appearance. As a result, the fascia beams were given an additional topcoat.

An inspection by Kentucky Transportation Center personnel revealed that the wax remained tacky for an extended time. Three days after its application, the **Tectyl** smudged when touched. Due to its tendency to pick up airborne debris from blast-cleaning operations, Kentucky Transportation Center personnel recommended that this coating be discontinued from similar uses (4).

Existing Repainted Bridges

Most of the paint systems on the 13 repainted bridges inspected by Kentucky Transportation Center personnel were performing well (Figure 2). There were no instances of massive coating failure. However, some of the bridges had localized corrosion. Also, paint was peeling on several bridges.

The paints weathered well. The only evidence of paint deterioration was fading and chalking. That was more pronounced on the upper portions of truss bridges. Those locations have the most exposure to sunlight. Blue-pigmented paints appeared to be more susceptible to those problems than the green paints. Only one yellow-painted bridge, a girder structure, was inspected. The yellow paint did not show any signs of weathering or other deterioration. Gray bridge paints also performed well. However, that pigment color was predominantly used on new girder structures having only a few years of exposure. Weathering resistance should be evaluated after several more years of service.

Most repainted bridges inspected were truss structures. Only two of those were girder structures. The paint coatings ranged in age from two to seven years at the time of inspection.
Typically, the truss bridges had service lives exceeding 50 years. Most employed built-up members and were joined by rivetting. All truss bridges had numerous structural members. Those members had multiple surfaces and edges which complicated the cleaning and painting processes. Often, the built-up chord members had diagonally laced bars that hindered access to interior locations. The lacing bars also provided many small surfaces and edges which needed to be cleaned and painted. Rivet heads created surface protrusions on built-up members and at connections. Those complicated the cleaning and painting processes. Interfaces between faying plates and structural members were also difficult to clean and paint adequately.

Despite those difficulties, the paint quality on most of those bridges appeared to be good. Nine maintenance painted bridges were rated good to very good.

Most corrosion was detected at locations near deck level where chlorides are normally present (Figure 3). The most commonly corroded locations were between the end posts and lower chords and along the lower chords. Another corrosion-prone location was along walkway and guardrails. The floor systems of several bridges had some rust at the ends of spans. Those were the only locations where rust was observed on girder and stringer spans.

Occasionally, rust was present at edges between faying sections of built-up or closely mating members. Those locations were difficult to clean and paint. A typical example of that was at joints between rivet heads and plates. In some instances, extensive pack rust had occurred between mating surfaces of built-up chord members. Rust expanded between the mating surfaces and distorted angles between the rivets. Pack rust cannot be removed by blast cleaning. Locations where it occurred were sites for incipient corrosion after repainting.

Several bridges had good paint at locations that were previously corrosion pitted and decayed. Those locations were in a severely corroded condition before cleaning and repainting (Figure 4). Other bridges had similar damage, but the paint was depleted and the members were covered with rust. In those cases, the initial corrosion damage apparently hindered adequate cleaning and adversely affected paint performance.

On several truss bridges, rust was present at elevated locations (Figure 5). Typical locations were the vertical posts (on the interior faces of the flanges and on the webs), upper chords, and lateral bracing. Several bridges had only minor cleaning on the interior of the upper chord box members. In some cases, an aluminized epoxy mastic was applied on those surfaces. Sometimes, rust was present at those locations.

Most bridge floor systems were in good condition. The exceptions were two of the bridges that were cleaned by spot blasting. The floor system on one of those bridges did not appear to have been cleaned or painted. On several bridges, a small amount of rust was present on the ends of beams and bearings near the joints. In several instances, rust bled from the unpainted top surfaces of the floorbeams in contact with the deck. The rust stains discolored the floorbeams, but did not represent paint failure.

The appearance of paint on most of the bridges was good. There were no signs of runs or sags on a majority of those bridges.

The one paint application rated poor by Kentucky Transportation Center personnel had peeled in many spots (Figure 6). Inspections of the substrates and adjacent areas that retained paint revealed poor surface preparation. Mill scale was present at areas where peeling occurred. Irregular patches of preexisting paint were visible under the new paint.

Many of those areas were adjacent to rust spots. That indicates the new paint was placed over a surface consisting of deteriorated paint and bare (and possibly corroded) metal.

On one bridge, Kentucky Transportation Center inspectors noted utility pipes that were extensively corroded and in need of painting. The utility owner was not providing needed maintenance of those pipes.

Kentucky Transportation Center personnel inspected three girder bridges that had previously been repainted. One bridge, US 27 over the Licking River was given a near-white metal blast cleaning. The paint was in very good condition. The other structures were the I 64 twin bridges over the Kentucky River in Franklin County. Those bridges were given a near-white blast cleaning and an inorganic zinc primer near the ends of the bridge. The remaining portions of those structures were spot blast cleaned and given a BLSC primer. The bridges were topcoated with gray alkyd paint. The ends of the girders held up well. However, the bridges exhibited spot rust and peeling where spot blasting was used with the BLSC primer. Mill scale was present at the locations where the paint peeled.

