Frequently Asked Questions (FAQ) About Epoxy-Coated Reinforcing Bars

Introduction

The Concrete Reinforcing Steel Institute (CRSI) routinely receives inquiries concerning various aspects of reinforcing bars, and reinforced concrete design and construction. This Technical Note presents a collection of typical questions that are asked regarding epoxy-coated reinforcing bars. Most of these questions come from licensed design professionals (LDPs), namely engineers and architects, field personnel (inspectors, code enforcement personnel, and contractors), and state DOTs.

Epoxy-coated reinforcing bars are the most commonly used corrosion-resistant reinforcing bar used in reinforced concrete projects due to corrosion-resistance and cost. Figure 1 shows epoxy-coated reinforcing bars on a bridge deck on I-294 near Chicago. Figure 2 shows epoxy-coated reinforcing bars on San Francisco-Oakland Bay Bridge in California.

Specific frequently asked questions (FAQ) and responses are provided below.

Basic Material Characteristics

What Standards govern epoxy-coated reinforcing bars?

Epoxy-coated reinforcing steel bars should be specified according to ASTM A775/A775M Standard Specification for Epoxy-Coated Steel Reinforcing Bars or ASTM A934/A934M Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars. ASTM A775/A775M defines epoxy-coated reinforcing steel as reinforcing bars with protective epoxy coating applied by the electrostatic spray method. Bars produced to this standard are fabricated after coating. ASTM A934/A934M covers deformed and plain steel reinforcing bars which are prefabricated prior to surface preparation and then coated with a protective fusion-bonded epoxy coating by electrostatic spray or other suitable method. ASTM D3963/D3963M Standard Specification for Fabrication and Jobsite Handling of Epoxy-Coated Steel Reinforcing Bars covers the fabrication and field installation of epoxy-coated reinforcing bars.

What Reinforcing bars do the ASTM standards permit to be coated?

ASTM A775/775M and ASTM A934/A934M permit bars meeting ASTM A615/A615M Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement, A706/A706M Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement, and A996/A996M Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement to be coated. Bars meeting ASTM A615/A615M are available in yield strength grades of 40, 60, 75, 80 and 100 [280, 420, 520, 550, and 690]. Bars meeting ASTM A706/A706M are available in yield strength grades of 60 and 80 [420 and 550]. Bars meeting ASTM A996/A996M are not as readily available as the other two steel types, but rail-steel bars are available in yield strength grades of 50 and 60 [350 and 420], while axle-steel bars are available in yield strength grades of 40 and 60 [280 and 420].
What are the available sizes of epoxy-coated steel reinforcing bars?

Epoxy-coated reinforcing bars are available in all of the U.S. conventional bar sizes and the metric sizes used in Canada. U.S. bar sizes are #3 through #11, #14, #18, and #20 (#10 through #36, #43, #57, and #64). Metric sizes in Canada are 10M, 15M, 20M, 25M, 30M, 35M, 45M, and 55M.

Do epoxy-coated reinforcing bars have the same weight per foot as normal “black” carbon reinforcing steel bars?

Yes, epoxy-coated reinforcing bars have the same weight per foot as normal “black” carbon reinforcing steel bars (that is, bar conforming to ASTM A615/ A615M, A706/A706M or A996/A996M).

What is a fusion-bonded coating?

Fusion bonding refers to the process used to apply the epoxy coating to the reinforcing steel. The bars are blast cleaned and the surface heated to around 425°F (220°C) and then passed through an electrostatic spray containing fine epoxy powder. The powder is attracted to the bars based upon electrostatic forces. When the epoxy encounters the heated bars, it melts and fuses, forming a thermosetting polymer. The resultant coating is significantly more uniform in thickness than could be achieved using other methods, such as non-electrostatic coating or dipping.

Availability and Cost

What is the availability of epoxy-coated reinforcing bars?

Epoxy-coated reinforcing bars are readily available from over 35 CRSI Certified Manufacturing Plants throughout North America. A link for a listing of certified plants may be found at http://www.crsi.org/index.cfm/certification/plant. Approximately 10 percent of all reinforcing bars are epoxy-coated and the most commonly available product is Grade 60 (420) in both ASTM A615/A615M and A706/A706M, coated according to ASTM A775/A775M.

