Pragmatic Rehabilitation Strategies

Second National Covered Bridge Conference

Dayton, OH

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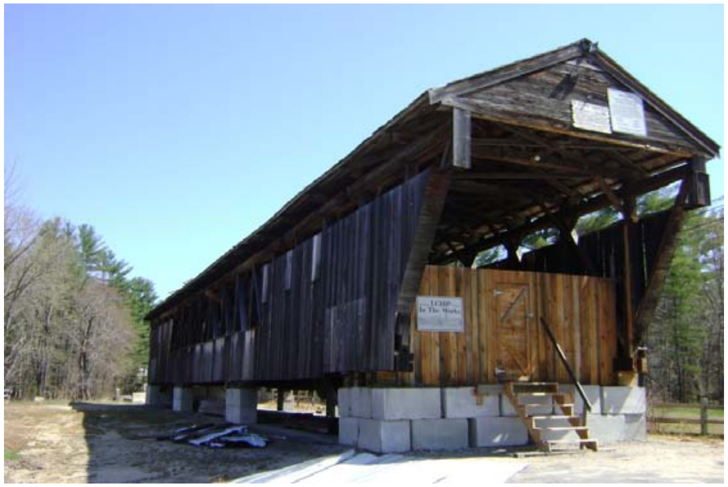
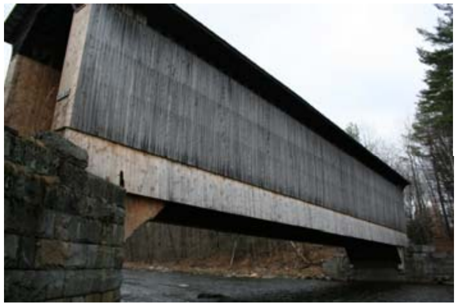


Whittier Bridge Rehabilitation, Ossipee, NH

Presentation Outline



Wright's Bridge
Newport, NH

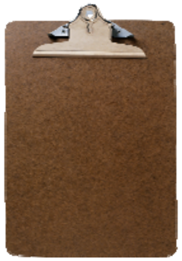
1. Introduction
2. Standards
3. Traditional Materials
4. Practical Strategies
5. Case Studies
6. Summary
7. Questions

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)

Standards

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
  - o 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

Traditional Materials

Old growth trees

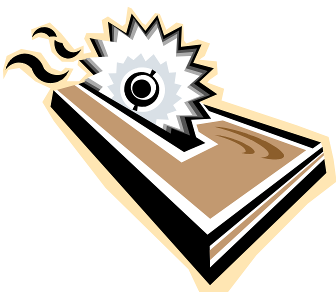
Structural timber

- 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

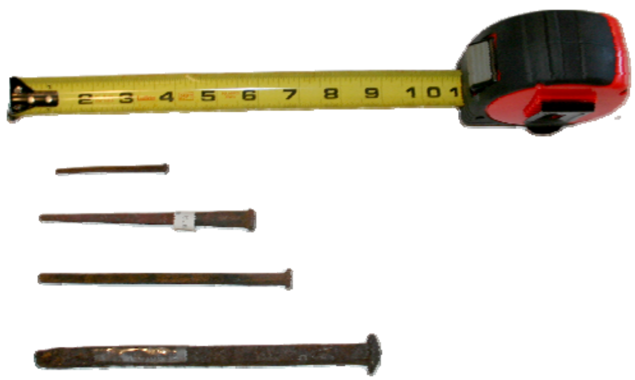
Materials



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

Traditional Materials



Iron and Steel Hardware

Typical hardware included:

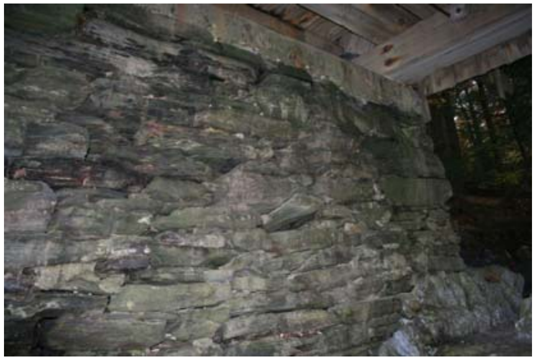
- Cut nails
- Spikes
- Lag bolts & through bolts, nuts & washers
- Rods (hangers, truss verticals)

Material:

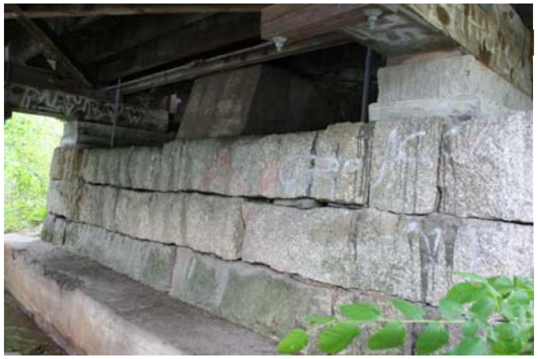
- Early 1800s – wrought iron or malleable iron
- Mid to later 1800s – low grade steel
- Acquiring hardware produced with wrought iron or malleable iron is either unavailable, or cost prohibitive.

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.

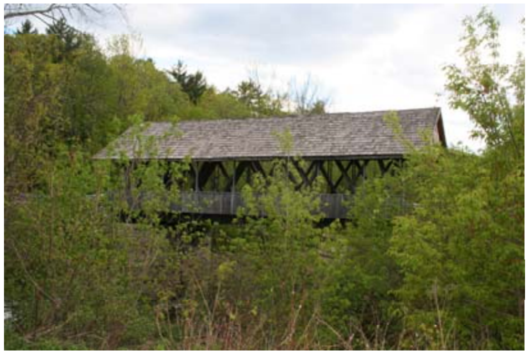


Field stone abutment



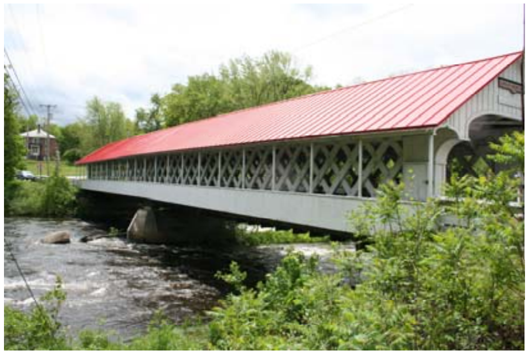
Granite block abutment

Pragmatic Strategies: Roofing



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.

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Pragmatic Strategies: Structural Members

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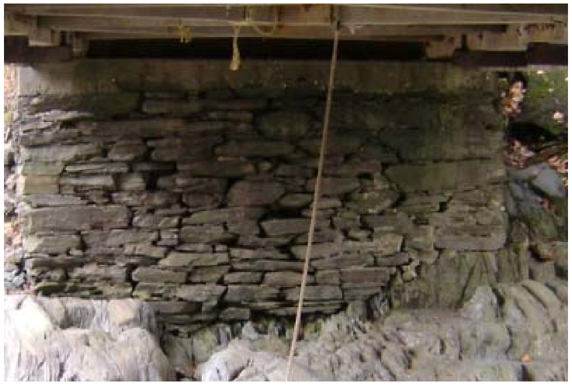
- Replace existing members with stronger material of same size and appearance
  - Increase strength/capacity by almost 2 times
- Timbers commercially available in Southern Pine or Douglas Fir
- Available tensile strengths:
  - Southern Pine No.1 Dense, F_T= 1,550 psi
  - Douglas Fir Select Structural, 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.

Pragmatic Strategies: Hardware

- 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



Failing abutment, Green River Covered Bridge, MA.