DISCUSSION

The condition of most high-performance paints inspected by Kentucky Transportation Center personnel supports the contention that they will last 20 years. Part of that longevity must be credited to the high quality of most of those paint systems. Since many of those paint systems were relatively untried when applied, it is likely that their performance will improve in future applications. Coating lives of 20 to 30 years may be commonplace.

Department of Highways Bridge Inspectors

Department of Highways paint inspectors observed by Kentucky Transportation Center personnel were well trained and highly motivated. They were also well equipped to inspect painting operations. The Transportation Cabinet demonstrated good personnel management of inspectors in using personnel skilled at climbing.

Inorganic zinc primers performed satisfactorily on repainted bridges. It is likely that inorganic zinc should be placed on surfaces given a near-white blast cleaning. No paint bubbling or peeling problems were detected in topcoats covering inorganic zinc primers. Those have been widespread problems with inorganic zinc paints. The absence of such problems is further indication that Department of Highways paint inspectors are providing proper supervision.

Surface Preparation

Spot blasting did not provide a satisfactory surface preparation for high-performance paints. It should be replaced, with a near-white blast cleaning in accordance with specification SSPC-SP10. A bridge scheduled for replacement within 10 to 15 years may be nominally cleaned by wire brushing or brush blasting. A coating that is tolerant of poor application surfaces may be applied over those surfaces.

Durability of high-performance paints depends, in part, on a clean surface having the proper surface profile (tooth). The surface must also be free of surface contaminants such as retained chloride, sulfur, and metallic salts and ions. Dry abrasive blasting commonly used to clean steel before painting does not remove all such contaminants.

Department of Highways personnel currently test blast-cleaned steel for surface profile. However, there are no common tests performed in the U.S for salts and ions. Indicating papers can be used on blast-cleaned steel to test for salts and ions (5). Kentucky Transportation Center inspections revealed that paint deterioration on most existing truss bridges tends to be more prevalent near deck level. That is probably due to retained

chloride ions. A test for the presence of those ions after blast cleaning could lead to improved paint durability. Surfaces that had contamination after dry blast cleaning could be specially cleaned to remove those contaminants. Further work would be necessary to determine the proper method for treating contaminated surfaces.
Consideration should be given to investigating wet blast cleaning of surfaces near deck level, especially on bridges that have serious rust damage. Wet abrasive blasting may prove useful for removing surface contaminants such as chloride ions (6). However, wet abrasive blasting may present other problems.

In 1980, Kentucky Transportation Center personnel examined the use of cleaning compounds and conversion coatings on rust-pitted steel beams exposed to chlorides (7). The results of those tests indicate that conversion coatings should be investigated for use on previously corroded surfaces that have surface contamination.

High-performance coatings need good blast-cleaned surfaces to perform properly. To achieve maximum return for such expensive surface conditioning, the life of the applied paint should be extended as long as possible. Maintenance spot painting and renewable paint systems are two good methods for achieving that goal.

Extending Painting Durability

When oleoresinous paints were in prevalent use, it was estimated that the service life of a typical bridge paint was about 10 years. That limited life rendered maintenance spot painting impractical. The concept may be feasible with the advent of the new high-performance paints that may last 20 to 30 years. Maintenance spot painting is desirable for several reasons: 1) it allows for correction of inadvertent workmanship flaws in recent paint jobs, 2) it provides needed repairs in high-deterioration areas that fail prematurely, 3) it prevents localized corrosion that would be difficult to clean in future paint applications, 4) it prevents severe corrosion damage to structural members, and 5) it extends the painting cycle.

Questions remain relative to the best methods for making spot repairs to corroded steel. The necessary degree of cleaning should be determined. In a recent study, it was concluded that the oleoresinous paints performed as well on marginally prepared surfaces as coatings commonly considered effective for marginally prepared surfaces (8). Those coatings included epoxy mastics, epoxy amino urethanes, moisture-cured urethanes, and petroleum waxes. If maintenance spot painting is employed to rehabilitate high-performance paints, suitable cleaning procedures and maintenance coatings compatible with existing paints will need to be determined.

A paint system has been formulated that offers an estimated service life of 50 years (9). That system employs an inorganic zinc primer with an epoxy mid coat and a urethane topcoat. The system is designed to have the urethane renewed every 15 years. That is necessary, since with time, the urethane topcoat would become deteriorated and saturated with corrodants. The primer and mid coat would remain intact for the life of the coating. The renewal of the urethane topcoat would be much less expensive than a near-white blast-cleaning and a complete repainting. There would not be the need to coat the surface promptly since bare metal would not be exposed. Areas requiring more extensive rehabilitation would be those near bridge joints.

Potential Experimental Paint Systems and Procedures

Other paint systems should be investigated even though the paint systems inspected are functioning well.

