US 65 Oak Street Bridge

DESIGN, CONSTRUCTION & STRUCTURAL HEALTH MONITORING OF A STEEL ARCH BRIDGE

Iowa Falls, Iowa
Location of Project

Part of City of Iowa Falls, Iowa
Introduction

» Demolition Concepts
» Concept Design
» Final Design
» Construction
» Health Monitoring
Existing Bridge

- Built in 1928
- 255-foot Open Spandrel Concrete Arch Bridge
- 24-foot Roadway and Two Sidewalks
- Deck Supported by R/C Floor Beams
Existing Bridge

» Rehabilitated 7 Different Occasions
» Needed Widening and Strengthening
» Replace Rather than Rehabilitate
Concept Stage Type Study

» Identify Constraints and Constructability Concerns
» Identify Feasible Demolition Concepts
» Identify Feasible Replacement Alternatives
» Cost
» Timeline for Construction
Constraints and Constructability Issues

» Site Access

[Map with marked areas: US 65 Oak Street Bridge and City Boat Ramp]
Constraints and Constructability Issues

- Historic Church
  - NW Corner of Bridge
  - Listed on the National Register of Historic Places

Photo by: iaflalls.com
Constraints and Constructability Issues

» Dam
  – Maintain Water Level
Demolition Concepts Assumptions

- No Environmental Restrictions
- Access to River is Available
- No Prohibition on Use of Engineered Explosives
- Vibration Monitoring Required
- Cost versus Clean up
Actual Demolition

» Started mid October 2010 and Finished mid December 2010.
» Lowered the Iowa River with Cooperation of the Downstream Dam
» Constructed an Access Road and Causeway Utilizing a System of Steel Bridge Beams and Crane Mats over the Open Water
Actual Demolition

» Constructed a System to Protect the Sanitary Sewer Lines
» Demolished the Bridge using the Causeway
» Deck and Columns were Demolished using two Excavators with Hydraulic Breakers
» Each excavator started at the Center of the Bridge
Actual Demolition

- Demolished the Arches Using the same Excavators with a Mounted Hammer
- Arch Pieces were Broken Down and Hauled Off-Site by Truck
- Vibration Monitoring was Provided at the Adjacent Church and Residences
Bridge Replacement Alternatives

- City of Iowa Falls
  - Scenic City
  - River Cruises is a Major City Attraction
  - Several Types of Bridges that Span Across Iowa River

Photo by: EmpressBoatClub.com
Bridge Replacement Alternatives
Washington Avenue Concrete Arch Bridge

US 65 Oak Street Bridge
Washington Avenue Bridge

Photo by: HistoricBridges.org
Bridge Replacement Alternatives
Assumptions

» No Environmental Restrictions

» Access to River
  - Launch Segmental Barges
  - Erect a Suitable 150-ton Crane

» Vibration Monitoring Required
Bridge Replacement Alternatives
Two Span Prestressed Concrete Alternative

» Easiest to Construct
» Drilled Shaft at Pier Eliminates Need for Cofferdam
» Drilled Shaft at Abutments Reduces Vibration Impacts
» Less Rock Excavation than other Alternatives
» Most Economical Option
Bridge Replacement Alternatives
Simple Span Haunched Girder Alternative

» Non-conventional Super Type
» Heavy Girder Pieces
» Require Temporary Bents or Falsework
» Substantial Rock Excavation
» Require Lead Time for Fabrication
Bridge Replacement Alternatives
Partial Thru Steel Arch Alternative

- Easier to Construct Relative to Concrete Arch
- Shorter Construction Period than Concrete Arch
- Require Temporary Bents, Falsework or Tied-Back Systems to Construct
- Additional Inspection and Maintenance of Suspenders
- Requires Construction Engineering
Bridge Replacement Alternatives
Concrete Deck Arch Alternative

» Most Difficult/Complex to Construct
» Rib Shortening Issues
» Requires Temporary Bents or Falsework or Tied-Back Systems
» Longest Construction Period
» Requires Construction Engineering
Bridge Replacement Alternatives

The Alternatives

- Existing Concrete Deck Arch
- Prestressed Concrete Girder
- Haunched Steel Girder
- Partial Thru Steel Arch
- Concrete Deck Arch
Final Design Considerations

- Tight Geometrics
- Bridge Footprint
- Retaining Walls and Rock Cuts
- Substructure Sizing and Sustainability
- Protection of the Superstructure
Tight Geometrics
Existing Church Retaining Wall
Micropile Retaining Wall
Rock Cut Support Walls
Rock Cut and Concrete Fascia Walls
Aesthetics and Renderings

» Kimball Olson
   Aesthetics coordinator – Iowa DOT

» Used to convey
   - Size
   - Perspective
   - Spatial relationships

» Useful in Design and Presentation to the General Public
Rendering – Showing Trail
Actual Bridge
Deck and Hanger Cables

» Floor Beam and Stinger system suspended from the Arch Rib

» End Floor Beams frame directly into the Arch Rib

» Deepened Exterior Stringer / Stiffening Girder
  - Distributes vehicular loads from deck to multiple hanger cables
  - Minimize local live load deflections
Arch Design

» Grade 50 Weathering Steel with Protective Coatings
» Built in Replacement of Hanger Cables
» Pinned Bearings
» Wide aspect ratio
  - Length to Width ratio = 4
  - No trussed sway bracing.
Interior Floor Beam and Hangers
End Floor Beam

TYPE "B" FLOORBEAM ELEVATION
(LOOKING NORTH)
Pinned Bearings

» Net Zero Change in Steel Weight from a Fixed Connection
» Reduced Footing Size
» Minimized Impacts to Surrounding Properties
Foundations

» Issues:
  - Existing Bridge Showed Signs of Undermining
  - Arch Skew Back Behave Differently than the Retaining Wall Abutment.

» Solutions:
  - High Capacity Micropiles
  - Separate Foundations
  - Tied-back Abutment
  - Lightweight Backfill
Foundation Issues

» Existing Bridge Undermining
Micropiles
Abutment and Micropile Schematic
Pin and Hanger Steel Tolerances

» Construction tolerance issues during fabrication of the Pins and Hangers:
  - ASHTO 6.8.7.3
    • Requirement: 0.031"

» Maximum Difference
» As Fabricated
» Pin to Pin Plate: 0.04”
» Pin to Socket: 0.14”
Pin and Hanger Steel Tolerances

» Resolution – Perform additional tests on the Pin to Socket connection to quantify permanent deformation under load.
  - 55% Proof load – No permanent deformation allowed as measured to nearest 0.001”
  - Contractor also tested two connections to 100% load
Pin and Hanger Steel Tolerances

» Observed Deformations
  - Proof load = 0.00”
  - 100% load = 0.04”

» Contractor was allowed to use the pins and sockets as fabricated.
Fabricated Bearing Tolerances

» Bearing Side Plates
  - Warped out of tolerance
  - Would not allow upper unit to fit with the lower unit

» Masonry Plate
  - Curved upward on the edges
  - Would not allow full bearing on the concrete skew back
Fabricated Bearing Tolerances

» Bearing Side Plates
- Total conflict 1/4”
- Fabricator milled 1/8” from upper and lower units
- Difference was evaluated and deemed acceptable
- Complicated fit
Fabricated Bearing Tolerances

» Masonry Plate
  - Maximum gap of 3/4” at the edge
  - Steel erection allowed to proceed
  - Jacked and grouted prior to pouring the concrete deck
Health Monitoring

Iowa State University - Dr. Brent Phares
US 65 Oak Street Bridge

QUESTIONS?