CRSI

ANTI-CORROSION TIMES

REPORTING ON INDUSTRY NEWS, NOTEWORTHY APPLICATIONS & NEW DEVELOPMENTS ON FUSION BONDED EPOXY COATINGS FOR CORROSION PROTECTION ON STEEL REBAR.

VOLUME 16, NO. 1 SPRING 1999

Published by CONCRETE REINFORCING STEEL INSTITUTE, 933 N. Plum Grove Rd, Schaumburg, IL 60173, 847-517-1200

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Indiana investigates bridge decks

Corrosion damage to underside of deck constructed with uncoated reinforcement

Prior to the use of deicing salts on bridge decks, concrete was believed to be a maintenance free material. The damage of bridge decks in the USA due to the corrosion of reinforcing steel resulting from salt application has changed this image. The result of using deicing salts in the 1950s started to show up as corrosion of the reinforcing steel in the 1960s. The use of epoxy-coated reinforcement was then thought to significantly increase the service life of bridge decks. However, several experimental studies and field observations suggest that premature corrosion of the epoxy-coated reinforcement could occur.

As other corrosion protection systems begin to economically compete with epoxy-coated bars, a reassessment of the benefits of epoxy-coated bars was justified. Alternate corrosion methods used in Indiana include latex modified concrete topping with additional concrete cover over the black bar, use of class A and C concrete cover with black steel and class C concrete cover over galvanized steel.

A field study of 114 bridge decks throughout Indiana was conducted. A second study of new bridge construction was also conducted to assess the damage created on epoxy-coated reinforcement in the transportation, placement and concrete casting operations.

Existing bridge decks studied were constructed between 1972 and 1980. All had original decks and had not been

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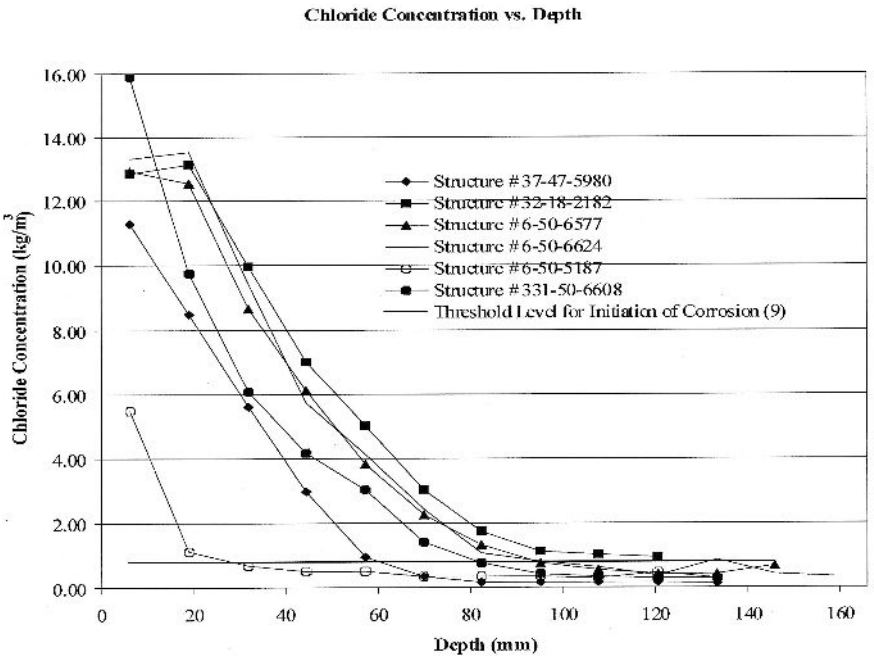
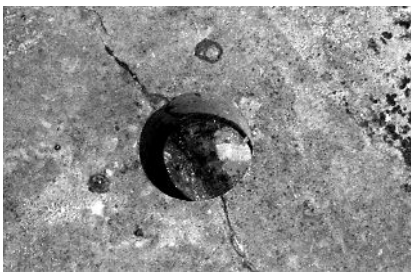
Indiana investigates bridge decks . . . *continued from page 1*



rehabilitated other than patching. The studied decks were categorized by the corrosion protection method used in construction. 46% of all the bridges show signs of distress, including: spalling, areas of delamination debonding and rust stains. Also, 36% of the decks had cover readings below what was specified.

After the initial inspection, one bridge deck from each of the corrosion protection methods was given a more detailed field investigation. For each of the five main corrosion protection



Core removed for testing

methods, the bridge deck with the highest level of distress was chosen for the detailed survey.

