BRIDGES

EIG CRSI®
EPOXY INTEREST GROUP

About EIG

History of the Epoxy Interest Group

Since 1973, the use of epoxy-coated reinforcing bars has continued to grow. In response to this growth, the industry formed the Fusion Bonded Coaters Association (FBCA) in 1982. FBCA published the first edition of Anti-Corrosion Times in August 1983.

In 1985, the FBCA merged with the Concrete Reinforcing Steel Institute (CRSI). Founded in 1924, CRSI stands as the authoritative resource for information related to steel reinforced concrete construction. CRSI members are manufacturers, fabricators and placers of steel reinforcing bar and related products, as well as professionals who are involved in the research, design and construction of reinforced concrete.

In March 2008, a new group was formed within CRSI. The Epoxy Interest Group (EIG) of CRSI operates within the charter of CRSI, but promotes and markets epoxy-coated reinforcing steel and is able to create awareness and interest in these products and its important benefits for DOTs, engineering specifiers and contractors.

Our Mission

To promote the use and advance the quality of Epoxy-Coated Reinforcing Steel.

EIG CRSI®
EPOXY INTEREST GROUP

Benefits of Epoxy-Coated Reinforcing Steel

- Excellent Corrosion Protection.
- More than 35 Years of Experience.
- Extended Service Life.
- Cost Effective Life-Cycle.
- Nationwide Availability.
- CRSI Certified Plants.
- Sustainable.

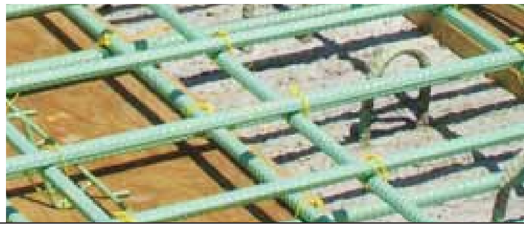
Free Publications Online

Register at www.epoxyinterestgroup.org to receive updated information on the use and performance of Epoxy-Coated Reinforcing Steel.

Cover Photo:
Reinforcing bars photo courtesy of AECOM USA

Back Cover Photo:
Reinforcing bars photo courtesy of FIGG, photographer Tim Davis

Photo: Shutterstock



Epoxy-Coated Reinforcing Steel

Epoxy-coated reinforcing steel has been used for more than 35 years to reduce the amount of expensive and disruptive repairs to concrete structures caused by corrosion.

Introduction

Epoxy-coated reinforcing steel was first used in 1973 on the Schuykill Bridge near Philadelphia, PA, as a method to reduce corrosion damage to bridge structures. Since then, epoxy-coated reinforcing steel has been used in over 65,000 bridges nationwide covering an area of 700,000,000 sq. ft. Structures built with epoxy-coated reinforcing steel have significantly longer lives than structures built with uncoated steel.

Epoxy-coated reinforcing steel can be used almost anywhere corrosion may cause damage. While the product is most commonly used on bridges, it can also be used in continuous reinforced concrete pavement, parking garages, piers and docks, water towers, walls, columns and parapets.

Manufacture

The manufacture of the majority of epoxy-coated reinforcing steel is covered in **ASTM A775** *Standard Specification for Epoxy-Coated Steel Reinforcing Bars*. This specification requires that suppliers of coated bars take steps to properly prepare the bars prior to coating, that contaminants are not present, and that the coatings are fully cross-linked and bonded to the bar.

The product may also be manufactured to **ASTM A884** *Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement* or **ASTM A934** *Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars*.

Certification and Quality

CERTIFIED PLANT

In 1991, the Concrete Reinforcing Steel Institute (CRSI) initiated a voluntary certification program for the manufacture of epoxy-coated reinforcing steel. This program significantly improved product quality. Developed to provide an independent certification, the program outlines the basic requirements for a quality control program to ensure that a plant and its employees are trained, equipped and capable of producing fusion bonded epoxy-coated reinforcing steel in conformance with the latest industry standards and recommendations. The program certifies the manufacturing process and is not a guarantee of product quality. It is intended to supplement, not to replace, the acceptance testing of materials. Many State Departments of Transportation require that bars are manufactured under this CRSI certification program.

