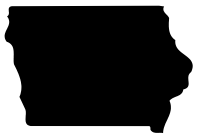

ADVANCES IN CONCRETE BRIDGES *in Iowa*

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For more than a century, Iowa has seen concrete bridges built with steadily advancing technology—cast-in-place (CIP); reinforced; precast, prestressed; high-performance (HPC); self-consolidating (SCC); post-tensioned; ultra-high-performance (UHPC); and combinations of technologies to accomplish accelerated bridge construction (ABC).

The history of Iowa's concrete bridges began in the late nineteenth century with the first CIP reinforced concrete Melan arch bridge, built when arches were popular for their efficiency and beauty. Soon after the Iowa State Highway Commission (IHC) was established early in the twentieth century, the IHC developed plans for several series of standard CIP reinforced concrete slab and beam bridges. These standard plans were created in the same era as the proprietary and competing concrete arch designs of James Barney Marsh and Daniel B. Luten.

Precast and Pretensioned Bridges

In the early 1950s, the bridge office developed standard designs for several new concrete bridges, often in conjunction with the Iowa Highway Research Board (IHRB). There were the H1 and H2 CIP reinforced concrete girder and continuous girder series for spans to 67.5 ft and 100 ft, respectively, and the J10 precast reinforced concrete series (reinforced channel slabs) for spans up to 30 ft. In 1954, the bridge office recognized the advantages of precast, prestressed concrete beams with the H10-series for spans up to 42.5 ft. As with all of the state-developed standard bridges, these were built by counties and cities as well as by the state. Updated versions of the H-series are still in use today.

The family of standard beams developed in the 1950s has grown to cover a wide range of span lengths and superstructure depths. The newest set of bulb-tee beams provides a competitive alternate for medium-span bridges. These bulb-tee beams have proven to be a perfect solution for many two-span overhead structures, multiple-span urban viaducts, and the approach spans of major river crossings. Attributes of the new beams include AASHTO Load and Resistance Factor Design (LRFD) compliance, low permeability (< 2500 coulombs), high strength (up to 9000 psi), efficient design with longer spans (up to 155 ft), wider beam spacings (up to 9.25 ft), and an aesthetically pleasing shape. It is interesting to note that the majority of Iowa bridges utilize precast, prestressed concrete beams. In fact, prestressed concrete was the material of choice for bridges over the interstate system.

High-Performance and Self-Consolidating Concretes

In early 2000, as a part of the reconstruction of I-235 in Des Moines, the Iowa Department of Transportation (IowaDOT) introduced HPC and SCC. Although HPC and SCC have been used widely in the United States, deploying these mixtures in Des Moines was not a simple task. A group of IowaDOT engineers from various disciplines, along with the Federal Highway Administration (FHWA), collaborated on developing mix designs and construction specifications that were suitable for central Iowa. The HPC mix designs had to utilize locally available aggregates, and meet new design requirements in terms of strength and permeability. Many challenges were encountered along the way, including a lack of local experience in producing mixtures such as HPC; implementation of a new aggressive policy on starting curing procedures for concrete within minutes after placing; and dealing with harsh winter conditions.

The I-235 experience laid the groundwork for statewide implementation of HPC, which is currently being used on major reconstruction projects in western Iowa (I-29/I-80 in Council Bluffs) and eastern Iowa (I-74 in the Quad Cities and U.S. 20 in Dubuque). These projects include several Missouri River and Mississippi River crossings. Although HPC has not been officially adopted for statewide use, many elements of HPC are being added to traditional mixtures.This can be attributed to the successes achieved on the I-235 project. Furthermore, some changes to IowaDOT's construction specifications were made to take advantage of

The Marsh rainbow arch bridge constructed in 1914 across the Raccoon River near Lake City has three 80-ft-long spans. Photos and drawings: IowaDOT.

Bridges have become a prime focus of aesthetic enhancement efforts.

the proven practices, such as improved concrete curing methods.

Iowa has earned a good reputation for bridge deck longevity despite the harsh winter environment and the use of deicing chemicals. This success can be attributed to its proactive use of deck overlays. In the late 1960s, Iowa introduced a low-slump dense overlay. The 1.5-in. to 2.0-in.-thick layer has provided excellent protection for bridge decks that were built with uncoated reinforcing steel. In fact, deck replacement projects have been rare in Iowa. Some decks have received multiple overlays prior to replacement. Recently, an alternative HPC overlay mix design was introduced to take advantage of common HPC benefits. Unlike the low-slump overlay mix, the new HPC deck overlay mix does not require specialized mixing and casting equipment because it can be cast using standard deck construction techniques and equipment, thus reducing cost. The biggest advantage of using HPC in deck overlays is the elimination of nuclear density testing and its associated safety and security issues.

Accelerated Construction and Ultra-High-Performance Concrete

Similar to the nationwide trend, precast concrete has played a major role in accelerated bridge construction (ABC) in Iowa, primarily with the use of precast deck panels, beams, pier caps, and abutment footings. The ABC efforts in Iowa began in 2006 when two local system bridges were constructed in Boone and Madison counties using precast superstructure and substructure components. This effort continued with the construction of 24th Street over I-29/I-80 in Council Bluffs. In 2009, a third totally precast bridge was built in Buena Vista County. The use of precast concrete has since been expanded to include bridge pavement approaches in Iowa. (See *ASPIRE*,™ Spring 2007.) So far, precast concrete panels have been used in two approach roadway projects, and a third will be constructed in 2010.