New Construction

New construction bridge sites were visited to perform holiday testing on epoxy-coated reinforcement. Testing was performed in three phases: arrival at site, after placed in the bridge deck and after the concrete pour.

Holiday inspection at bridge site

Findings – Existing Bridge Decks

After reviewing all the data, epoxy-coated reinforcement combined with Class C concrete provided the most successful corrosion protection method. Only 11% of the bridge decks in this category showed distress, the lowest of all categories studied. The detailed field investigation found corrosion of epoxy-coated reinforcement was caused by cracking and insufficient concrete cover.

Findings – New Bridge Deck Construction

The results of the field investigation found more defects than expected. Most were created in the concrete casting operation, using the pump method of concrete placement. It was found that increasing the epoxy coating thickness dramatically reduces the number of defects by an average of 73%, in the concrete casting operation when using the pump method.

To date, this and previous studies have shown that epoxy-coated bars have performed satisfactorily in Indiana. To increase the effectiveness of epoxy-coated reinforcement as a corrosion protection method, sufficient cover of high quality concrete and increased thickness of epoxy coating is recommended.

This research was completed by Lisa M. Samples, Graduate Research Assistant and Julio A. Ramirez, Professor, Structural Engineering, Purdue University, School of Civil Engineering. For a complete copy of the report that includes comparative charts, graphs and detailed information about the studied bridges, contact CRSI and request Research Series - 6, Field Investigations of Existing and New Construction Concrete Bridge Decks. ♦

Epoxy-coated rebar reduces life-cycle costs in bridges

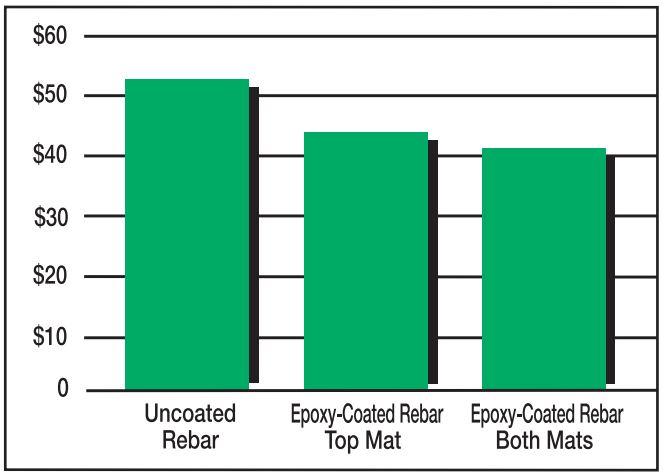
First used in 1973, epoxy-coated reinforcement has been placed in thousands of cast-in-place concrete structures. Those built in the 1970s and early 1980s have now reached corrosive conditions because of long exposure to deicing salts, sea water or harsh chemicals. Research has shown that the epoxy-coated reinforcement is performing well, significantly increasing the service life of projects and effectively reducing life-cycle costs. When compared to other systems, or no protection at all, epoxy-coated reinforcement offers low life-cycle costs and has proven to be a very cost effective corrosion protection method.

In a recent CRSI brochure, the cost effectiveness of epoxy-coated reinforcement is discussed along with the history and value of this corrosion control product. Included is a typical example of life-cycle cost analysis for bridges in a northern, deicing salt environments. It illustrates the relative cost-effectiveness of epoxy-coated reinforcement.

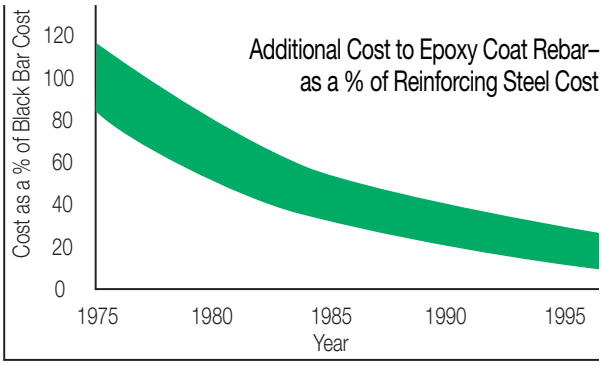
Comparisons are made with uncoated rebar on bridge decks, epoxy-coated rebar on the top mat only and epoxy-coated rebar on both mats. Although using epoxy-coated rebar on both decks increases initial cost, the added service life makes it the best long-term investment.

The payback period required to offset the modest premium for specifying epoxy coating is often as little as a one-to-two year life extension, making epoxy-coated reinforcement one of the most cost effective alternatives for corrosion protection.