The purpose of the voluntary certification program is:

- To ensure that coating applicator plants have the capabilities and quality control procedures in place to ensure a high level of excellence in materials produced and delivered to the job site.
- To assist plant management in achieving a high level of excellence in the plant and its operations.
- To provide recognition to plants which demonstrate a high degree of excellence.

Job Site Handling

Transport and Handling

Just like any material used on a jobsite, appropriate handling of epoxy-coated reinforcing steel is required. These steps are aimed at reducing damage to the coating that would reduce its corrosion protection performance.

Handling and storage requirements for epoxy-coated reinforcing steel may be included in contract documents by reference to many different sources including ASTM A775 (AASHTO M284), A934, A884, D3963 (AASHTO M317), ACI 301 or individual agency specifications. The following provides a guide to these specifications:

- Use spreader bars with nylon or padded slings
- Store on cribbing and keep bundles straight
- Cover if exposed for more than 30 days
- Lift and set bars in place
- Minimize traffic
- Use coated tie wire
- Use coated or plastic bar supports
- Cut using power shears or chop saw
- Inspect and patch prior to concrete
- Repair cut ends
- Repair all damage
- Use approved two part patching material
- Use plastic-headed vibrator to consolidate concrete

Corrosion And Steel Reinforcement

Corrosion Mechanisms

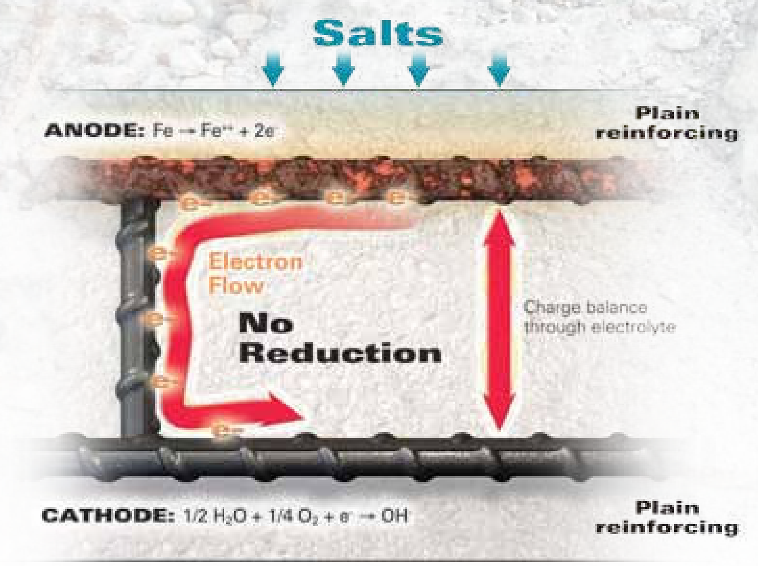
When steel is placed into concrete it develops a passive oxide film due to the high pH of the concrete. This passive film prevents further corrosion. Bars extracted from very old concrete may exhibit no evidence of corrosion.