Stone pattern in concrete

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

Pragmatic Strategies: Strengthening

- Existing covered bridge live load capacity is typically H3-H6 (3-6 tons)
  - Limited by decking and floorbeams

- Strengthening employed to increase capacity

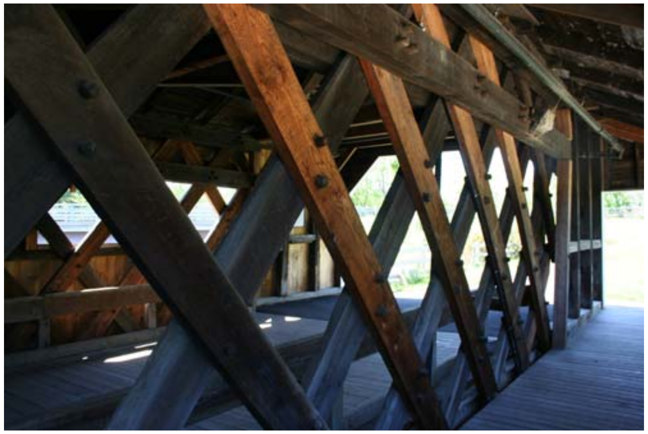
- Typical goals:
  - 15-ton snow plow
  - 20-ton fire truck

Pragmatic Strategies: Strengthening

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



Web member strengthening
Haverhill-Bath Bridge, NH

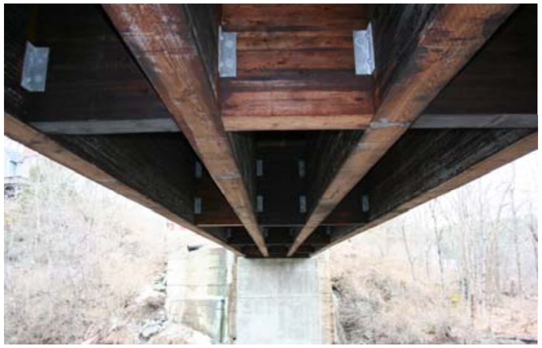
Conclusion:

Strengthening approach and methods should be used sparingly!

Pragmatic Strategies: Strengthening

Co-functional Structural System

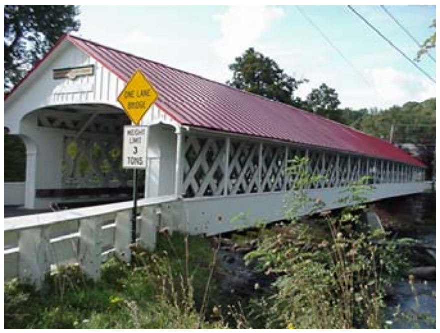
- A co-functional structural system is a better solution
- A co-functional system:
  - Allows bridge to support typical, routine loads
  - Independently supports higher loads up to 20 tons
- This system does not damage historic fabric
- Bridge functions on a limited basis as was intended
- Easily reversible



Glulam support system
Union Village Bridge
Thetford, VT

Pragmatic Strategies: Restricted Use

- 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!!!



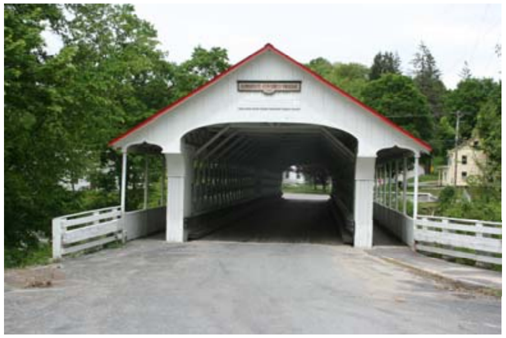
Bridge posted for 3-ton load

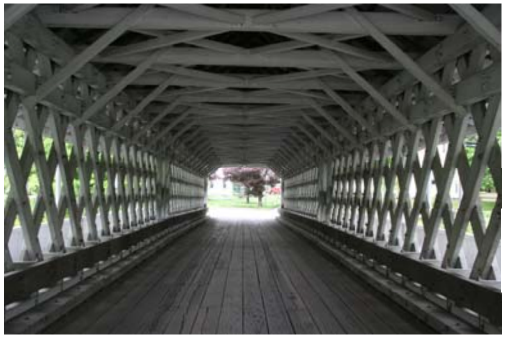
<u>Strategy:</u>

- Perform limited repairs
- Post bridge for 3 ton or 6 ton restriction
- Provide alternate route (detour) for heavier truck loads

