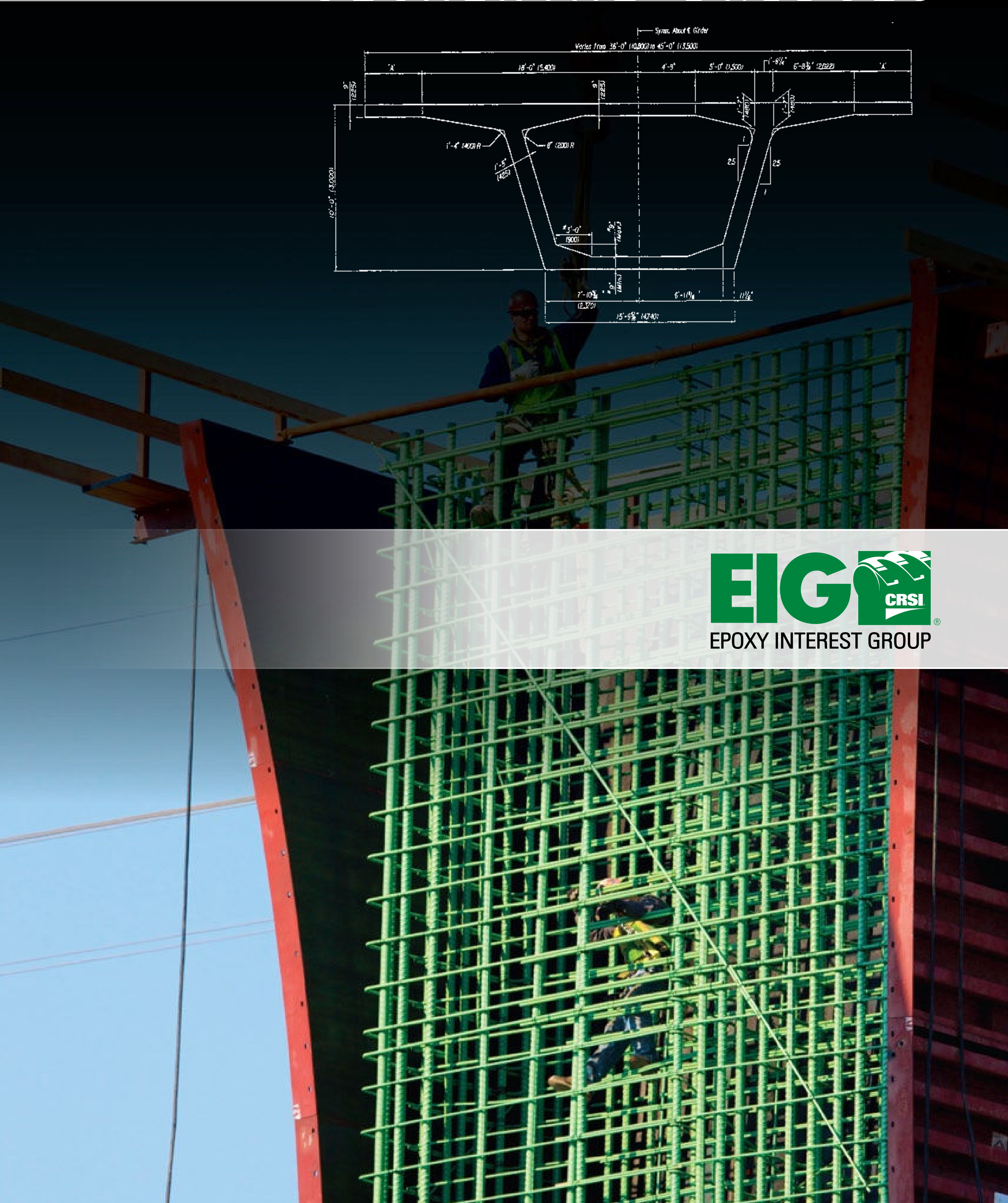
SEGMENTAL BRIDGES



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 bars 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 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

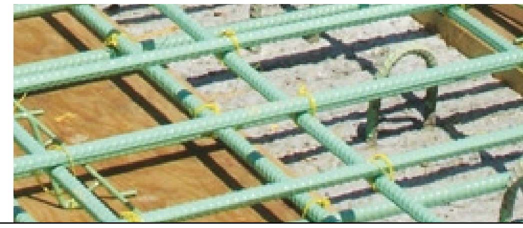
- Excellent Corrosion Protection.
- More than 35 Years of Experience.
- Extended Service Life.
- Cost Effective Life-Cycle.
- Nationwide Availability.
- CRSI Certified Plants.
- Sustainable.

