# Landmark Launch

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Environmental and access requirements lead to a launched steel I-girder highway bridge in northern Iowa, a first in the United States.

The creation of the U.S. 20 bridge solved a decades-old problem: creating a crossing for the Iowa River to complete the Iowa Departmart of Transportation's U.S. 20 improvement project. For the first time in the United States, an incremental launching method was used to erect an I-girder highway bridge. When the bridge opened on Aug. 22, 2003, it marked the culmination of nearly 35 years of environmental studies, engineering design and construction.

The original U.S. 20 route was constructed in the 1920s as one of the main east-west roadways across northern Iowa. During the past 20 years, Iowa DOT replaced and relocated the two-lane road with a limited-access four-lane highway. But the project could not be complete without building a river crossing, a process complicated by environmental and access concerns.

The incremental launching method was developed by Fritz Leonhardt in the early 1960s for use with precast-concrete box-girder bridges.

This method offers a number of benefits to the owner and contractor, including:

- minimal disturbance to surrounding areas;
- smaller and more concentrated erection area; and
- increased worker safety, since all erection work is performed at a lower elevation.

The steps in the incrementally launched erection of the Iowa River Bridge consisted of the following:

- Erect all of the structural steel for the first 154 m (505′) of the eastbound bridge (including girders, diaphragms and upper and lower lateral bracing) on temporary pile bents behind the east abutment in a launching pit.
- Attach launching nose (leading end) and tail section (trailing end) to girder train.
- Jack the girder train forward longitudinally 92 m (302′) from Pier 6 to Pier 5.
- Remove tail section, splice additional girder sections to the tail end of the girder train.
- Reinstall tail section.
- Jack girder train longitudinally to Pier 4.
- Repeat sequence for a total of five spans.

The entire eastbound steel unit bridge was launched first. Then the temporary pile bents were removed and reinstalled for use in launching the westbound steel unit.

## Environmental Considerations

The selection of the incremental launching method was made to minimize disturbance of the environmentally sensitive Iowa River Greenbelt. The greenbelt is one of the few remaining areas of old-growth timber in central Iowa. A number of environmental issues were considered in the design and construction of the bridge:

- freshwater mussels that inhabit the Iowa River;
- bald eagle roosting area adjacent to the bridge;
- nearby ancient Native American campsites; and
- endangered Northern Monkshood plant.

The Iowa River is the preferred habitat of at least three rare species of freshwater mussels. These mussels are highly sensitive to changes in the temperature and clarity of the river, so strict environmental limitations were included in the contract documents. The use of causeways or temporary bridges to cross the river was prohibited. The contractor was required to provide containment for all equipment in the event that a spill would occur; and all drilling spoils, including artesian water, had to be removed from the contractually defined Environmentally Sensitive Work Zone (ESWZ).

The contract also provided for monitoring of bald eagle behavior during the winter months; if disturbance of the eagles was observed, construction work could be suspended for several months.

Alignment of the highway was adjusted to avoid interference with all of these areas. Construction activities in the ESWZ were defined in the project plans. Six zones were identified in the plans, each requiring specific methods for clearing existing trees and grubbing undergrowth.

*Above:* A launching pit excavated behind the east end of the span was approximately 200 m long by 36 m wide by 6 m deep (660' by 120' by 20').

*Below:* The tapered "launching nose" bolted to the girder allowed the deflected cantilever to "catch" each bridge pier as the launch progressed.

## Preliminary Design

The Iowa DOT hired HNTB Corporation in 1994 to perform the preliminary design of a bridge across the Iowa River. A number of bridge types were evaluated, and the selection of the preferred bridge type was based on both cost and aesthetics. The Iowa DOT wanted a low-profile structure to minimize the visual impact on this scenic area. A steel I-girder bridge was selected in 1996. The incremental launching method was determined the only feasible way to construct the bridge, while minimizing environmental impact to the valley.