What are the lead times necessary to order and get the bars fabricated?

As stated above, epoxy-coated reinforcing bars are readily available from over 35 different CRSI Certified manufacturing plants. Purchasers are encouraged to inquire with a local fabricator about lead times for specific grades, sizes, and quantities early in the project schedule. For the most current CRSI certified Epoxy-Coated Steel Reinforcing Bar Manufacturers, please see www.crsi.org under the Standards & Certification tab.

What is the cost of epoxy-coated reinforcing bars compared with normal “black” bars or other corrosion resistant bars on the market?

As a trade organization, CRSI does not comment on costs, and costs will vary by location and with the price of uncoated reinforcing steel. Manufacturers or suppliers should be contacted for current pricing information.

Are epoxy-coated steel reinforcing bars environmentally friendly?

Epoxy-coated steel reinforcing bars have the following sustainable attributes:

- Manufactured using reinforcing bars that are made using over 95% recycled steel
- Can be readily recycled after use
- Manufactured using low amounts of energy compared with other systems
- No VOCs produced during the powder coating process
- Structures that use epoxy-coated steel reinforcing bars are more durable than those that use black bars.
- Epoxy-coated bars are locally available, thereby minimizing transportation.

Engineering Design Issues

What are the yield and tensile strengths of epoxy-coated reinforcing bars?

Bars meeting ASTM A615/A615 M are available in yield strength grades of 40, 60, 75, 80 and 100 ksi [280, 420, 520, 550 and 690]. Bars meeting ASTM A706/A706M are available in yield strength grades of 60 and 80 ksi [420 and 550]. Bars meeting ASTM 996/A996M are not as readily available as the other two steel types, but these are available in yield strength grades of 40, 50, and 60 [280, 350 and 420].

Are there any special design guidelines for epoxy-coated reinforcing bars in ACI 318 or AASHTO Bridge Design Specifications?

ACI 318 Building Code Requirements for Structural Concrete and AASHTO LRFD Bridge Design Specifications generally treat epoxy-coated reinforcing bars the same as black bars in terms of structural design except that additional development length is required.

Can epoxy-coated reinforcing bars be mixed with other reinforcing steel bars?

Epoxy-coated bars can be used in structures with other reinforcing steel bars; however, when using epoxy-coated reinforcing steel in bridge decks, it is recommended that all the deck reinforcement is coated as this will reduce the overall rate of corrosion if the coating is damaged.

In piers subjected to chloride exposure, the use of epoxy-coated reinforcing bars should be continued from below the waterline into an area above the splash zone to minimize corrosion risks.
Can the concrete cover to epoxy-coated bars be reduced?

The AASHTO LRFD Bridge Design Specifications permit a reduction in concrete cover when epoxy-coated reinforcing steel is used, while the ACI 318 Building Code Requirements for Structural Concrete does not permit a reduction in concrete cover when epoxy-coated reinforcing steel is used.

Is development length greater when using epoxy-coated reinforcing steel?

The development length is the length of bar embedded in concrete required to obtain yield of the steel. This length is greater for epoxy-coated reinforcement compared to uncoated bars as the coating reduces the bond to the concrete from 20 to 50%, depending on the spacing and concrete cover on the bars. The increased development length has been well established by testing and is considered in design codes such as ACI 318 Building Code Requirements for Structural Concrete and AASHTO LRFD Bridge Design Specifications.

What is the effect of coating damage on the bars’ performance?

Epoxy-coated reinforcing steel without damage will resist corrosion better than bars with damaged coatings; however, field and laboratory data has shown that even bars with coating damage perform significantly better than black bars. All visible damage to epoxy-coated reinforcing steel should be repaired prior to concrete placement. Essentially all tests evaluating epoxy-coated reinforcing steel are conducted using bars with deliberate damage to simulate worst-case situations.

Is it better to lap splice or mechanically splice epoxy-coated reinforcing bars?