Free Publications Online

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

Front and 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 Schuylkill 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 can 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 can 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 with 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

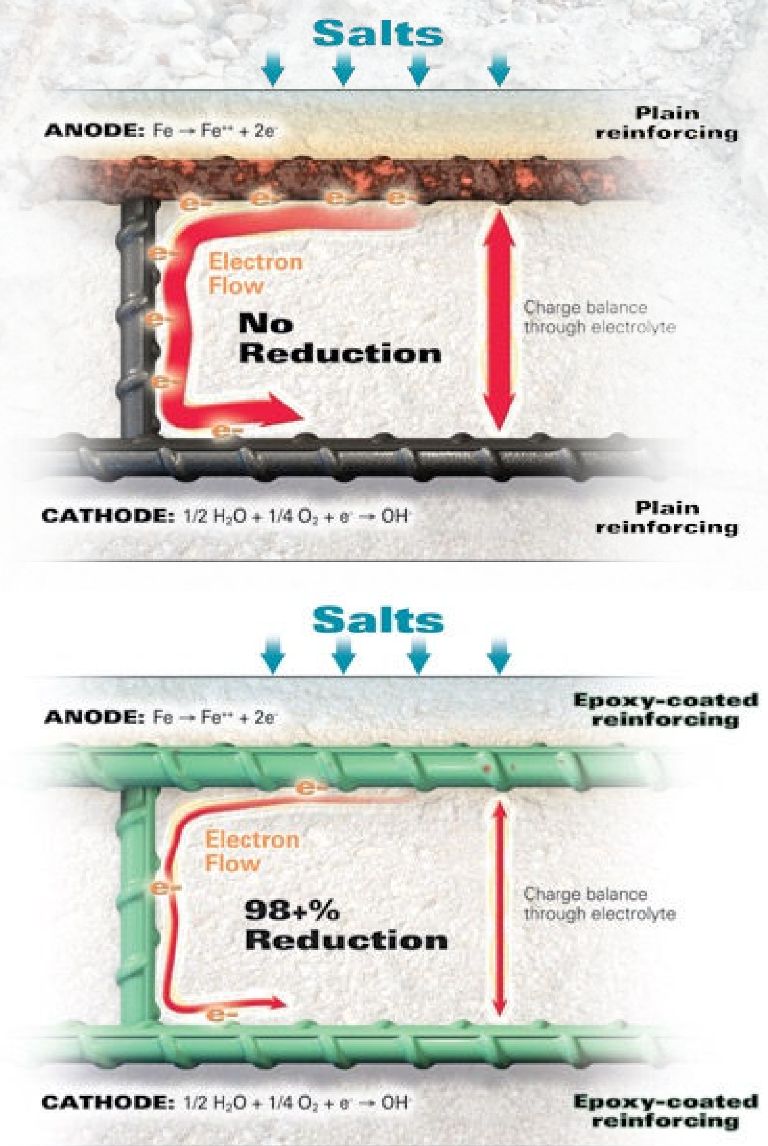
When steel is placed into concrete it develops a passive oxide film due to the high pH of the concrete. This passive film prevents further corrosion. Bars extracted from very old concrete may exhibit no evidence of corrosion.

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 can 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 can 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.



Woodrow Wilson Bridge, I-95 / I-495

Alexandria, Virginia / Oxon Hill, Maryland

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

Designer: **A joint venture between Parsons, URS, and Rummel, Klepper and Kahl, LLP**

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**

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.

per year. The bridge is twelve lanes, of which eight are general purpose lanes, two allow exiting, and two are for future HOV/express bus/rail transit lines.

All photos courtesy of Parsons.