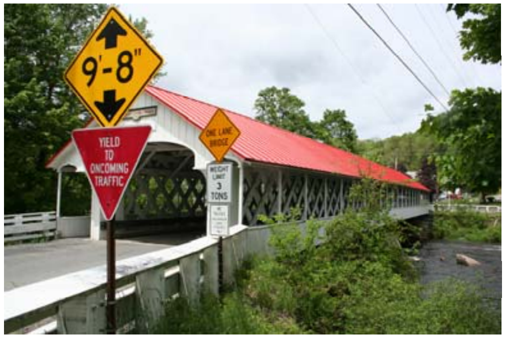
Case Study – Ashuelot Bridge
Winchester, NH

Restricted Use





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

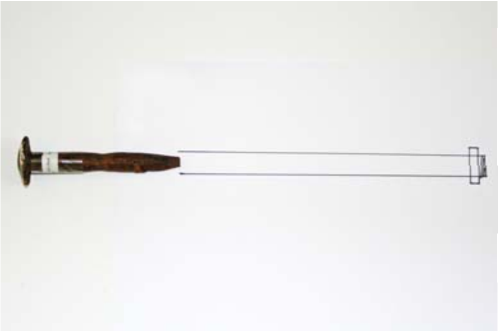


Posted bridge for 3-ton limit and permanent detour for heavy loads

Case Study – Ashuelot Bridge Winchester, NH

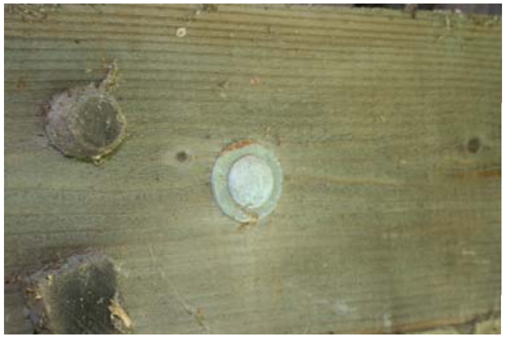
Unique Existing Hardware

Existing bolted connection

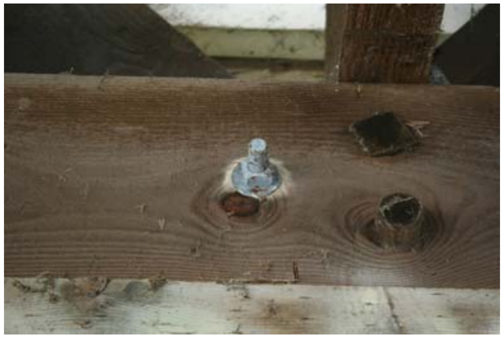


Extracted bolt

Replacement hardware to match



Standard carriage bolt with washer added



Square nut replicated

Case Study – Slate Bridge
Swanzey, NH

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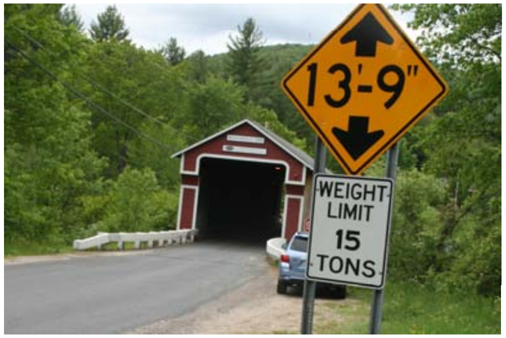