To learn more about this cost analysis, contact CRSI and request the brochure, *Epoxy-Coated Rebar Delivers Cost Effective Value*. ♦



Net Present Cost—Typical Bridge Deck
(per square foot)



CRSI Epoxy Coating Plant Certification program matures

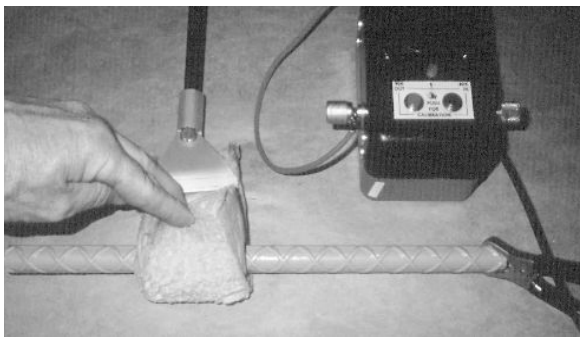
Now in its eighth year, the CRSI Plant Certification program has gained widespread acceptance. Approximately 95% of all epoxy coating plants are certified. Many state highway agencies and Canadian provinces require epoxy coating applicators to be certified in order to do business with them. In addition, the Federal Highway Administration is very supportive and strongly encourages state Departments Of Transportation to require certification.

The CRSI voluntary certification of epoxy coating plants program was instituted to increase the quality of epoxy-coated reinforcing bars. Consisting of both planned and unplanned inspections by an outside agency, the certification program has helped raise the overall quality of the final product. The plants are responsible for over 90% of epoxy-coated reinforcement production. Most participating plants make the effort to record the highest scores possible. For those plants who don't score as high, the inspectors address noted deficiencies to help improve future quality.

A series of workshops for quality control representatives of certified plants is planned; the first was held in Chicago in March of this year.

Topics discussed at the workshop include program administration, technical requirements, fabrication guidelines and quality control. Demonstrations included chloride, backside contamination, anchor profile and others. Inspectors were available to answer questions on both general and specific topics.

CRSI offers a brochure that describes the certification program in detail. For a free brochure, notice of upcoming seminars or more information on the CRSI Voluntary Certification Program for Fusion Bonded Coated Application Plants, contact: Theodore L. Neff, P.E., CRSI Certification Program Administrator. ♦



Holiday testing

Cathodic Disbondment testing

Holiday testing and Cathodic Disbondment testing are included in the program.

For a current listing of certified plants in the U.S.A. and Canada, visit the CRSI Website: www.crsi.org

The role of adhesion and wetting properties using fusion bonded coating

Through the years many field and laboratory tests have shown that Fusion Bonded Epoxy (FBE) coatings have performed well on bridge decks. However in some cases, field samples show poor adhesion and disbondment of the epoxy-coated rebar (ECR). In order to quantify the life extension of concrete structures using epoxy coating, life cycle studies have been conducted by a few state DOTs. Here are some of the findings.

Corrosion control of the coating is dependent on its ability to be an excellent barrier against water, oxygen, chloride and other aggressive elements that could permeate and attack the metal surface. However, for epoxy coating to be an effective long-term corrosion protection system, it is essential that the coating stay bonded to the substrate during the life of the structure. Polar elements such as water, once permeated, can reduce the overall adhesive strength. Therefore, epoxy coatings, including FBE, exposed to a wet environment will not have the same adhesive strength as a newly applied coating or one kept in a totally dry condition. Since reduction in adhesive strength is inherent during its service life, the important question is whether a reduction in adhesive strength signals the end of its performance. It is important to know how much adhesive strength is needed for a coating to continue to perform.

Another corrosion control mechanism of a coating is related to its electrical properties. Protective coatings offer a high resistance between the cathode and the anode of the corrosion cells and minimize the number of micro cells on the substrate. Success depends on the ability to place itself between the cathode and the anode, which are separated only by microns. Known as the wetting property, this controls the sites where water can accumulate and lead to coating blisters and poor adhesion. Although there are other critical properties required for corrosion protection coatings, adhesion and wetting properties are critically important to epoxy coatings for rebar.

…the important question is how much adhesive strength is needed for a coating to perform.

Conclusion

Reduction in the adhesive strength of FBE exposed to a wet environment is a concern regarding long term protection.

There is a difference between total adhesion loss that results in coating disbondment and a reduced adhesion where a mechanical force is needed to remove the coating from the substrate. With FBE, total adhesion loss indicates the absence of sufficient chemical bonds, loss of polar-polar bonds and inadequate mechanical bonds. Reduced adhesion in water suggests the temporary or permanent loss of only some of the polar-polar adhesion, with still enough chemical and mechanical bonds to provide sufficient adhesive strength. As long as adhesive strength remains positive, the coating will stay on the substrate.