## Bridge Description

The bridge consists of two parallel deck superstructures, each with five equal spans of 92 m (302'). A 19 m (62') prestressed concrete jump span is provided on each end of the steel unit. The I-girders were fabricated from ASTM A709 Grade 345 weathering steel; they are 3450 mm (11') deep and spaced at 3600 mm (12') centers. The web-depth choice was based not on strength requirements, but to reduce dead-load deflection during the cantilever-launching phase to a reasonable level. Since any point along the girder length could become a bearing location during launching operations, the constant 22 mm (7/8") web thickness was designed to serve as an unstiffened element for steel dead load.

Vertical bearing rollers supported the mass of each girder on its bottom flange, and horizontal guide rollers provided alignment control at each bent.

To make the I-girder superstructure act as much like a torsionally rigid box girder as possible during launching, a stiff system of diaphragms and lateral bracing was used. A diaphragm spacing of 7,000 mm (23′) was used for spans two thru five, but was reduced to 3,500 mm (11′6″) in the leading span that would be cantilevered during launching.

Center-bay upper and lower lateral bracing, consisting of WT sections up to 113 kg/m (76 lb/ft), forms the "spine" of the girder system. In the two leading panels of the girder system, additional lateral bracing was provided in the outer girder bays as well.

The concrete deck consists of a 230 mm (9″) concrete slab with a 38 mm (1$^{1}/_{2}$″) low-slump concrete wearing surface. A high-performance concrete mix was used for the deck to minimize the potential for shrinkage and cracking in positive-moment deck regions.

The bridge foundations are 890 kN (10 ton) steel H-pile foundations driven to rock at Piers 1, 2 and 5 and 890 kN (10 ton) steel H-piles driven to refusal in clay at Pier 6. To minimize the footprint of the pier foundations near the river, Piers 3 and 4 are founded on 2440 mm-diameter (8′) drilled shafts approximately 30 m (98′) deep.

## Launching System

HNTB developed a conceptual launching system for the bridge that was illustrated in the contract plans. This system was modified to suit the contractor's equipment by the erection engineer, Ashton Engineering of Davenport, IA.

A launching pit was excavated behind the east end of the steel girder unit exclusively for the erection and launching of the steel girder spans. The pit was approximately 200 m long by 36 m wide by 6 m deep (660′ by 120′ by 20′). The launching pit presented environmental concerns, so the contractor was required to confine all storm water and direct it to three intakes in the center of the launching pit.

A series of seven temporary pile bents were constructed in the launching pit. Five of these bents were equipped with vertical and horizontal rollers to support and guide the girders during launching operations, while two bents were used to provide support only during steel assembly. A vertical bearing roller beneath the bottom flange of each girder supported the mass of each girder line, and a pair of horizontal guide rollers provided alignment control at each bent. The guide rollers were positioned to roll against the edge of the bottom flange. The same type of rollers were installed atop each permanent concrete pier.

The guide rollers were equipped with a 450 kN (51 ton) hydraulic jack to apply a transverse force against the girder bottom flange during launching. By actively controlling the hydraulic pressure in these jacks, the contractor was able to provide steering control of the girders.

The structural steel was completely erected on the temporary pile bents. All bolts were tightened and a bridge-drainage piping system was installed prior to launching the girder train. The drainage system consists of two 356 mm (14″) pipes that run the length of each superstructure unit. The drainage system collects storm water and runoff and prevents it from directly entering the river.

The incremental launching method originally was developed for stiff concrete box girders. For the steel I-girders on the Iowa River Bridge to act as torsionally rigid as possible, the center bay of each superstructure was provided with a stiff "spine" of upper and lower lateral bracing.

This stiff "spine" caused concern following launching of the steel girder units. When the girders reached their final position and were jacked down, they did not bear fully on the permanent bearings. In some cases, a gap of up to 12 mm ($^{1}/_{2}$″) was observed between the bearing and bottom flange. These gap locations were fitted with a shim to fill the gap and preload the bearing, so all girder reactions were uniform at a given pier.