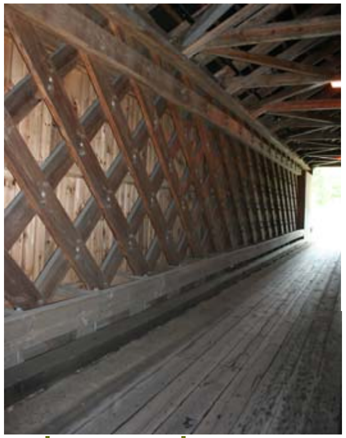
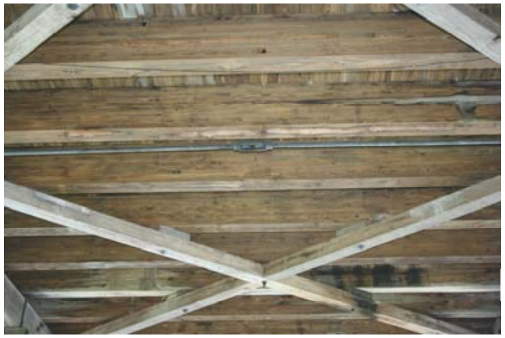


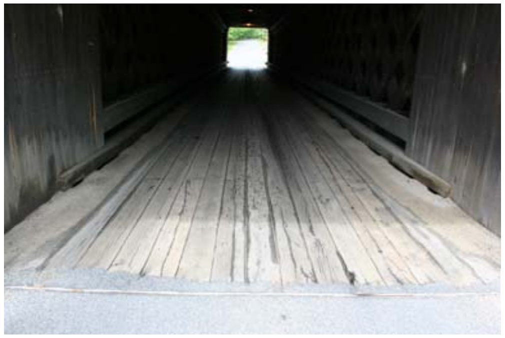


Southern pine members

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

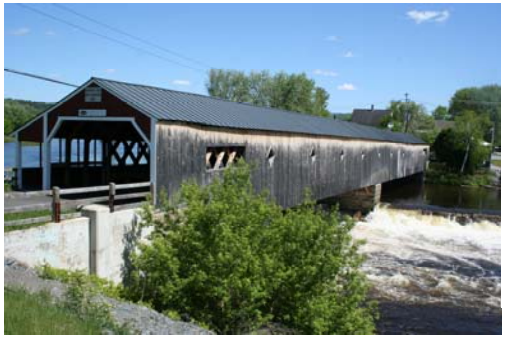


Glulam deck and floorbeams

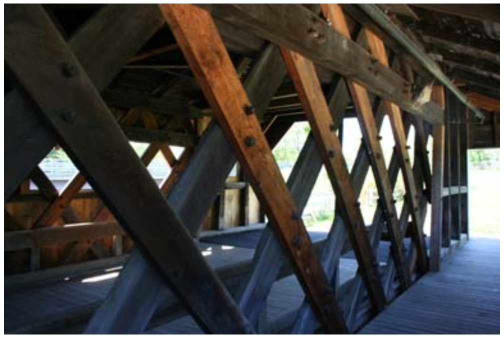


Sawn timber runners
to hide glulam material

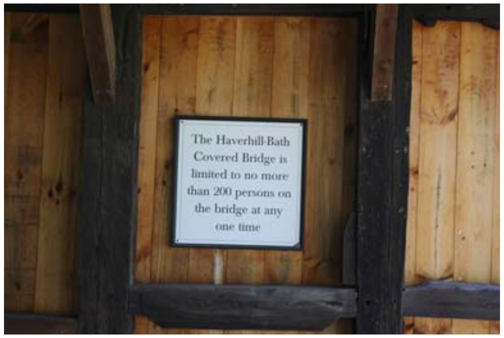
Case Study – Haverhill/Bath Covered Bridge



- 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

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Case Study – Union Village Covered Bridge, Thetford, VT

