3D Modeling Applications for the St. Croix River Crossing Project

3D Design and Modeling for Highway Structures Conference
April 14, 2015
Presentation Overview

- Project Background
- Extradosed Structure 101
- Schedule
- 3D Model Development and Usage
  - Design Aid
  - Visual Quality
  - Public Involvement
  - 4D Schedule
- Current Construction Status
• SFEIS identified several important areas of concern for design:
  • visibility of bridge
  • height of towers
  • number of piers in the river
  • the effects of the piers on the natural environment, wildlife, aquatic life, MN wetlands, and the WS bluffs
• An extradosed solution was identified as the **Preferred Alternative** bridge type
The New St. Croix Crossing

St. Croix Crossing project
Aerial view looking west toward Sunnyside Marina
The New St. Croix Crossing

St. Croix Crossing project
Aerial view looking west toward Xcel King power plant

This photo simulation is based on designs available in June 2013. It does not necessarily represent the final appearance.
The New St. Croix Crossing
Roadway View
Extradosed Bridges

- Relatively new bridge form – 1988 France
- First was constructed in Japan in 1994
- More than 100 worldwide, mostly in Japan
- Very new form to North America
- Selected to address specific site constraints
- Similar to cable stay and segmental box
Extradosed Bridges

Pearl Harbor Memorial - New Haven, CT
515’ (157 m) main span – under construction

First in United States
Extradosed Bridges

Extradosed Concrete Box Girder
### OVERALL ST. CROIX RIVER CROSSING PROJECT SCHEDULE

<table>
<thead>
<tr>
<th>Task Name</th>
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<td>River Bridge Design</td>
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<td>River Bridge Construction</td>
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<td>Wisconsin Roadway Approach Construction</td>
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3D Model Development and Usage

• Started with original model developed in preliminary and conceptual design phase

• 3D Studio Max

• Model Usage – integrated effort
  – Optimization Efforts and Design Aid
  – Visual Quality – Renderings and VQ Committee
  – Public Involvement – Photo-Simulations and Fly-Thru
  – 4D Schedule
Design Optimization

- Baseline 450’ Spans
- 7 extradosed piers, 6 in water
Design Optimization

- Spans increased from 480' to 600'
- Elimination of two extradosed piers
- 5 extradosed piers, all in water
- Conventional pier on WS bluff slope
Design Optimization

• Blue – Original Layout
• Red – Optimized Layout

• Adjustment of Roadway Alignment
• Improved Bridge Drainage System
• Reduced Complexity of Extradosd End Span
3D Model - Crossbeam
4D Schedule

• Utilized 3D Studio Max Model and Synchro
• Early Foundation
• Full Bridge
• Wisconsin Bluff
• Tower Vignette
• Contractors Schedule Review
3D Model Development and Usage

- Insert models from 3D Studio Max

St. Croix Crossing
Construction Sequencing
## 4D Schedule - Early Foundation

<table>
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<tr>
<th>ST. CROIX RIVER CROSSING - EARLY FOUNDATION</th>
<th>OVERALL MATERIAL ONLY</th>
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4D Schedule - Full Bridge
4D Schedule - Wisconsin Bluff
4D Schedule - Tower Vignette
4D Schedule - Contractors Schedule
Early Foundations
Early Foundations
Current Construction
Current Construction
Current Construction
Current Construction
Current Construction
Current Construction
Current Construction
Current Construction
Current Construction
Segment Dimensions

Approach Segments
• Width of 45’ / Depth 10’ to 14’
• 338 Segments – weight 90 to 120 tons

River Span Segments
• Width of 50’ / Depth 18’
• 656 Segments – weight 140 to 180 tons
The extradosed form would:

- Maximize spans without overpowering the natural setting of the lower St. Croix with tall towers
- Minimize the footprint in the river, the MN wetlands, and on the WS bluff
Signature Bridge
Community Involvement – Visual Quality Advisory Committee
  • Visual Quality Manual Addendum (2011)
  • VQAC Meetings During Design Phase (2012)
Design Phase Visual Refinements
  • Maintain Architectural Intent
Visual Quality

• An "organic" theme was identified
• Parts intended to look as if they were "found in nature", or "shaped by natural forces"
• Vertical pier forms are "reed-like"
• Girders rounded and tapered "like bones or tree branches"
• Transitions are gradual and smooth
• These commitments set the aesthetic direction
• All design issues were vetted to ensure that the design stayed true to the final EIS and mitigation commitments
Segmental Box Bridge
Segmental Box Bridge

- Cantilever
- Load
- Steel Tendons Compressing Superstructure
- Pier in Compression
- Water Surface Elevation
- River
- Pile Cap
- Pier
- Pile or Drilled Shafts
- River Bed
- Rock

Segmental Concrete Box Girder
Extradosed Bridges

North Arm Bridge – Vancouver, BC
590’ (180m) main span - 2008

First in North America
Design Optimization

- Goal was a single structural unit
- Avoid in span joints
- Avoid sliding the deck at end extradosed piers
- Twin leg piers for flexibility
- Serviceability for time dependence and thermal effects