The results of these studies have provided the direction needed to improve the adhesive strength of the coating. This was accomplished by developing better coating systems along with the improvement of application procedures.

Some of the improvements include coating systems with different chemistries and/or chromate surface treatments. In addition, primer systems are currently being researched.

Improving mechanical adhesion and chemical adhesion are also areas of attention. Procedures include a higher application temperature and an abrasive blast cleaning to provide an angular instead of spherical profile. Other areas of importance for quality include controlled transportation and construction practices that reduce damage to ECR.

This article is based on the presentation, "Role of Adhesion and Wetting Properties of Fusion Bonded Epoxy (FBE) Coating in Corrosion Control of Rebars used in Bridge Decks," originally presented by Kuruvila Varughese, Product Manager, Herberts-O'Brien, Inc., at the International Conference on Corrosion and Rehabilitation of Reinforced Concrete Structures in Orlando, Florida, December 1998. ♦

Increase the service life of parking garages

During the past 25 years, the cost of maintaining, rehabilitating and reconstructing corrosion damaged reinforced concrete structures has grown dramatically. Consequently, more cost-effective corrosion protection systems were needed. Epoxy-coated reinforcement has gained widespread acceptance for extending the service life of many reinforced concrete structures susceptible to corrosion.

To better manage these costs and to ensure an acceptable Return On Investment (ROI), many owners and specifiers are employing life cycle cost analysis to evaluate their future expenditures and to justify corrosion protection strategies.

In its second cost-effective series, CRSI reviews life-cycle costs for parking garage decks. In most studied cases, epoxy-coating has out-performed originally projected life-cycles with increased service life and reduced life-cycle costs. As with bridge decks, the additional cost to coat both deck mats with epoxy coating increases the service life considerably. With a minimal initial investment, using coated rebar on both deck mats extends the service life to 40 years.

The voluntary certification program instituted by applicators of epoxy protection has helped produce a very high quality product. With increased usage, production costs have decreased, making the initial cost of epoxy coating even more cost-effective. With the cost of epoxy coating often recouped in the first or second year of life extension, epoxy coating is one of the most effective corrosion protection investments available—and a very good value.

For more information about the cost-effective value of epoxy coated reinforcement for parking garages, contact CRSI for a copy of *Epoxy-Coated Rebar Delivers Cost Effective Value for Parking Garages.* ♦

Life-cycle Cost Analysis of Epoxy-Coated Rebar Corrosion Protection Systems for Typical Parking Garage

	Uncoated Rebar—Parking Deck	Epoxy-Coated Rebar—Top Mat	Epoxy-Coated Rebar—Both Mats
Added Cost of Protection System	N/A	$0.15 per lb.	$0.15 per lb.
Initial Investment (construction & protection)	$25 per sf	$25.30 per sf	$25.60 per sf
Discount Rate	4%	4%	4%
Life Extension from Protection System	N/A	15 years	25 years
Service Life	15 years	30 years	40 years
Repair/Rehab Cost	$10.00 per sf	$10.00 per sf	$10.00 per sf
Annual Rate of Return On Investment	N/A	27%	22%
Net Present Cost (per sq. ft.)	$42	$31	$28

CRSI announces "Call for Entries 2000"

CRSI's 15th biennial design awards competition is open to owner/developers, architects, structural engineers, contractors and others involved in the construction of site-cast concrete structures. All cast-in-place concrete structures built in Canada, Mexico and the United States between January 1997 and October 1999 can be entered in the competition. New construction projects, as well as reconstruction projects are eligible. Entries are due by October 1999.

Entries are open, but not limited to bridges, parking garages, high rises, stadiums, airports, highways. Entries will be judged individually for design aesthetics, contextural response, engineering achievement, functional excellence and economy.

ENTRIES DUE BY OCTOBER 1999

AWARD CATEGORIES:

Bridges and Infrastructure

Innovative Engineering

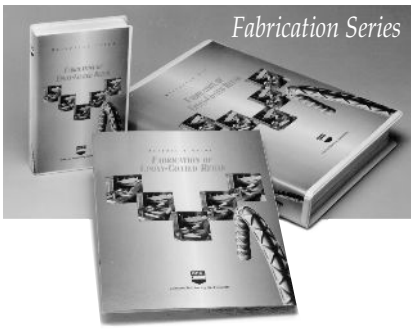
Buildings

There will be multiple winners. Each will be featured in a highly circulated full-color brochure and in both local and national publicity campaigns. All entrants will be reviewed for inclusion in the CRSI seminar series, in a CD-ROM, in the "Reinforcing Concrete Design" series, in case histories and in national advertising.