Epoxy-coated reinforcing steel may be spliced using either lap splices or mechanical splices. Use of the particular method depends on many factors and this will likely become an economic decision. For the smaller bar sizes, the “extra” length of epoxy-coated steel bars to facilitate the lap splice requirements will likely be less expensive than the selected mechanical splice. For the larger bar sizes, the coupler becomes more economical than the “extra” length of bar used to make the lap splice. A mechanical splice may, however, be a better alternative given job specific constructability conditions, congestion issues, and/or spacing requirements. ACI 318 Building Code Requirements for Structural Concrete or AASHTO LRFD Bridge Design Specifications provisions may also influence this decision.

What types of mechanical splices are available?

Many mechanical splices are commercially available in standard size threaded couplers. Some of these are coated with epoxy-coating, similar to that used for epoxy-coated reinforcing bars, while others are left uncoated and protected using a water-proof sleeve at the jobsite that is placed tightly around the ends of the bars and the couplers to prevent moisture intrusion. As with any mechanical splice, test data should be utilized to determine suitability of available products.

Are there any issues to using mechanical splices with epoxy-coated steel bars?

When mechanical splices are used, they should be inspected for any coating damage prior to placement of concrete. If damage is observed, the steel should be cleaned to remove any surface corrosion and coated with an approved two-part epoxy coating, formulated for use with epoxy-coated reinforcing steel.

Fabrication

Into what shapes can epoxy-coated reinforcing bars be bent?

Epoxy-coated reinforcing steel meeting ASTM A775/A775M can be fabricated into the entire array of standard bend shapes found in the CRSI Manual of Standard Practice and ACI 315 Details and Detailing of Concrete Reinforcement. The bars are bent to the same diameters as black bars.

Bars meeting ASTM A934/A934M should only be bent after coating with the permission of the engineer and any damage to the coating should be repaired using a two-part epoxy repair material.

Fabrication of epoxy-coated reinforcing bars uses the same process as for black bars except the bending pins are covered with a polymer outer wrap. The contact surfaces of equipment used to fabricate or handle epoxy-coated bars should be protected using plastic or other material to protect the bars against damage.

Do sheared ends of epoxy-coated bars need to be coated after shearing?

All exposed steel, including sheared ends, should be coated using a two-part epoxy. Generally, end coating is conducted as part of standard fabrication practices.

Construction Handling

Are there any special handling requirements for epoxy-coated reinforcing steel?

The fabrication and field handling of epoxy-coated reinforcing steel is covered by ASTM D3963/D3963M and in the Appendices of ASTM A775/A775M or A934/A934M. Further information is also found in the CRSI Publication Specialty and Corrosion-Resistant Steel Reinforcement: A Product Guide and from the Epoxy Interest Group of CRSI (www.epoxyinterestgroup.org).
Recommendations include:

- When lifting individual bars or bundles of epoxy-coated reinforcing bars, spreader bars or strong backs with multiple pick-up points should be used to minimize sags.
- Synthetic or padded slings should be used and at no time should epoxy-coated reinforcing bars be lifted using bare chains or cables.
- Bundles of epoxy-coated reinforcing bars should be stored off the ground on suitable materials, such as timber cribbing.
- Epoxy-coated reinforcing bars should be stored separately from uncoated steel reinforcing bars to prevent abrasion of coating.
- During storage and shipping, all contact points (e.g. trailers, storage racks) should be wood or plastic-lined.
- Epoxy-coated reinforcing bars should be covered using opaque polyethylene sheeting or other suitable opaque material if they are to be stored outdoors for more than two months.
- Epoxy-coated bars should be protected against coating damage through appropriate lifting, handling, placing and concrete placement operations.
- During placement, bars should be lifted and set in place.
- Epoxy-coated reinforcing bars should not be dragged into place and other materials should not be dragged across placed epoxy-coated reinforcing bars.
- Movement of personnel and materials across the epoxy-coated bars should be minimized.
- Prior to concrete placement, epoxy-coated bars should be inspected and damaged coating repaired with a two-part epoxy material meeting ASTM A775/A775M or A934/A934M.
- Plastic-headed vibrators should be used to consolidate the concrete.