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-long Potomac River drawbridge was constructed with a 70 ft total clearance, some 20 feet greater than the old structure. This allows for 70 percent fewer openings

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

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)

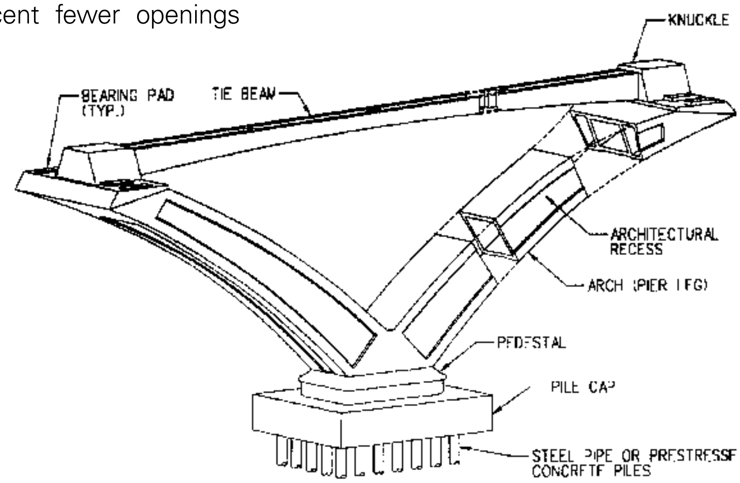


Diagram: SP-228—53, High-Performance Concrete for the Woodrow Wilson Bridge, by T.A. Kite, American Concrete Institute (ACI).

Four Bears Bridge

New Town, North Dakota

The Four Bears Bridge, near New Town, North Dakota, serves as a critical link for the communities of the Fort Berthold Indian Reservation. The location of the project presented a significant issue. The bridge is being built outside a town of 1,500 people and this is the largest town for 70 miles.

Construction on the new Four Bears Bridge started in April 2003. The new bridge design includes two abutments, 14 piers placed 316 ft. apart, 454 9.5-ft. typical segments in the spans between the piers, 28 5.5-ft. pier segments on top of the 14 pier columns, and 15 2-ft. closure joints at the mid-point of each span between piers. Pier segments weigh about 98 tons each, and include 47 cu. yds. of concrete and 12,338 lbs. of epoxy-coated rebar. The typical segments weigh about 70 tons each, and include 35 cu. yds. of concrete and 5,500 lbs. of epoxy-coated rebar. The main challenge to this project was climate, with the lake freezing during construction. A comprehensive ice report determined that an ice criterion of 36" ice thickness, with a crushing strength of 200 psi would most likely impose the maximum loading on the circular columns. The piers are protected against ice using cone-shaped concrete piers 39 feet in diameter. The side walls of the cones are set at 65-degrees, which will deflect ice upwards, reducing the stress on the piers. The piers are each supported by 13 or 14 pilings driving into the riverbed between 90 and 160 feet. The piers range from 45 feet to 73 feet, and the bridge ranges in thickness from 8 feet to 17 feet, placing the roadway as high as 90 feet above the water.

The Four Bears Bridge is named after two Indian chiefs, both of whom are named Chief Four Bears. One is from the Mandan Tribe, the other from the Hidatsa Tribe. The bridge is decorated with a series of 10-foot diameter medallions that represent the heritage of the three tribes that live on the reservation (Arikara, Hidatsa, and Mandan).

Owner: **North Dakota Department of Transportation**

Designer: **Figg Engineering Group**

Builder: **Fru- Con Construction (Bilfinger Berger Civil, Inc.)**

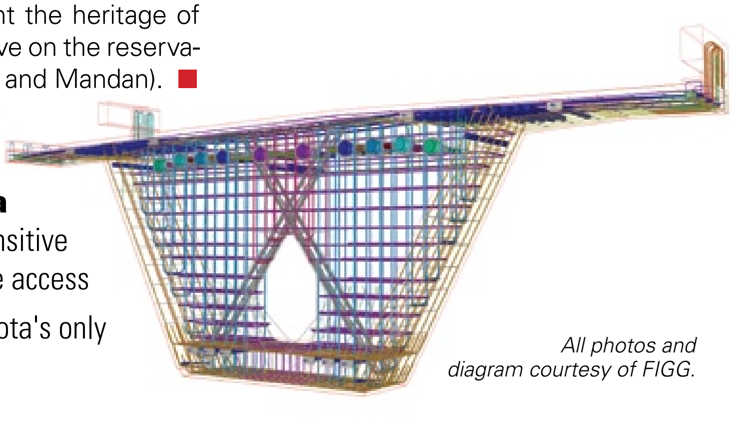
Total Cost: **$55 million**

Date Opened: **September 2005**

Epoxy-Coated Bars: **13,000 tons of epoxy-coated reinforcing steel (approximately)**