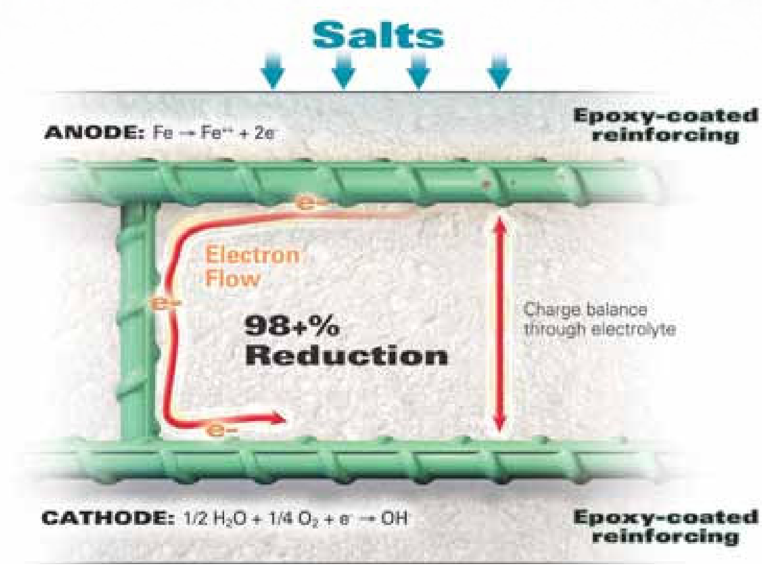
The protective film may be disrupted by carbonation of the cement paste, which reduces the pH, or through the ingress of chloride ions into the concrete, from either deicing salts or sea water. The rate of carbonation and penetration of chloride ions is governed by the permeability of the concrete, which may be reduced using concrete with lower water-cement ratios or additions of materials such as fly ash, silica fume or slag cement.

The amount of chloride ion to initiate corrosion of uncoated steel in concrete is generally considered to be 1.2 lb cu yd (0.7 kg/m^3) by weight of concrete. Once this level is reached, the passive film on the steel is disrupted and corrosion initiates. As the volume of corrosion products of iron are greater than the initial metal, cracking and damage to the concrete occurs.

Where epoxy-coated steel is used, corrosion may initiate at breaks or holes in the coating; however, the corrosion rates are substantially reduced. Laboratory tests have demonstrated over 98 percent reduction in corrosion rates even when damage is present.[1]

[1] Lee, S.K. and Krauss, P.D., *"Long-Term Performance of Epoxy-Coated Reinforcing Steel in Heavy Salt-Contaminated Concrete,"* FHWA Report FHWA HRT-04-090, 2004.





Hood Canal Bridge

Olympic and Kitsap, Washington State

Photos courtesy of Washington State Department of Transportation.

The Hood Canal Bridge carries Washington State Route 104 across the Hood Canal connecting the Olympic and Kitsap Peninsulas. The bridge, first opened in 1961, provides a vital link between these two peninsulas, carrying approximately 16,500 vehicles per day. The 7,869 ft long bridge has a 600 ft draw span to allow for shipping.

A floating bridge was chosen for this location as the canal is up to 340 ft deep and soils in the area are deep and soft. The bridge is also located in a high seismic region. It is the third longest floating bridge and only one of 11 floating bridges, worldwide.

Design Criteria

- Provide a cost-effective deep channel crossing in a high seismic region
- Design a replacement bridge with a 600 ft draw span to allow for shipping

The original floating bridge was built between 1958 and 1961; however in 1979 the west-side of the structure overturned due to high winds from the south and currents from the north. A replacement section was opened in 1982, containing over 6,000 tons of epoxy-coated reinforcing steel.

Between 2003 and 2009, Washington State Department of Transportation (WSDOT) replaced the 1961 era east-half floating portion of the bridge along with the east and west approach spans and transition spans at a cost of almost $500 million.

Fourteen pontoons were constructed with the largest measuring over 60 ft wide, 18 ft tall and 360 ft long. These pontoons were cast using over 30,000 cubic yards of self-compacting concrete. The concrete used had a nominal compressive strength of 6500 psi and a 22 in. spread, using fly ash and silica fume to reduce chloride permeability. After casting, the pontoons were transported from Tacoma by tugboat through Puget Sound to Hood Canal for assembly alongside the existing bridge. Over 4,000 tons of epoxy-coated reinforcing steel was used through the structure to protect the concrete against corrosion-induced damage. ■

Owner: **Washington State Department of Transportation**

Designer: **Washington State Department of Transportation**

Builder: **Kiewit-General**

Total Cost: **$500 million**

Date Opened: **June 2009**

Traffic: **16,500 vehicles per day**

Epoxy-Coated Bars: **4,000 tons**

Photos courtesy of Washington State Department of Transportation.