The leading end of the steel girder unit was equipped with a tapered launching nose, which consisted of a pair of tapered I-girders bolted to the leading end of the permanent interior girders. The nose was approximately 44.6 m (146′) long, and tapered from 3450 mm (11′) deep at the connection to the permanent girders to 1200 mm (4′) deep at the tip. The nose served two purposes: it reduced the weight of the cantilever span during launching and provided a method to "recover" the leading end of the girders as they approached each pier. The calculated deflection during the maximum cantilever stage of the bridge was 2150 mm (7′).

The trailing end of the steel unit was equipped with an 8380 mm-long (27′ 6″) tail section. The tail section consisted of a four-girder assembly bolted to the trailing end of the girder train. The trailing end of the tail section provided a dapped seat 1525 mm wide and 2030 mm deep (5′ by 6′ 8″). The tail also served two purposes: it provided a location to apply the jacking force to the rear of the girder lines, and the tapered shape (6:1 ratio) provided a smooth transition as the trailing end of the girders "dropped off" the roller supports in the pit and the girders were launched forward. The dapped end of the tail supported a transverse tugger beam: two W920x223 sections welded tip-to-tip with 63 mm (2½") cover plates.

The jacking system used to launch the steel unit was supported by two groups of battered-steel H-piles located near the east end of the launching pit. Each pile group supported a 1350 kN-capacity (152 ton) hydraulic ram that was oriented parallel and adjacent to the exterior girder.

Each hydraulic jack was attached to a line of 64 mm-diameter (2½"), 1035 MPa (150 ksi) post-tensioning bars. These bars were spliced at 4.6 m (15') intervals. The dead end of the bar was anchored to a transverse tugger beam that was supported on the dapped end of the tail section at the trailing end of the girders. When the jacks were engaged, the threadbars were advanced longitudinally at approximately 0.3 m per minute (1' per minute). A section of threadbar was removed from each jack unit following a 4.6 m (15') stroke by the jacks.

For the bolted girder splices to negotiate the bearing rollers, a tapered (6:1 ratio) ramp plate was installed at the leading and trailing end of each splice. During launch operations, each time a ramp plate would encounter a roller, a measurable increase in jacking force was observed. This additional energy was released as a girder "lunge" as the ramp plate was cleared and rollers returned to the flat region of the flange.

Launch operations were not permitted to proceed if wind speeds in excess of 32 km/hr (20 mph) were anticipated within a 12-hour period. Two of the 10 scheduled launch events were postponed due to this restriction. The steel girders were launched in one-span increments in order to minimize the exposure time of the free cantilever.

## Construction Timeline

The 10 launches of the U.S. 20 Iowa River Bridge were performed at two- to three-week intervals between August 2001 and March 2002. Following completion of the eastbound bridge launching in October 2001, the contractor removed all of the temporary pile bents in the launching pit. These pile bents were reinstalled for use in launching the westbound bridge starting in January 2002.

The launching rollers were removed when the girders reached their final horizontal position. The mass of the girders was lifted just enough to unload the rollers using a 1780 kN (200 ton) jack at each girder location; the rollers were slid out from beneath the girders and permanent pot bearings were slid into position. The jacks had a very small range of motion, so the girders were lowered in 25 mm (1") increments using a series of shim packs. The jacking operation started at one end of the steel unit and continued in sequence to avoid overloading the jack units.

## Summary

The U.S. 20 Iowa River Bridge is the first launched I-girder highway bridge constructed in the United States.

This project is proof that the incremental-launching erection method can be successfully performed on longer-span steel I-girder bridges. It is anticipated that this method of construction will become more commonplace in the U.S.A. as bridge owners recognize its potential benefits. Incremental launching is applicable to either environmentally sensitive areas or locations limited by restricted access.

The project has received top honors in award competitions sponsored by the Missouri and Iowa chapters of the American Council of Engineering Companies.

Additional project information and a construction photo archive can be found on the project website: **www.iowariver-bridge.org**. ★

## Reference

Svensson, H. and Zellner, W., "Incremental Launching of Structures," *ASCE Journal of Structural Engineering*, Vol. 109, No. 2, February, 1983.

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