Uncoated inorganic zinc may be a practical single-system coating. All bridges investigated during this study having inorganic zinc primer also had mid coats and topcoats of vinyl or epoxy paint. Untopcoated inorganic zinc primer has performed equivalently well as topcoated systems have in some applications (10). In many locations, the topcoating of inorganic zinc is mostly for decorative purposes. Untopcoated inorganic zinc paint may be durable in rural areas where the concentration of harmful atmospheric pollutants are low. That paint system has a low cost and may be a good choice for new girder bridges in those areas.

Organic zinc paints may function better than inorganic zinc paints on bridges that have extensive prior corrosion damage. Apparently, those paints are not as sensitive to surface preparation. None of the experimental bridges investigated during this study employed organic zinc paints. Inorganic zinc paints are probably better for new bridges and bridges that have not experienced significant corrosion. Transportation Cabinet officials should consider using organic zinc paints on several truss bridges that have significant visible corrosion damage.

Transportation Cabinet personnel should investigate inorganic zinc primer having the epoxy mid coat and urethane topcoat previously discussed. The use of epoxy and urethane topcoats over inorganic zinc should be investigated.

The use of inorganic zinc primer to prevent corrosion at high deterioration locations on the ends of the I 64 bridges is an example of "specific utility." Specific utility is the use of different paints, additional film thickness, or extra coats of paint to resist high-deterioration rates. It also includes the elimination of mid coats or topcoats at low-deterioration locations. The specific utility concept is intended to provide for a uniform rate of coating deterioration at all locations on a bridge.

Other possibilities exist for treating high-deterioration locations. If direct water entrainment is a problem as a result of leaking joints, water diversion and direction schemes may prove useful. Another possibility is to coat the ends of beams and rockers with glue-backed strips of stainless steel foil. The strips could be placed on good paint. The strips could be lapped to prevent moisture intrusion at the interface between the foil and painted steel. This coating could extend only a few feet from the beam ends. It would be relatively inexpensive and might extend the durability of the underlying paint.

Epoxy mastic did not perform well as a single-system paint over spot blast-cleaned steel. That was due to the inadequacy of the surface preparation. BLSC/oleoresinous paints would probably perform as well if not better than an epoxy mastic with spot blast cleaning. Both paints would benefit from better surface preparation. Bridges to be replaced before the next painting cycle could employ a lead-based paint since future paint removal would not be an issue.

A sulfonated wax such as **Valvoline Tectyl** might be useful for small trusses. In a recent study, sulfonated waxes performed well on marginally prepared surfaces (11). Small truss bridges could be given a quick, superficial blast cleaning and covered with the wax after the blast-cleaning operations were completed. That would avoid problems with airborne debris similar to those encountered with the US 25 bridge in Scott County. Sulfonated waxes may function well as a topcoat over inorganic zinc primers.

It might be desirable to attempt to seal joints where pack rust is detected. A sulfonated wax has been used successfully to treat pack rust. It was cut back with a solvent and injected between faying surfaces in pack rust situations by the Illinois Department of Transportation (12).

Several highway agencies have used thermal spray coatings of zinc and aluminum-zinc alloys on bridges. Typically, those coatings employ alloys of zinc and aluminum with a urethane topcoat for protection from sulfur compounds.

Thermal spray coatings have a high initial cost. They may be practical when their life-cycle costs are low. The Ohio Department of Transportation has used it on many bridges. It may be advantageous to inspect the thermal sprayed Ohio bridges and obtain cost data from the Ohio Department of Transportation to determine the potential benefit of that method.

Several states have investigated complete shop painting of new bridges. Normally, those coatings have encountered little damage during shipping and erection. Any damage to a coating is usually spot repaired in the field with an epoxy mastic. Complete shop painting may lead to lower cost and improved coating quality compared to field painting. That practice minimizes field paint inspections, speeds bridge opening, and eliminates environmental concerns related to paint application.

Environmental Aspects of Bridge Painting

Environmental concerns will be a major national issue in the 1990s. Undoubtedly, Transportation Cabinet officials will need to address paint-related environmental issues. It would be beneficial to have some experience with those issues to preclude any problems if the Transportation Cabinet personnel must change paint-related procedures.

Transportation Cabinet staff should investigate water-based and low volatile organic compound (VOC) paints to meet anticipated organic solvent restrictions (13, 14). Those paints are being used by other highway agencies on both a regular and experimental basis. Waterborne barrier coatings are especially promising.

Transportation Cabinet staff might investigate means of containment and disposal of blast-cleaning debris. A large amount of that debris is generated during cleaning operations. Over 1,500 tons of blast media were used in painting the US 231 bridge over the Ohio River at Owensboro. In the future, processing of blast-cleaning refuse may become an environmental issue, especially if lead-based paints are being removed.

Paint Management System

The increased use of high-performance coatings and environmental concerns regarding bridge painting operations warrant the creation of a bridge paint management system. That system could track the performance of paints on all steel bridges in the state.