Woodrow Wilson Bridge, I-95 / I-495

Alexandria, Virginia/Oxon Hill, Maryland

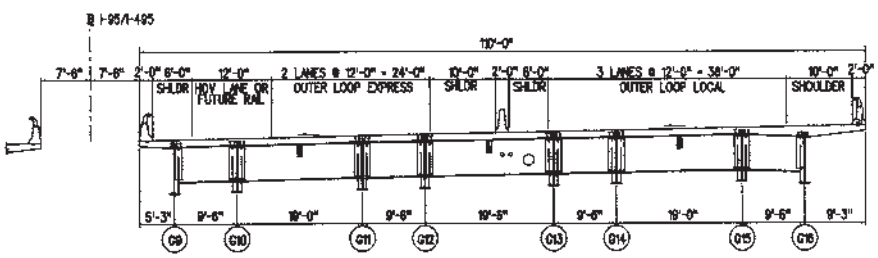
Photos courtesy of Parsons.

The Woodrow Wilson Bridge over the Potomac River is one of the most congested bridges in the nation and it currently handles 200,000 vehicles per day. At least 1.3% ($58 billion) of trucked GDP crossed the bridge in 1993. Prior to reconstruction, the bridge opened 260 times per year to enable access for high mast recreation sail boats, tall mast ships and marine vessels. The old bridge also had nearly twice the accident rate of similar highways in Maryland and Virginia.

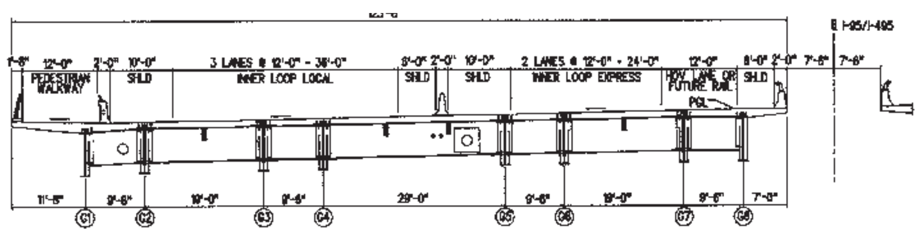
The Woodrow Wilson Bridge is one of only nine bridges on the U.S. Interstate Highway System that contains a movable span. The 6,075-ft-

Design Criteria

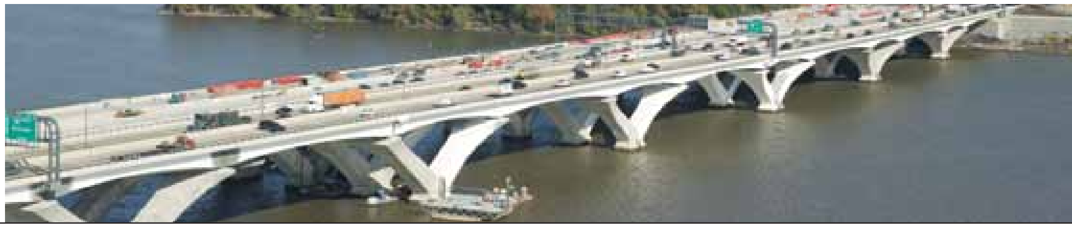
- 75-Year Service Life
- 12 lanes of traffic (four travel with one exit in each direction and two lanes for bus/rail transit)
- Corrosion protection provisions — aggressive winter environment (extensive use of deicing salts)
- Compatible with other Potomac River Bridges and environmental standards
- Movable span for water traffic (reduce bridge openings from 200 to 60 per year)