To receive your Design Awards 2000 Entry Kit or for additional information contact Gary Keclik, Director of Architectural Programs.♦

Epoxy-coated rebar videos and guides available

Fabrication



This series, available from CRSI , includes a video and a reference guide on the fabrication of epoxy-coated rebar.

The series was developed for use by inspectors, manufacturers, consultants and others involved in the fabrication of epoxy-coated rebar. The video is approximately 7-1/2 minutes long. The 12-page reference guide is fully illustrated. Both show the approved method of receiving, storing, shearing, bending, repairing, handling and shipping epoxy-coated rebar.

These materials were developed to help those involved in the manufacturing and fabrication of epoxy-coated rebar produce an end product that assures high quality and increases the life-cycle of concrete structures.

Field handling techniques

The CRSI Field Handling Techniques for Epoxy-Coated Rebar series also includes a video and reference guide.

This series was developed for industry users including contractors, inspectors and others involved in construction. Both the 8-1/2 minute video and 12-page reference guide give the most current information about field handling procedures. Subject matter includes receiving, inspection, long and short term storage, placing with use of accessories, inspection, field repair and guidelines for the concrete pour.

The CRSI Epoxy Coating Technical Committee produced both video and reference guide series. You can order either series.

❑ Reference guide . . . . .$10 each ❑ Video . . . . .$25 each

— ALSO AVAILABLE —

COMBINED KITS AT A REDUCED RATE:

❑ Fabrication of Epoxy-Coated Rebar Kit, video and guide $30

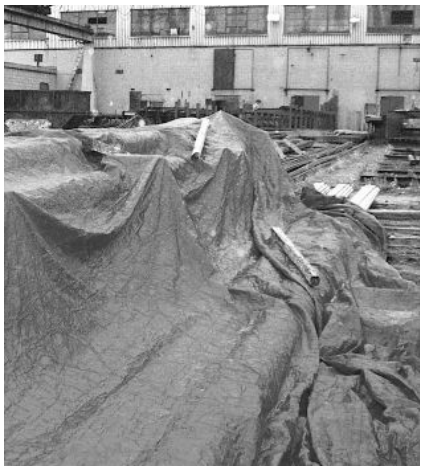
❑ Field Handling Techniques for Epoxy-Coated Rebar at the Job Site Kit, video and guide $30

Call, fax or write to CRSI for these colorfully illustrated reference materials.

Epoxy Tips

Outside Storage

As the use of epoxy-coated rebar increases, recommendations on field handling practices have been formalized to help maintain the quality of the product at the job site. These quality practices are have proven to increase the service life of the cast-in-place project.



Draped bar bundles in long-term storage

Occasionally, epoxy-coated rebar is delivered before it is needed. If this occurs, take these precautions to protect the bars. Bundles should always be stored above ground on protective cribbing. The cribbing should be easily accessible and provide enough support to prevent excessive sagging of the bundles.

Store bars above ground on protective cribbing

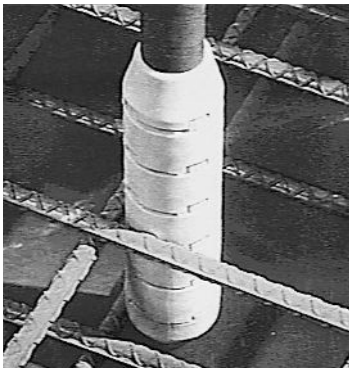
The ideal solution is to schedule delivery as close to the placing schedule as possible. However, if storage is expected to exceed two months, the bars should also be protected from weather by covering the bundles with opaque plastic sheeting. The sheeting should be draped over the bundles while still allowing for adequate air circulation around the bars to minimize condensation under the sheeting. ♦

Concrete Operations

After the epoxy-coated rebar has been placed, repaired and fully cured and all forms have been set, strict guidelines for pour completion must be followed in order to minimize damage to the epoxy-coating. It is very important to protect the epoxy-coated bars because they are the foundation for the project. Well protected bars will extend the service life of the project. To minimize damage to the coating, take care to ensure that the following steps are taken:

- ✔ Set up runways for concrete buggies, hoses and support them well.
- ✔ Prevent shifting of placed bars.
- ✔ When compacting the concrete, use only rubber or non-metallic vibrator heads. Metal heads should not be used. They can cause damage to the epoxy-coating bars within the concrete. ♦

Compaction using non-metallic vibrator heads



Non-metallic vibrator head