Design Criteria

- Provide context-sensitive structure to provide access
- Replace North Dakota's only deep-water bridge



All photos and diagram courtesy of FIGG.

U.S. 191 Bridge over the Colorado River

Moab, Utah

Owner: **Utah Department of Transportation**

Designer: **FIGG**

Builder: **Wadsworth Brothers Construction**

Total Cost: **$26 million**

Date Opened: **December 2010**

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

Photo courtesy of Summit Engineering.

Design Criteria

- Construction of this massive structure is tip-toeing through a highly environmentally sensitive area that houses the Arches National Park and Canyonlands National Park
- A special mineral-based stain and rock texture blend the bridge into the landscape, keeping the focus on nature
- Balanced cantilever construction from above keeps construction out of the river and maintains recreational uses in the area

The U.S. 191 Colorado River Bridge primarily serves as a transport for tourism, and the revenue generated from tourism is the mainstay of the local economy. It is the gateway to Arches National Park, Canyonlands National Park, Dead Horse Point State Park, white-water rafting down the Colorado River, and hundreds of miles of world famous, multi-use trails.

The Project Team recognized that the success of this project ultimately depended on providing the community with a new river crossing that was designed to blend in and allow the natural landscape to remain in the forefront. They developed and presented to the community a concept that mimicked the graceful form of an iconic local landmark: Landscape Arch. The shallow, arched profile of Landscape Arch is naturally structurally efficient and lends itself well to variable depth, post-tensioned, concrete segmental box girder technology constructed in balanced cantilever. This structure type allows the bridge to be built top-down with the use of traveling forms, with little environmental impact to the river. The resulting long spans allowed for only one pier in the river, three fewer than the previous bridge. In addition, the concrete mix was engineered to have a service life of over 100 years, which will dramatically reduce the life-cycle impact to the environment. Artfully applied, non-toxic, water-based mineral stain blends the concrete structure seamlessly with the complex palette of the surrounding sandstone cliffs.

Utah's first concrete segmental bridges were built from above, cast-in-place in balanced cantilever, to minimize impact to the channel and to allow for continual recreational use of the river and surrounding trails during construction. The bridge is also Utah's longest concrete span. The 440 foot main span minimizes the bridge footprint, and spans a sensitive environment home to several endangered species.

The first of the twin structures was constructed completely off-line so as to not interrupt traffic, demolition was completed off-line after traffic had moved over to the new bridge, and traffic was switched seamlessly between the twin structures to allow for staining operations to progress unimpeded. The contractor achieved casting rates of six segments per week with two sets of form-travelers, and the twin 1,022 foot bridges were completed in just 21 months, nearly a year faster than the original project schedule and nearly $3M under the Engineers Estimate. ■

All photos courtesy of FIGG.

Photo courtesy of MassDOT (Massachusetts Department of Transportation.)

DCR Access Road Bridge over Route 24

Randolph, Massachusetts

The precast concrete "channel" design for the DCR Access Road Bridge over Route 24 will improve clearance for the heavily traveled road below, complement the surrounding scenic areas and reuse existing materials to reduce waste and lower costs. It also offers significant opportunities for expanding the capabilities of post-tensioned segmental construction.

The DCR Bridge is a 248-ft-long, two-span continuous precast concrete structure that increases vertical clearance over Route 24 to 16'5", adding more than 2 feet. The substructure consists of two new reinforced concrete stub-type abutments supported on steel piles and a new center pier.

The channel cross-section features a precast concrete superstructure with two edge beams that function as the main load-carrying elements, with the girders supported between them. The 8.2-ft-long U-shaped segmental girders feature a flange on both top edges that support the girders on erection beams that run from pier to pier on both sides.