OUTER LOOP



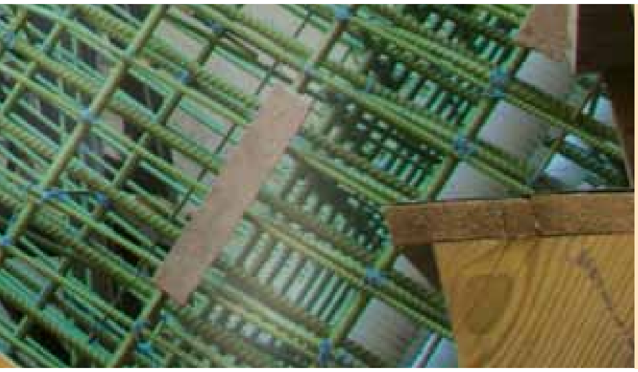
INNER LOOP



long Potomac River drawbridge was constructed with a 70 ft total clearance, some 20 ft greater than the old structure. This allows for 70 percent less openings per year. The bridge is twelve lanes, of which eight are general purpose lanes, two to allow exiting, and two lanes for future HOV/express bus/rail transit lines.

Over 4,200 tons of epoxy-coated reinforcing steel is used in the 10-in. (254-mm) thick fixed span decks, pile caps, pedestals and the bascule pier. ■

Photos courtesy of Parsons.



Owner: **State of Maryland and Commonwealth of Virginia**

Designer: **Parsons Transportation Group**

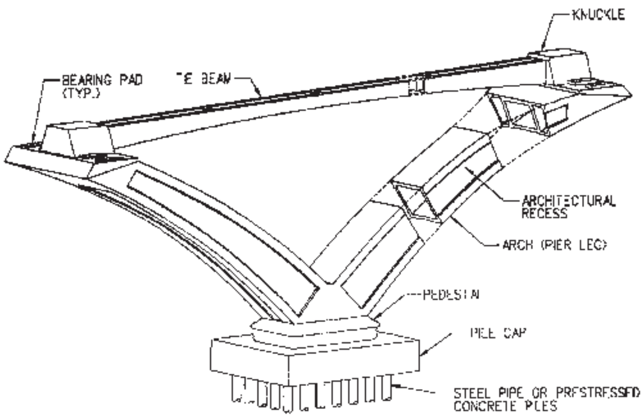
Builder: **Weeks Marine, Tidewater/Kiewit/Clark, American Bridge/Edward Kraemer, Virginia Approach Constructors and Potomac Constructors**

Total Cost: **$680 million**

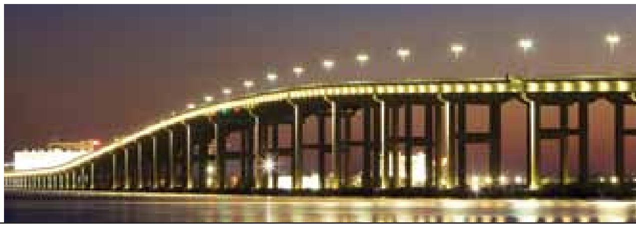
Date Opened: **June 2006 and May 2008**

Traffic: **200,000 vehicles per day**

Epoxy-Coated Bars: **4,200 tons**



Diagrams: (Above and Left) SP-228—53, High-Performance Concrete for the Woodrow Wilson Bridge, by T.A. Kite, American Concrete Institute (ACI).



Biloxi Bay Bridge, U.S. 90

Biloxi, Mississippi

The Gulf Coast of Mississippi suffered massive damage from the impact of Hurricane Katrina on August 29, 2005. During this storm, the Biloxi Bay Bridge was destroyed. As a consequence, Biloxi and Ocean Springs commuters faced a 30-minute detour to what was normally a one-minute commute from one community to the other. The new, much-improved structure was rebuilt in less than 21 months, and its six lanes were opened to traffic on November 1, 2007.

The old bridge was built in 1962 and featured two side-by-side structures, two lanes each and no shoulder, with about 21 ft of clearance between the water and the bridge. The new 1.6-mile bridge was designed by Parsons and the contractor was GC Constructors, a joint venture of Massman Construction Co. of Kansas City, Traylor Bros. Inc. of Evansville, Ind., and Kiewit Southern Co. of Peachtree, GA.

This new bridge carries three lanes of traffic in each direction. In addition to its shared-use pathway, the bridge features three overlook areas, and a dual-lighting design that makes an elegant aesthetic statement at nightfall. It provides about 95 ft of vertical clearance to accommodate marine traffic.