Before the advent of high-performance paints, paint management was not necessary. Oleoresinous paint was used on nearly every structure up to that time and its performance was reasonably predictable. Now, various high-performance paints from several manufacturers are being used on Kentucky bridges. Additional paint systems will probably be introduced and used in the future. Transportation Cabinet personnel may need bridge-specific condition information to determine which systems perform well in specific environments. They may also need to track paint types and conditions if they desire to extend the lives of those systems by spot maintenance or topcoat renewal.

A paint management system would benefit from improved procedures for inspecting and rating existing bridge paint systems. The procedures could classify the paint condition based on rigid guidelines and tests, not solely on visual impressions.

A private firm has developed such procedures for the Virginia Department of Transportation (15). The Virginia Department of Transportation has incorporated those procedures into a paint management system. The system is used to 1) select maintenance actions, 2) schedule bridge repainting and maintenance spot painting work, and 3) determine future painting requirements.

The proposed paint management system could be made part of the existing Structural Inventory and Appraisal (SI&A) data base. Transportation Cabinet personnel could use the paint management system and the SI&A data to formulate paint strategies and rehabilitation or replacement decisions for individual structures.

Field Trials and Exposure Testing

Due to the ongoing need to assess new bridge paints, it may be desirable to commence a field trials and exposure test program. That program would entail painting either portions of bridges or test coupons mounted on bridges with experimental and currently specified paint systems. The program would emulate the one instituted by the Florida Department of Transportation (16).

The proposed test program would 1) determine the relative performance of new and existing paint systems under actual bridge exposure conditions, 2) identify new paint systems that offer superior performance than those currently specified, 3) determine qualified brands of paints and manufacturers using a service-based performance criterion, 4) select and qualify paints based on their performance in specific regional atmospheres, and 5) experiment with new paint systems for developmental purposes. Control of the test variables for this program would provide more information than the experimental paint applications inspected during this study. The proposed program would allow improved comparison tests between brands and types of paints.

CONCLUSIONS

Overall, the high-performance paints were performing very well. However, it is too early to judge the durability of the newly constructed and recently repainted bridges. Only one repainted bridge showed signs of premature coating failure. That failure is probably due to inadequate surface preparation.

Transportation Cabinet personnel appear to have good control over most aspects of both new and maintenance painting operations. None of the bridges inspected had a material-related coating failure. That indicates that the quality assurance testing of bridge paints is satisfactory. The high overall quality of the paints on new and existing bridges indicates that Transportation Cabinet paint inspections are effective.

Several of the truss bridges had localized corrosion. The bulk of the paint on those bridges was in good to very good condition. Corrosion on the girder bridge was present on rocker bearings at the joints which are high deterioration locations. On the truss bridges, the rust was observed at some locations where high deterioration was expected and in other areas where it was not anticipated.

Rust in unanticipated areas on truss bridges indicates either inadequate cleaning or insufficient paint application. In either case, rust could have been prevented by more thorough inspection. Most of those locations had poor access to the paint surfaces or the member was small or structurally insignificant. Paint inspectors should be instructed to pay closer attention to those locations. Truss bridges are difficult to inspect during painting. Due to their complexity, it is likely that a few locations may be overlooked.

Kentucky Transportation Center personnel suspect that on the bridges inspected, inadequate surface preparation was more responsible for the corrosion than insufficient paint application or lack of paint durability. That suspicion is based on short service lives of those paints on bridges that had corrosion damage. Unfortunately, most of the bridges were painted with one surface preparation, using one type of paint applied at one coating thickness. Therefore, those factors cannot be isolated for comparisons.

The I 64 bridges could have provided a useful paint comparison. However, the high-performance paint was applied at the high-deterioration locations at the ends of the bridges. The high-performance paint areas were given a near-white metal cleaning, whereas the conventional oleoresinous system was applied over a different surface treatment. The differences in test location and surface preparation hindered comparisons of paint performance. The one possible conclusion is that high-performance paints over well prepared surfaces are superior to oleoresinous paints over marginally prepared surfaces.

The interior portions of the upper chord boxes that were spot blast cleaned had a poor surface appearance compared to other areas of the truss bridges. Some of those locations had corroded. That practice should be restricted to old truss bridges that are scheduled for eventual removal.

The corrosion of utility pipes running under bridges may be a problem. If such pipes are not painted, they may fail and release their contents into the atmosphere or waterway. If a corroded utility pipe carried natural gas, it could create a fire hazard. Bare metal pipes clamped to a painted steel bridge may corrode at an accelerated rate. It would be desirable to paint those pipes and charge the utilities.

More weather-resistant pigments should be sought for the vinyl topcoat paints. Consideration should also be given to replacing vinyl with a paint that is inherently more resistant to ultraviolet radiation deterioration from sunlight. Possible replacements include urethanes, silicone alkyds, and acrylics. The overspray problem with the vinyl paints also should be corrected. Solutions to those problems should be solicited from paint manufacturers.

Spot blasting and topcoating with an aluminized epoxy mastic may provide some rust protection. However, it does not completely protect the bridge especially in problem areas that have experienced previous corrosion damage. It would be more desirable to provide a commercial quality blast cleaning in accordance with Structural Steels Painting Council specification SSPC-SP6. For high-quality maintenance painting, a near-white blast cleaning in accordance with specification SSPC-SP10 is desirable. That is evident by the good performance of the paint systems on bridges given SSPC-SP10 blast cleaning.