Photos courtesy of Unistress Corporation.

This system eliminates the need for a below-deck support system, minimizing clearance and construction time while reducing life-cycle costs. The longitudinal edge beams also serve as traffic barriers. They are fully post-tensioned using a mix of 12- and 19-strand tendons. Additional longitudinal tendons are provided in the deck slab, using flat 4-strand tendons. All reinforcing steel in the deck sections is epoxy-coated reinforcing steel.

Once the existing bridge was demolished, the bridge's existing steel I-girders were rewelded to serve as the temporary erection beams supporting the precast concrete channel segments. Once the segments were post-tensioned, the steel beams were removed and recycled for reuse.

The channel design provides a sleek, low-profile appearance that provides functional clearance benefits while keeping it unobtrusive in scenic areas. Best of all, it minimizes long-term maintenance needs that will improve safety of construction crews and users while reducing costs over its service life. ■

Owner: **Massachusetts Highway Department (MassHighway)**

Designer: **International Bridge Technologies, Inc., and Purcell Associates**

Builder: **R. Zoppo Corp.**

Total Cost: **$3.86 million**

Date Opened: **Fall 2010**

Design Criteria

- Add clearance without raising approach roads
- Create an appearance that blends with the surroundings
- Minimize long-term maintenance needs
- Reuse or recycle as much material as possible

Indian River Inlet Bridge

Sussex County, Delaware

The Indian River Inlet Bridge is located on the Delaware coast, in the town of Bethany Beach. This new precast concrete cable-stayed superstructure has a projected 100-year minimum service life.

The location is susceptible to Atlantic hurricanes. The bridge was designed at the Strength limit state for a 100 year return period, and at the Extreme limit state for a 2,000 year return period.

The replacement bridge has a total length of 2600 feet. The main bridge is a three span concrete cable-stayed structure with a main span of 950 ft, and side spans of 400 ft supported by 240-foot high towers on each side of the bridge.

All supports will be out of the water, eliminating scour conditions that severely reduced the performance of the existing bridge.

The bridge has two 12-foot wide travel lanes, a 10-foot wide outside shoulder, and a 4-foot wide inside shoulder in each direction. Additionally, one 12-foot wide sidewalk will be accessed from the east side of the bridge. The reduced embankment limits will result in the elimination of massive embankments and will provide an open view.

Design features were also chosen by public voting resulting in blue cable stays, slanted pylon tops and nautical light fixtures. ■

Owner: **Delaware Department of Transportation (DelDOT)**

Designer: **AECOM**

Builder: **Skanska USA Civil Southeast, Inc.**

Total Cost: **$150 million**

Date Opened: **January 2012**

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

All photos courtesy of AECOM.

Design Criteria

- Provide 100+ year design life
- Provide public input into design features
- Design a deck that has zero tension under dead loads (including the effects of creep and shrinkage)

All photos courtesy of TXDOT.

Dallas High Five Segmental Ramps

Dallas, Texas

Faster construction and the ability to minimize impacts to traffic were key goals for the construction of concrete segmental ramps on the Dallas High Five project, which consisted of five ramps with span lengths up to 300 ft long.

The ramps are part of an overall upgrade of the LBJ/Central Expressway Interchange to eliminate bottlenecking, loop ramps, and confusing left-hand exits. It provides a five-level junction with an assortment of flyover ramps, highway widenings and high-occupancy vehicle lanes.

Precast concrete segments were match-cast offsite, allowing the contractors to complete the interchange faster with less traffic disruption.

The ramps were erected in a balanced-cantilever method using a specially designed rubber-tire segment erector on top of the cantilever. Two of the five ramps were opened to traffic early, with the other three completed on schedule. Beating the planned schedule reduced concerns about worker safety and minimized user costs by minimizing congestion or eliminating detours earlier. ■

Owner: **Texas Department of Transportation Dallas District**

Designer: **Parsons Corp.**

Builder: **Zachry Construction Co.**

Total Cost: **$100+ million**

Date Opened: **May 2004**

Traffic: **500,000 vehicles per day**

Design Criteria

- Provide a high volume interchange
- Complete within 60 months
- Construct 2.3 million square feet of deck

Providing Corrosion Protection

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