**Do I need to use special accessories (e.g., supports, ties, etc.) if I am using epoxy-coated reinforcing bars?**

When placing epoxy-coated steel reinforcing bars, all wire bar supports, spacers, and tying wire should be coated with dielectric material, for example, an epoxy-coated or plastic coated material compatible with concrete. Composite (plastic) bar supports and spacers may be used if approved by the purchaser.

**Are there any storage issues on the project site that could impact the use of epoxy-coated reinforcing bars?**

Epoxy-coated reinforcing steel should be stored separately from uncoated steel to prevent damage. Stored epoxy-coated bars should be elevated off the ground on timber dunnage.

Additionally, ASTM D3963/D3963M requires that: “Placed coated bars shall be covered with opaque polyethylene or similar protective material if cumulative environmental exposure of the coated bars, including previously uncovered storage time, of greater than two months prior to concrete embedment is expected.”

The provision for two-months of exposure was developed from testing conducted by C-SHRP where bars were left exposed and then tested. (See: http://www.cshr.org/products/outdoor.pdf) It is known that extended exposure is often unforeseen and that bars may be exposed for longer periods than that covered by ASTM D3963/D3963M. Fusion-bonded epoxy coatings may undergo surface discoloration and chalking from exposure. Should extended exposures occur, it is strongly recommended that the bars be carefully inspected and any site of damage or localized corrosion be repaired following ASTM D3963 using a two-part epoxy, recommended for use on epoxy-coated steel reinforcing.

CRSI recommends that bars stored outside be covered after 30 days.

**Can I weld epoxy-coated reinforcing bars?**

According to the CRSI Manual of Standard Practice reinforcing steel should be welded according to the American Welding Society, AWS D1.4/D1.4M Structural Welding Code – Reinforcing Steel. If the steel used for the coated bars meets ASTM A706/A706M, the bars are intended for welding without preheating and therefore should be specified for applications that require an appreciable amount of welding.

ASTM A615/A615M reinforcing bars can be welded, but may require preheating the bars up to 500°F (260°C). Tack welding is not permitted.

After completion of the welding on epoxy-coated bars, the damaged areas should be repaired using patch materials meeting ASTM A775/A775M or A934/A934M.

**Fabrication**

**If corrosion occurs on epoxy-coated reinforcing steel bars, does the corrosion result in rapid section loss?**

Field evaluations of epoxy-coated reinforcing steel have observed that when corrosion does occur it does not focus at a single location, but can spread underneath the coating.

**Can a “Rebar Green” pressurized spray can be used to repair epoxy-coated reinforcing steel?**

The epoxy-coating reinforcing steel industry does not recommend use of one-part spray coating materials to repair damaged areas or sheared ends of bars.
These coatings generally cannot be applied to adequate thicknesses and tend to be more porous than two-part non-sprayed materials. Two part liquid epoxies provide superior coating thickness, adhesion, and coverage when compared to one-part sprays. Two-part epoxy coatings are designed to function as a system with powder coating epoxies.

**What is the appropriate method of repairing or touching up epoxy-coated reinforcing bars?**

The process for repairing damaged coating on epoxy-coated reinforcing bars typically involves cleaning any corrosion off the bars at the damage site using a wire brush followed by application of a two-part epoxy repair material, typically using a paint brush. Patch material manufacturer recommendations should be followed.

**When installing a spall repair or concrete patch on an existing concrete structure, what is the best way to repair the existing epoxy-coated reinforcing bars?**

If epoxy-coated reinforcing steel is exposed during concrete repair, the exposed areas of steel on the coated bars should be field coated or new epoxy-coated bars spliced into the repaired area to minimize the ability of those bar sections to become cathodic to the adjacent steel in concrete. While field coating will provide less protection than plant coated reinforcement, the field coating will provide some protection.

**References**


American Concrete Institute - ACI Committee 315 (1999), Details and Detailing of Concrete Reinforcing, ACI 315-99, American Concrete Institute, Farmington Hills, Michigan, 44 pp.

American Concrete Institute - ACI Committee 318 (2014), Building Code Requirements for Structural Concrete (ACI 318-14) and Commentary (ACI 318R-14), American Concrete Institute, Farmington Hills, Michigan, 520 pp.


Contributors: The principal author on this publication is David McDonald with review by members of the CRSI Durability Committee.

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