Kentucky Transportation Center personnel were unable to assess the relative quality of the paint systems. This is due to: 1) differences in original condition of the various bridges, 2) the use of one paint system on each bridge, 3) variations in quality of surface preparation, 4) different service environments, and 5) the short service lives of those coatings. Additional service experience with the experimental bridges may provide the necessary service experience. However, more closely controlled field tests are necessary to eliminate major variables such as original surface condition, environment, and surface preparation.

All of the maintenance paint systems are performing satisfactorily, except those incorporating spot blasting. They may be recommended with the provision that the application surface be given better surface preparation before painting.

RECOMMENDATIONS

The following items are recommended for consideration by Transportation Cabinet Officials.

1. Continue to use high-performance paints on bridges for new and maintenance paint applications. Those paints should supplant oleoresinous paints for most bridge applications.

2. Require a near-white metal (SSPC-SP10) blast cleaning of all bridge steel to be coated with high-performance paint. The practice of not painting the interior of truss chord boxes should be eliminated except where necessitated by access restrictions.

3. Eliminate spot blasting for most high-performance paints. Possible exceptions include bridges painted with sulfonated waxes or BLSC/alkyd paints.

4. Establish a paint management system to monitor the condition of bridge paints. Develop a new method for field classification of bridge paint condition.

5. Establish a field trials and exposure test program to evaluate paints. The program should be regionalized to determine the effectiveness of different paint systems in specific areas of the state.

6. Investigate environmentally related bridge painting practices. That includes the capture and disposal of blast-cleaning products and the development of waterborne and low VOC paint systems.

7. Consider the use of completely shop-painted bridge steel.

8. Investigate the use of indicating papers to detect surface contamination of blast-cleaned steel for maintenance painting inspection. Methods for cleaning or treating contaminated areas should also be investigated.

9. Investigate additional coating and painting systems including urethane topcoats, untopcoated inorganic zinc, organic zinc, and thermal sprayed coatings.

10. Investigate special treatments for high-deterioration areas and reduced coating requirements for high-durability areas.

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Table 1. Construction Bridges Having Experimental High-Performance Paint Systems

Bridge	Description	County Type	Bridge	Date Painted	Surface Preparation, Paint No. System, and (Manufacturer)
1.	Old Scottsville Road	Warren	Girder	6/82	Bare metal blast, 2-component inorganic zinc, green vinyl topcoat (Carboline)
2.	US 62 over I 65	Hardin	Girder	5/85	Bare metal blast, 1-component inorganic zinc primer, grey vinyl topcoat (Valspar - Mobil)
3.	I 65 over Rolling Fork River	Hardin/ Bullitt	Girder	7/85	Bare metal blast, 2-component inorganic zinc primer, grey vinyl topcoat (Valspar - Mobil)
4.	KY 2 over Little Sandy River	Greenup	Girder	7/82	Bare metal blast, 2-component inorganic zinc, grey vinyl topcoat (Valspar - Mobil)

Table 2. Bridges Repainted with Experimental High-Performance Paint Systems

Bridge	Description	County Type	Bridge	Date Painted	Surface Preparation, Paint No. System, and (Manufacturer)
1.	I 64 over Kentucky River	Franklin	Girder	9/80	Bare metal blast, 2-component inorganic zinc primer, epoxy mastic midcoat (Carboline) -- This treatment was applied 10 ft. of the ends of the bridge. Spot blast, basic lead silico chromate primer and alkyd midcoat (Marcus) -- This treatment was applied to the rest of the bridge. Topcoat grey alkyd (Marcus) -- This treament was applied to all bridge steel.
2.	US 27 over Licking River	Pendleton	Girder	6/80	Bare metal blast, 2-component inorganic zinc primer, yellow vinyl topcoat (Carboline)
3.	US 25 over I 75	Scott	Girder	6/87	Bare metal blast, calcium sulfonate wax (Valvoline Oil)
4.	KY 34 over Dix River	Boyle/ Carlisle	Truss	7/82	Bare metal blast, modified epoxy-bitumen primer, blue vinyl topcoat (Carboline)
5.	KY 89 over Red River	Clark	Truss	7/82	Bare metal blast, modified epoxy mastic primer, blue vinyl topcoat (Carboline)
6.	KY 81 over Green River	McLean	Truss/ Stringer	11/80	Bare metal blast, 2-component inorganic zinc primer, green vinyl topcoat (Carboline)
7.	US 231 over Ohio River	Daviess	Truss/ Girder	11/87	Bare metal blast, 2-component inorganic zinc primer, cobalt blue vinyl topcoat (Carboline)
8.	US 60 over Clover Creek	Breckinridge	Truss	7/85	Bare metal blast, 2-component inorganic zinc primer, blue vinyl topcoat (Valspar)
9.	KY 55 over Salt River	Spencer	Truss	6/83	Bare metal blast except inside box chords, 2-component inorganic zinc primer, blue vinyl topcoat, epoxy inside box chords (Valspar - Mobil)
10.	KY 32 over L & N R.R.	Nicholas	Truss	6/85	Bare metal blast, 1-component inorganic zinc primer, epoxy midcoat, and grey vinyl topcoat (Ameron)
11.	KY 1443 over Cabin Creek	Mason	Truss	7/83	Spot blast, aluminized epoxy mastic (Carboline)
12.	KY 10 over Kinniconick Creek	Lewis	Truss	9/82	Bare metal blast, epoxy mastic primer, blue vinyl topcoat (Carboline)
13.	KY 7 over Tygarts Creek	Greenup	Truss	6/85	Bare metal blast, 1-component inorganic zinc primer, epoxy midcoat, blue vinyl topcoat (Ameron)
14.	KY 1661 over Little Sandy River	Carter/ Greenup	Truss	5/85	Bare metal blast, 1-component inorganic zinc primer, epoxy midcoat, blue vinyl topcoat (Ameron)
15.	KY 7 over Little Sandy River	Mason/ Elliot	Truss	7/82	Spot blast, aluminized epoxy mastic (Carboline)

