Pragmatic Rehabilitation Strategies

Second National Covered Bridge Conference
Dayton, OH
June 6, 2013

Robert H. Durfee, PE, SECB
Vice President, Transportation Division
DuBois & King, Inc.
831 Union Avenue, Suite 2
Laconia, NH 03246
rdurfee@dubois-king.com

Whittier Bridge Rehabilitation, Ossipee, NH
1. Introduction

2. Standards

3. Traditional Materials

4. Practical Strategies

5. Case Studies

6. Summary

7. Questions
Introduction

The Problem:

- Funding sources are decreasing
- Costs for bridge repairs or rehabilitations are high, and increasing.
- Bridge owners are only able to fund a one-time repair or rehabilitation.

The Solution:

- Develop pragmatic or practical solutions
- Utilize cost effective products and materials
- Spend construction funds on high priority repairs (weathering, structural, and/or fire protection)
The prevalent and commonly applied standards are:

- Secretary of the Interior’s Standards for the Treatment of Historic Properties
- Burlington Charter for the Preservation of Historic Covered Bridges
- State Historic Preservation Officer (SHIPO) procedures
  - Example: Vermont Historic Covered Bridge Preservation Plan

All of these standards have a common priority for applying treatments:

- Retain historic fabric
- First repair, then replace
- Additions will be reversible
Structural timber

- Local, native species used
- Harvested from “old growth” forests
- Excellent quality, high grade
- Long timbers (35 feet+) with wide dimensions (14-16 inches)

Species Used

- Northeast: Pine, Spruce, Hemlock, and Larch
- Southeast: Southern Pine
- West Coast: Douglas Fir
Structural Timber – Present Day

• Difficult, to obtain native species in the Northeast in the quantity and grade needed

• Native species not commercially available in “Timbers” (5”x5” or greater) for the Northeast

• If timbers can be found:
  • “Old Growth” forest gone
  • Grading or certificates of grade are not readily available
  • Must assume 20-30% of sawn timber is rejected during grading
Iron and Steel Hardware

Typical hardware included:

- Cut nails
- Spikes
- Lag bolts & through bolts, nuts & washers
- Rods (hangers, truss verticals)

Material:

- Early 1800s – wrought iron or malleable iron
- Mid to later 1800s – low grade steel
- Acquiring hardware produced with wrought iron or malleable iron is either unavailable, or cost prohibitive.
Masonry:

- Bridge abutments, wingwalls, and piers were constructed of stone masonry.
- Different types of stone materials and masonry construction employed.
- Stone was quarried (stone blocks and flagstone) and transported to the site or acquired nearby in fields (field stone) or from the river (cobbles).
- Masonry construction was either dry laid (no mortar) or mortared.
Wood Shakes (Shingles)

- Red cedar or white cedar
- Eventually leak and require repairs
- Wood shakes last 20-25 years until replacement is necessary

Metal (Standing Seam)

- First available/used in the 1890s
- Virtually leakproof
- Heaver gages (22 gage) last 30-40 years

Note: Wood shake roofs are 1.5 to 2 times more cost than metal and typically last about half as long.
• Replace existing members with stronger material of same size and appearance
  • Increase strength/capacity by almost 2 times
• Timbers commercially available in Southern Pine or Douglas Fir
• Available tensile strengths:
  • Southern Pine No.1 Dense, $F_T = 1,550$ psi
  • Douglas Fir Select Structural, $F_T = 1,550$ psi
• Native species strengths:
  • Eastern White Pine No. 1, $F_T = 850$ psi
• Over time, weathering of replacement timbers will match appearance of native timber.
• Nails
  • Cut nails still commercially available
  • Due to poor holding power, replace with wire nails or screws
  • Little noticeable difference in exposed cut nail head versus wire nail or screw head.
• Bolts, Turnbuckles, and Rods
  • Geometry (appearance) of hardware has not changed.
  • Available in higher strength steel
  • Use commercially available steel hardware over wrought iron or malleable iron.
Pragmatic Strategies: Masonry
Piers and Abutments

Existing
- Stone masonry cannot support modern loads (higher loads)
- Failing masonry from settlement, bulging, splitting of stones
- Rebuilding “in kind” does not solve the problem

Solution
- Replace with reinforced concrete structure
- Face with stone to give appearance of traditional masonry
- Cast stone relief pattern into concrete to give the appearance of masonry
• Existing covered bridge live load capacity is typically H3-H6 (3-6 tons)
  • Limited by decking and floorbeams

• Strengthening employed to increase capacity

• Typical goals:
  • 15-ton snow plow
  • 20-ton fire truck
Some strengthening methods employed have been to install glue-laminated or steel members, sister (add to) existing members, or add steel connection plates and bolts.

Many of the aforementioned methods are not easily reversible:

- Change character and appearance of the bridge
- Destroy historic fabric
- Change how the bridge functions structurally

Conclusion:

Strengthening approach and methods should be used sparingly!
Co-functional Structural System

- A co-functional structural system is a better solution

- A co-functional system:
  - Allows bridge to support typical, routine loads
  - Independently supports higher loads up to 20 tons

- This system does not damage historic fabric

- Bridge functions on a limited basis as was intended

- Easily reversible

Glulam support system
Union Village Bridge
Thetford, VT
• Historic covered bridge typical weight limit is 3 to 6 tons.
  • Passenger car and light truck use only
• Modern truck live load is 20 tons or more!!!

**Strategy:**
• Perform limited repairs
• Post bridge for 3 ton or 6 ton restriction
• Provide alternate route (detour) for heavier truck loads
Case Study – Ashuelot Bridge
Winchester, NH

Restricted Use

- Built in 1864
- Existing load capacity, 6 tons (with repairs)
- Four (4) mile detour over nearby modern bridge is available

Posted bridge for 3-ton limit and permanent detour for heavy loads
Unique Existing Hardware

Existing bolted connection

Replacement hardware to match

Standard carriage bolt with washer added

Extracted bolt

Square nut replicated
Case Study – Slate Bridge
Swanzey, NH

- Modern replacement for bridge destroyed by arson
- Funding requirement: H15 (15-ton) live load capacity

Southern pine members

Glulam deck and floorbeams

Sawn timber runners to hide glulam material
Case Study – Haverhill/Bath
Covered Bridge

- Bridge was built in 1827
- Closed to traffic in 1999
- Rehabilitated and converted to pedestrian bridge in 2008

Douglas fir lattice members
Weight limit posting

- Limited strengthening using Douglas Fir replacement
- Restricted use (load capacity) to 200 persons
Case Study – Union Village
Covered Bridge, Thetford, VT

Built 1867
Goal: support the Town’s fire Apparatus (H20)
Case Study – Union Village
Covered Bridge, Thetford, VT

Existing Capacity:
Trusses: H6.5
Deck: H4
Floorbeams: H5

Haupt Truss
Co-functional glulam beams added
• Funding sources are shrinking

• Project costs are increasing

• Standards that apply to covered bridges allow pragmatic solutions:
  
  • Use of modern materials and commercially available products and materials are cost-effective.
    • Modern hardware
    • Commercially available Douglas Fir or Southern Pine Timbers
    • Concrete abutments and piers with stone veneer

  • Restrict use to match capacity of bridge (6-ton), minimize strengthening
  • Co-functional systems a means to strengthen bridge
Green River Bridge Rehabilitation, Greenfield, MA
Robert H. Durfee, PE, SECB
rdurfee@dubois-king.com

DuBois & King, Inc.
831 Union Avenue, Laconia, NH 03246