The bridge uses pile footings, column caps and concrete girder construction and features two side-by-side structures. Each holds three lanes of traffic and two shoulders. The eastbound structure has an additional 12-ft-wide pedestrian and bike path.

The superstructure utilized precast, prestressed concrete bulb tees. The use of self-consolidating concrete reduced production costs through faster placement and the use of less skilled workers. The bridge received national recognition for its rapid reconstruction.

Over 11,000 tons of epoxy-coated reinforcing steel was used in the bridge superstructure. ■

Owner: **Mississippi Department of Transportation**

Designer: **Parsons**

Builder: **GC Constructors**

Total Cost: **$339 million**

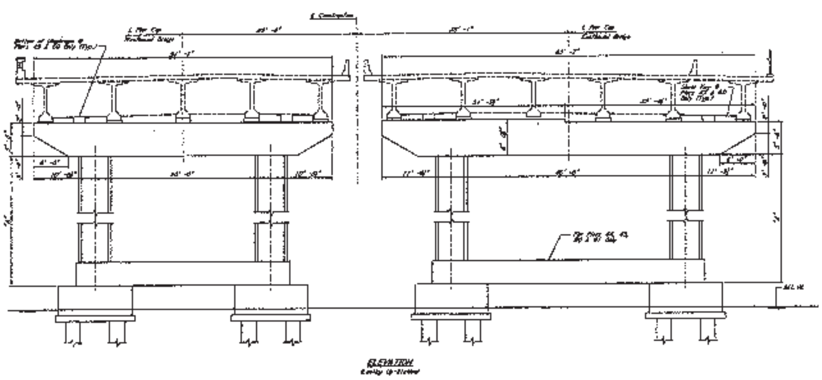
Date Opened: **November 2007**

Traffic: **35,000 vehicles per day**

Epoxy-Coated Bars: **11,000 tons**

Design Criteria

- Dual structures, each carrying three lanes of traffic
- 12 ft shared use path on eastbound structure
- One lane open to traffic in each direction within 18 months, and the entire project was required to be complete in just 22 months
- Designed to withstand hurricane-force winds and waves similar to those of Katrina
- Aesthetics an important consideration in the design development



All photos and diagrams courtesy of Parsons.

Galena Creek Bridge

Reno, Nevada

When completed, the twin Galena Creek Bridge on I-580 near Reno NV will be the largest concrete cathedral-arch bridge in the world, measuring over 1,725 ft with a central span of almost 690 ft. This bridge, designed by NDOT, is part of a $450-million, 8.5-mile-long I-580 Freeway Extension that will help connect Reno and Carson City. Construction on the bridge started in 2003.

The bridge consists of two parallel cast-in-place concrete arches and each arch has a width of 19.7 ft and a depth of 11.8 ft. Each box girder will carry three lanes of traffic. The structure serves as the centerpiece on a project that includes eight other cast-in-place bridges. The arched design of the project resulted from a Context Sensitive Solution format early in the process. This involved an integrated public-outreach plan to solicit public involvement and communicate openly with stakeholders about the design concept.

All concrete in the project included fly ash while the concrete in the deck also used silica fume. Over 3,000 tons of epoxy-coated reinforcing steel are used throughout the bridge, including the barrier rails, due to the large amount of deicing salts used to keep the bridge accessible through the winter. ■

Owner: **Nevada Department of Transportation**

Designer: **Nevada Department of Transportation**

Builder: **Edward Kramer & Sons, C.C. Myers Inc., and Fisher Industries**

Total Cost: **$80 million**

Date Opened: **Fall 2011**

Epoxy-Coated Bars: **3,000 tons**

Design Criteria

- Design an efficient bridge that will be the largest cathedral-arch bridge in the world
- Provide a design that blends with the terrain and is aesthetically pleasing
- Optimize alignment to minimize earthwork
- Incorporate maintenance and operational requirements, to address snow removal, bridge and roadway deicing, drainage and incident management

Providing Corrosion Protection

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