Another advance in concrete use in Iowa occurred in 2005, with construction of the first UHPC bridge in North America. Between 2005 and the present, three different types of UHPC superstructure components have been investigated for use in three Iowa bridges—bulb tee girders, pi-girders, and waffle deck panels.

Iowa has earned a good reputation for bridge deck longevity.

The first was a single-span, 110 ft long by 27 ft wide, Wapello County bridge (Mars Hill Bridge) with a cross section that consisted of three bulb-tee girders designed with concrete compressive strength of 24,000 psi and an allowable tensile stress at service of 600 psi. A typical UHPC mixture utilizes steel fibers in lieu of conventional shear reinforcing bars and has compressive strength that generally ranges from 16,000 psi to 30,000 psi. The tensile strength, usually neglected in concrete, can be as high as 1700 psi. The second bridge (Jakway Park Bridge) utilized a unique pi-shaped girder superstructure and was built by Buchanan County in 2008. In 2010, a third bridge with a UHPC waffle-shaped deck panel system will be built in Wapello County. It will also use field-placed UHPC to connect panels to panels and panels to girders. More details on the Wapello and Buchanon County bridges are given in *ASPIRE* Summer 2007 and Winter 2010 issues, respectively.

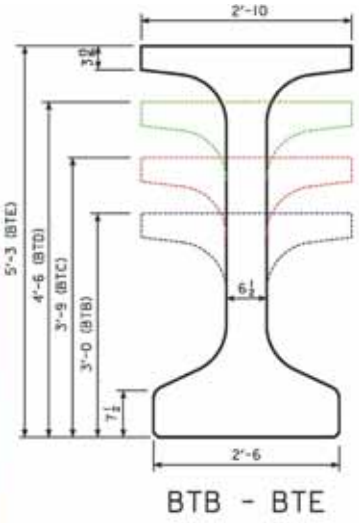
In O'Brien County, near Shelton, precast paving approach panels were installed on both ends of a new highway bridge to demonstrate rapid construction while eliminating settlement at the abutments. Each section was approximately 77 ft long and 28 ft wide.

The IowaDOT is currently working with Iowa State University (ISU) to investigate and test a new concept for a hybrid UHPC/HPC deck panel. The ISU/IowaDOT team has also investigated and field tested a UHPC H-pile for use in deep foundations, and a second phase of research is in progress.

Gateways and Enhancements

In recent years, the IowaDOT has become more responsive to the concerns of citizens about the appearance of state infrastructure projects. Bridges have become a prime focus of aesthetic enhancement efforts, especially when projects are built in and near communities. Routine structures are often considered by local municipalities to be community gateways, and the IowaDOT has tailored enhancement schemes to address these subjective project parameters. Occasionally, these aesthetic solutions become customized expressions of the communities in which they are situated. Instead of using an enhancement cookbook of ready design features, each effort has been uniquely

The new standard bulb-tee beams were installed in many bridges over I-235 in Des Moines.



An illustration of community gateway enhancement of a three-span, precast, prestressed bulb-tee beam bridge in Algona, Iowa, is U.S. 169 over the East Fork of the Des Moines River. The sculpted concrete aesthetic features capitalize on the city's railroad heritage.

orchestrated to design a project that strongly reflects aspects of its unique context.

Major interstate corridor reconstructions such as I-235 through Des Moines, I-29 through both Council Bluffs and Sioux City, and I-74 through the Quad Cities have all included aesthetic enhancements as a significant component of the planning and design process. Other individual bridge replacement projects in cities such as Algona, Keosauqua, Ankeny, and Bellevue have delivered community gateway solutions with unique aesthetic themes.

Concrete bridges are a mainstay on the Iowa highway system and will continue to improve with research, advancing concrete technology, and aesthetic enhancements.

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Precast UHPC waffle slab deck panels passed the testing program shown here at Iowa State University and are part of the design for a Wapello County bridge to be constructed in 2010.

Full-width deck panel placement at the 24th Street project site in Council Bluffs, the first Highways for LIFE project in Iowa.

Renderings of I-29 mainline bridges over local streets in Sioux City, projected for construction in 2014.

Iowa Bridges Timeline

1894
Melan reinforced concrete arch bridge, Lyon County
1904
Iowa State Highway Commission (IHC) established
1906
Standard plans developed for reinforced concrete box culverts
1913
IHC separated from Iowa State College
1920
Standard plans for I-Series reinforced concrete tee-beam bridges
1950
Iowa Highway Research Board (IHRB) established
1954
Standard plans developed for H10-Series precast, prestressed concrete beam bridges
1954
Standard plans developed for precast concrete channel slab bridges
1974
Iowa Department of Transportation established
2000
HPC and SCC methods and materials developed and used
2004–2005
Bulb-tee standard beams developed
2005
Mars Hill UHPC bulb-tee bridge built in Wapello County
2006
Precast concrete pavement approach slabs used in O'Brien County
2006
ABC project built in Boone County
2008
Jakway Park UHPC precast pi-girder bridge built in Wapello County
2010
UHPC precast waffle deck panel bridge to be built in Wapello County

The inspiration for articulation and coloring of the concrete elements of this two-span bridge, First Street over I-29 near Sergeant Bluff, came from nearby examples of Prairie School architecture.