Table 3. KTC Inspection Summaries for Experimental High-Performance Paints Used on Construction Painted Bridges

Bridge No.	Date Inspected	Paint Rating	Comments
1.	10/87	Excellent	The paint showed no sign of deterioration. No rust was detected.
2.	10/87	Excellent	The paint showed no signs of deterioration. The surface sheen varies due to overspray.
3.	10/87	Excellent	The paint showed no signs of deterioration.
4.	11/87	Excellent	The paint showed no signs of deterioration.

Table 4. KTC Inspection Summaries for Experimental High-Performance Paints Used on Repainted Bridges

Bridge No.	Date Inspected	Paint Rating	Comments
1.	3/86	Very Good/Fair	The sections of the bridge employing bare metal blast cleaning and inorganic zinc performed well with no signs of deterioration. The sections of the bridge employing spot blasting and BLSC primer were corroding at spots along the lower flanges of the exterior girders. The paint was peeling from the steel in the spot blast-cleaned areas exposing mill scale substrates.
2.	4/86	Very Good	The paint was performing well. A small amount of corrosion was present on the rocker bearings. The girders were rust free.
3.	6/87	Very Good	The coating finish was marred by blast-cleaning debris which adhered to the wet coating during application.
4.	8/87	Very Good	The paint had faded and chalked slightly. A small amount of spot rust was detected on the top lateral bracing and guardrails probably due to poor surface preparation.
5.	8/87	Fair	The paint had faded. Rust stains and surface rust were present on vertical and end posts. Most of those rust indications were at or near deck level. Some indications were present near the upper chords. Batten plates on the lower chord were rusty and several had been corroded through. This bridge probably had extensive corrosion damage prior to painting. The surface preparation was probably not good at locations where rust was present.
6.	10/87	Good	The paint had faded slightly. Rust was present on floorbeams and stringers near joints. Rust stains were noted on guardrails and guardrail posts. Rust on diagonals of steel bents,probably due to poor cleaning. Pack rust evident between mating angles of bent bracing. The paint is performing well in most locations on the trusses and stringers.
7.	10/87	Excellent	Inspected during painting. This is a very good looking paint job. The surface sheen varies due to overspray.
8.	10/87	Very Good	A white dust, possibly from atmospheric pollution, covered the upper exposed surfaces of the bridge. The paint had faded slightly. A small area of paint was peeling from the upper chord at one location. Rust stains are present on the walkway guard-rails and on edges of batten plates. Utility pipes on the underside of the bridge have rusted significantly and need painting.
9.	10/87	Fair	The paint had faded and chalked on the upper exposed surfaces. Rust and rust stains were present on guardrails. Rust was present on the edges of some I-beams used as vertical posts. That rust was probably related to poor surface preparation and/or inadequate paint coating. Rust was present in spots on the upper chord, the lateral struts and the lateral bracing. Rust bleeding was detected on some rivet heads. Rust was detected inside the upper chord box beams. Some of the floorbeams showed signs of extensive previous corrosion damage. That may have made proper surface conditioning difficult.
10.	10/87	Very Good	Minor rust spots were present on the guardrails. Lower chord members showed signs of previous severe corrosion damage. No signs of rust were detected on the on the upper or lower chords or the floor system.
11.	10/87	Fair	The paint had a poor appearance due to the surface preparation. Spots with underlying old paint were visible through the present paint. Rust stains were present 1) along the upper chord due to pack rust between riveted plates, 2) on the interior of the upper chords, 3) at the connections between the end posts and the lower chords, and 4) on the inside box beams of the upper chords. The floor system apparently was not painted.
12.	11/87	Good	The paint had chalked and faded on the upper exposed surfaces. Random rust and rust stains were present on the guardrails and the edges of the vertical posts near deck level. Rust was present at a few spots on the end portals and upper lateral bracing. The paint held up well in most locations.
13.	11/87	Very Good	The paint had chalked and faded on the upper exposed surfaces. A small amount of rust and rust stains was present on the guardrails.
14.	11/87	Very Good	The paint had chalked and faded on the upper exposed surfaces. Very little rust was detected.
15.	11/87	Poor	The paint was peeling at numerous locations where underlying mill scale was visible. Old paint was visible under the new paint in many locations. The paint application appeared to be poor with many drip marks and uncoated areas. Large amounts of rust were visible at many locations on the bridge. Both the surface preparation and paint application appeared to be inadequate.

