A CM/GC Approach for the Design of a Two-Girder Horizontally Curved Pedestrian Bridge

Irvin J. Lopez, P.E., Senior Bridge Engineer
Ken D. Price, PE, SE, PEng, Manager Complex Bridge Group
Project Overview

— Purpose and Challenges
— Concept Development and Acceptance
— CM/GC Procurement
— Design and Analysis
— Global stability and redundancy
— Lessons learned
Project Location

UVU is located approx. 39 miles south of Salt Lake City.
Purpose and Challenges

- Destination of choice for many students in Utah
- Current enrollment is over 37,000
- Largest university in Utah
- Campus growth and expansion
Challenging Site Conditions and Constraints

MSE Walls

- UPRR & UTA
- Private Property
- I-15 Interstate
- College Dr.
Concept Development and Acceptance

How did we get here?

Original Design
Inverted Fink Truss

Re-design Concept
Three Plate Girders
Constant Depth

Optimize
Two Plate Girders
Constant Depth

Cost Reduction

Final Concept
Two Plate Girders
Haunched

Notice to Proceed
Original (Complex) Fink Truss Concept

Original Design - Inverted Fink Truss Superstructure

Overall Length: 1022.5 ft.
S-Curve Alignment
Final Accepted Concept

Re-designed Bridge – Two Plate Girder Superstructure

Overall Length: 965 ft.
57.5 ft. Reduction (~6%)
Single Radial Curve Alignment
CM/GC Project Team

- **Client**: UDOT

- **Stakeholder**: Utah Valley University (UVU)

- **Stakeholder**: Utah Transit Authority (UTA)

- **Innovating Contracting Consultant**: CM/GC Lead for UDOT

- **WSP USA**: Lead Designer

- **Design Sub Consultants**: Architects, Environmental, Survey, Geotechnical

- **Kraemer North America**: Lead Contractor

- **Stanton Construction Services**: Cost Estimator
CM/GC Project Schedule

Concept Development
Steel Plate Girder Bridge

Nov 18
S&L Plans

Early Steel Package
Plans, Specs, & Estimate

Feb 19
Awarded to Kraemer Feb. 2019

Construction
12 month for substantial completion

Nov 18
Preliminary Design
30% Design Plans

Jan 19

Full Package Final Design
Plans, Specs, & Estimate

Feb 19
Awarded to Kraemer Aug. 2019

Complete Construction by Nov. 2020

Nov 19

Sept 18

VE Efforts
Bridge Aesthetics

Aesthetic Elements
- Roof Profile
- Haunched Girders
- Perforated Metal Enclosure
- Materials
- Lighting
Span Configuration

Site constraints resulted in *unbalanced span arrangement*

Sp. 1 / Sp. 2 = 1.15
Sp. 4 / Sp. 3 = 0.56 (Uplift at Bent 5?)

Ideal Ratio = 0.70
Typical Sections

Section at End Bents

Typical Section

Section at Interior Bents
Design Loads

Bridge Loads (AASHTO, UDOT SSDM)
- Pedestrian Live Load & \textit{H5 Truck}
- Temperature
- Wind
- Earthquake
- Fatigue (Wind AASHTO LTS)

Roof Loads (ASCE 7)
- Snow = \textbf{30.5 psf.}
- Maintenance Live Load = \textbf{20 psf.}
- Wind
Pedestrian Live Load

AASHTO LRFD Guide Specification for the Design of Pedestrian Bridges

Project Design Criteria

→ PL = 90 psf (no dynamic load allowance)
→ Load Factor (Strength) = 1.75
→ 90 psf. x 1.75 = **157.5 psf.**
3D Analysis Model

- Roof Structure
- Seismic Design
- Superstructure Design
- Substructure Design
- Global Effects:
  - Thermal
  - Wind
  - Stability
- Lateral Bracing
- Foundation Design

Other Analyses:
- Staging
- Dynamic
- Redundancy
Support Conditions

— Due to Seismic Demands, interior bent bearings were fixed.
Load Patterns for Maximum Demands

— “Patch” load cases were defined for PL, SN, and LLr.
Wind Load and Vibration Analysis

— RDWI conducted wind and pedestrian-vibration study
Wind Tunnel Testing
Fracture Critical and Redundancy Analysis

Reference Documents and Specifications

What about Pedestrian Bridges?
Pedestrian Bridges?

- Pedestrian bridges are not governed by fatigue
- Minimal guidance FCM requirements
- All referenced studies are based on vehicle loads
- Pedestrian loads and factors are calibrated differently than vehicular loads and factors
A Common Sense Approach

Damage Criteria

Complete failure of one girder at a critical location on the bridge with concurrent live load overload

Collapse Limit State

The bridge does not collapse under the above condition, and remains functional (deflection criteria)

How?

Lateral bracing, floorbeams, deck, and composite action all contributed to load path redundancy (system redundancy).
Redundancy Analysis
Two Girder System is redundant – will not collapse

An event scaling approach was adopted to prove redundancy of bridge superstructure.
Fabrication and Weight Efficiency

Weight efficiency does not always result in most economical design.

Fabrication costs must also be considered when detailing bridges.
Fabrication and Construction

- Large Field Sections (driven by site)
- Max. girder segment length (over RR) = 183 feet
- Max. weight = 70 tons.
Lessons Learned

— CM/GC worked well for this project.

— Two-girder bridges can be redundant.

— Refined analysis was utilized to identify system redundancy.
Thank you!