Railroad Flatcar Bridges for Economical Bridge Replacement Systems

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Topics of Interest

- Why flatcar bridges?
- Railroad flatcar (RRFC) selection
- RRFC Demonstration Bridges
  - Construction
  - Field Testing
  - Analysis
  - Economy
Background:

- Problem: Insufficient funds to address bridge needs on Iowa’s secondary roads
- Solution: Use viable, economical, low cost alternatives for low-volume road bridges
Potential Solution: RRFC Bridges

Attractive Characteristics:

- Quick to install
- Can be used on new or existing abutments
- Available in variable lengths
- Can be constructed by county work force
- Low cost
Objectives of Research:

- Develop a process for selecting structurally adequate flatcars
- Develop design and construction guidelines for RRFC bridges
- Design, construct, and test two demonstration bridges
  - Buchanan County Bridge (BCB)
  - Winnebago County Bridge (WCB)
Selection Criteria:

- Size of Longitudinal and Transverse Members, Support Locations, and Load Transferring Capabilities
- Member Straightness/Damage
- Structural Element Connections
- Uniform, Matching Cambers
- Availability
Original Buchanan County Bridge
RRFC Selected for the BCB

*Length = 56 ft.
Original Winnebago County Bridge
RRFC Selected for the WCB

*Length = 89 ft
Construction Process

- Phase 1: Substructure Construction and Flatcar Placement
- Phase 2: Development of Longitudinal Connections between Flatcars
- Phase 3: Installation of Driving Surface and Guardrail
Buchanan County Bridge

- 29 ft wide; 56 ft long
  (Original BCB = 16 ft wide; 39 ft long)

- Substructure material: Steel H-piles with R/C cap

- Means of Transverse Load Distribution
  - Reinforced concrete beams for longitudinal flatcar connection
BCB Layout
BCB Phase 1
BCB Phase 2
Completed BCB
Winnebago County Bridge

- 26.75 ft wide; 89 ft long
  (Original WCB: 20.7 ft wide; 56 ft long)

- Substructure material: Steel H-piles with steel cap

- Means of Transverse Load Distribution
  - Small R/C beams between RRFCs plus transverse timber planks
WCB Phase 1
Completed WCB
Field Testing of the RRFC Bridges

- Instrumented for measuring strains and deflections at critical locations

- Tandem Iowa legal load ≈ 50,000 lb gross
  - Load Test 1: Single RRFC
  - Load Test 2: Finished Bridge
  - Load Test 3: One year later
BCB Field Tests
WCB Field Tests
**RRFC Bridge Analytical Results**

- Grillage models generated for each bridge and subjected to tandem truck loads for each test

- Upper and lower analytical bounds established

- Good agreement between analytical and experimental results
BCB: Analytical and Experimental Results

![Graph showing deflection (in.) with comparison of Theory - Bound #1, Theory - Bound #2, and Experimental results.](graph.png)
Performance of Demonstration Bridges

- Maximum Stresses (DL + LL):
  - BCB = 12.7 ksi
  - WCB = 16.7 ksi
  - $f_y = 40$ ksi

- Maximum Live Load Deflections:
  - BCB = 0.38 in. (allowable = 0.84 in.)
  - WCB = 0.63 in. (allowable = 0.99 in.)
Approximate Costs of RRFC Bridges

- BCB = $20/ft^2
- WCB = $26/ft^2
- Conventional Iowa Slab Bridge ≈ $65/ft^2
Conclusions

- RRFC bridges are a viable, economic alternative for LVR bridges

- Design recommendations (which include the live load distribution of the two longitudinal connections employed) were developed

- Both longitudinal connections were determined to be structurally adequate

- RRFC bridges can be completely constructed by county personnel
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Questions?