Figure 1. New Painted Girder Bridge, US 62 over I 65 in Hardin County (August 1987).

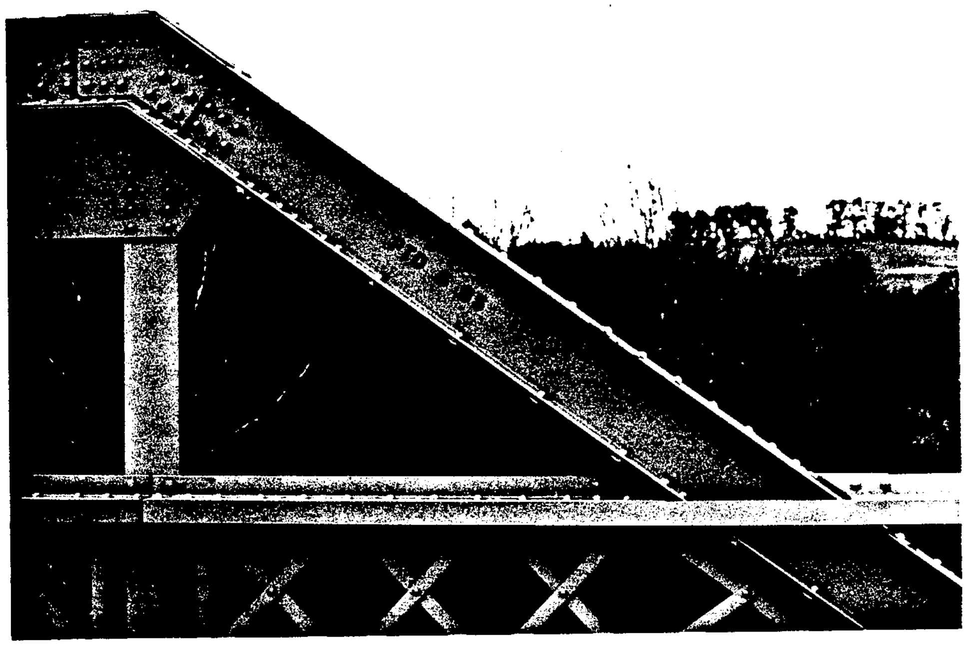

Figure 2. Guardrail and End Post of Truss Bridge, KY 32 over L & N RR (October 1987).

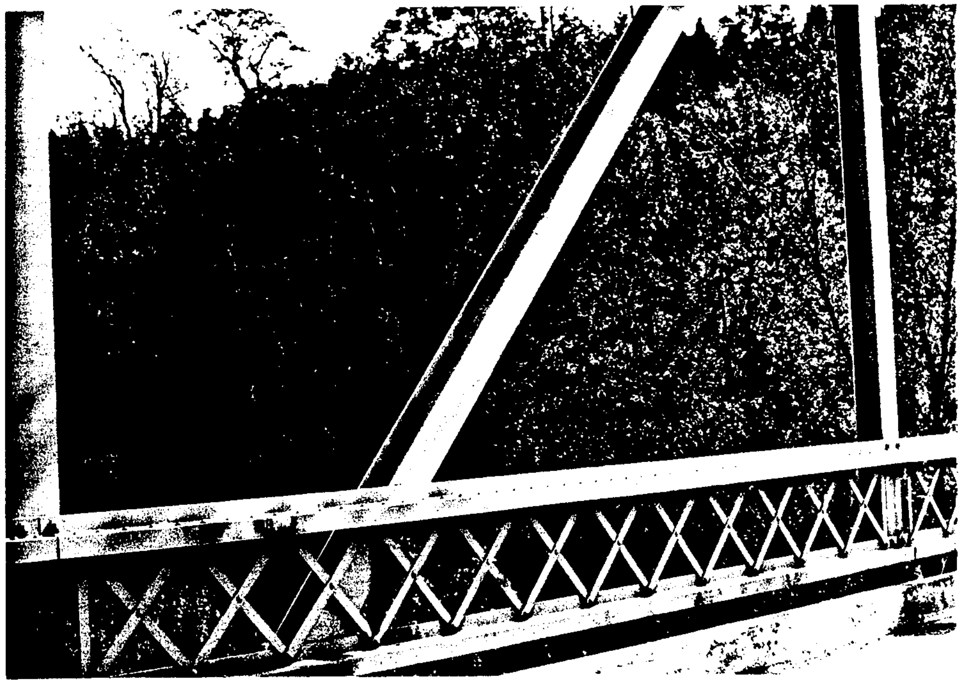

Figure 3. Diagonal and Guardrail on KY 89 over Red River (August 1987).

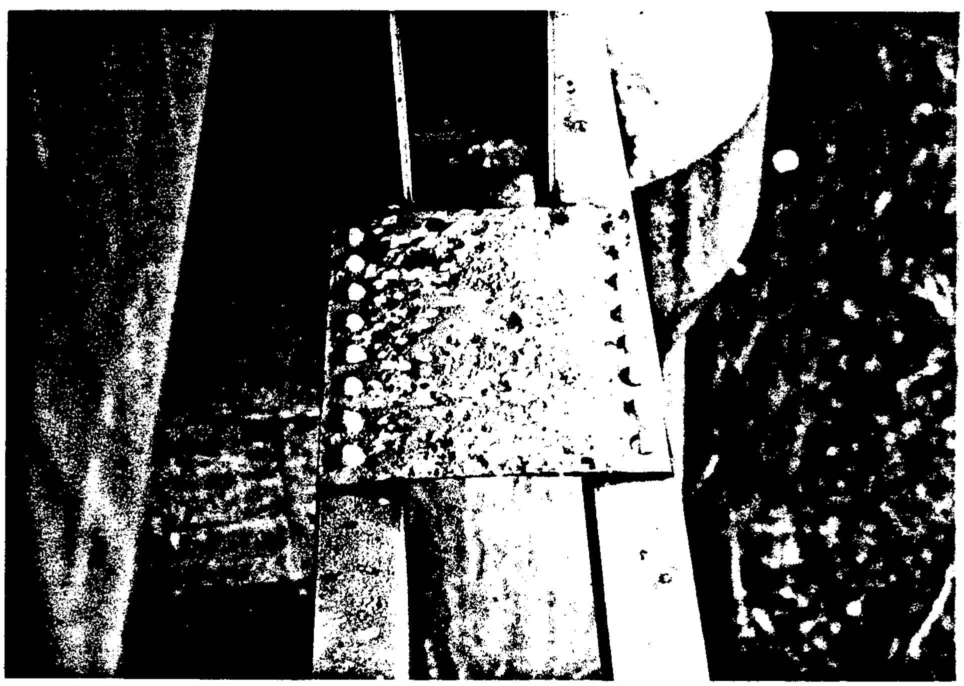

Figure 4. Batten Plate on Lower Chord Showing Previous Corrosion Damage, KY 32 over L&N RR (October 1987).

Figure 5. Rust Visible on Portal of Truss Bridge, KY 7 over Little Sandy River (November 1987).

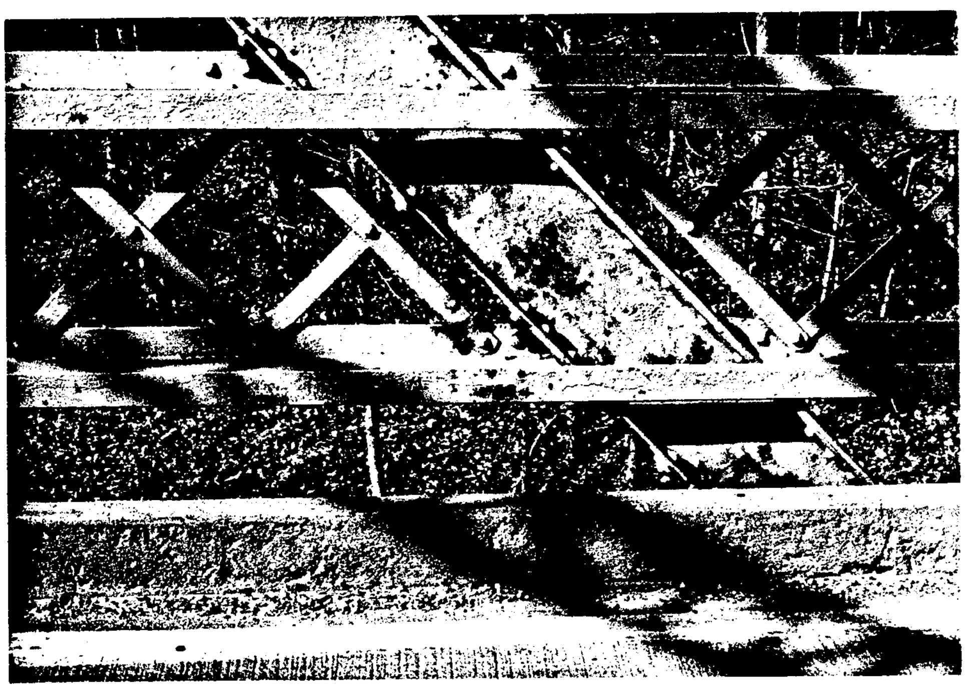

Figure 6. Peeling Paint and Rust on End Post of a Truss Bridge, KY 7 over Little Sandy River (November 1987).