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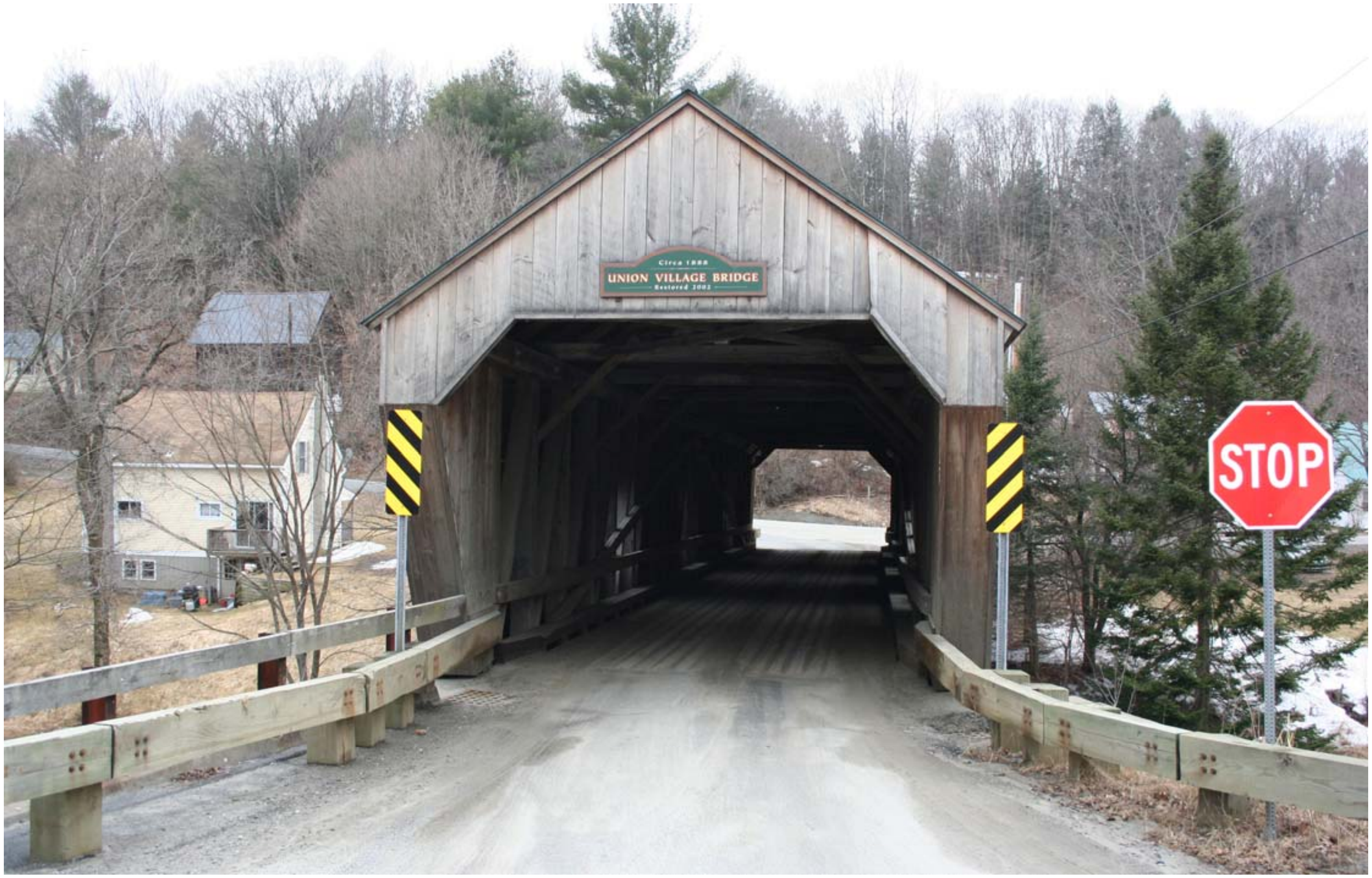
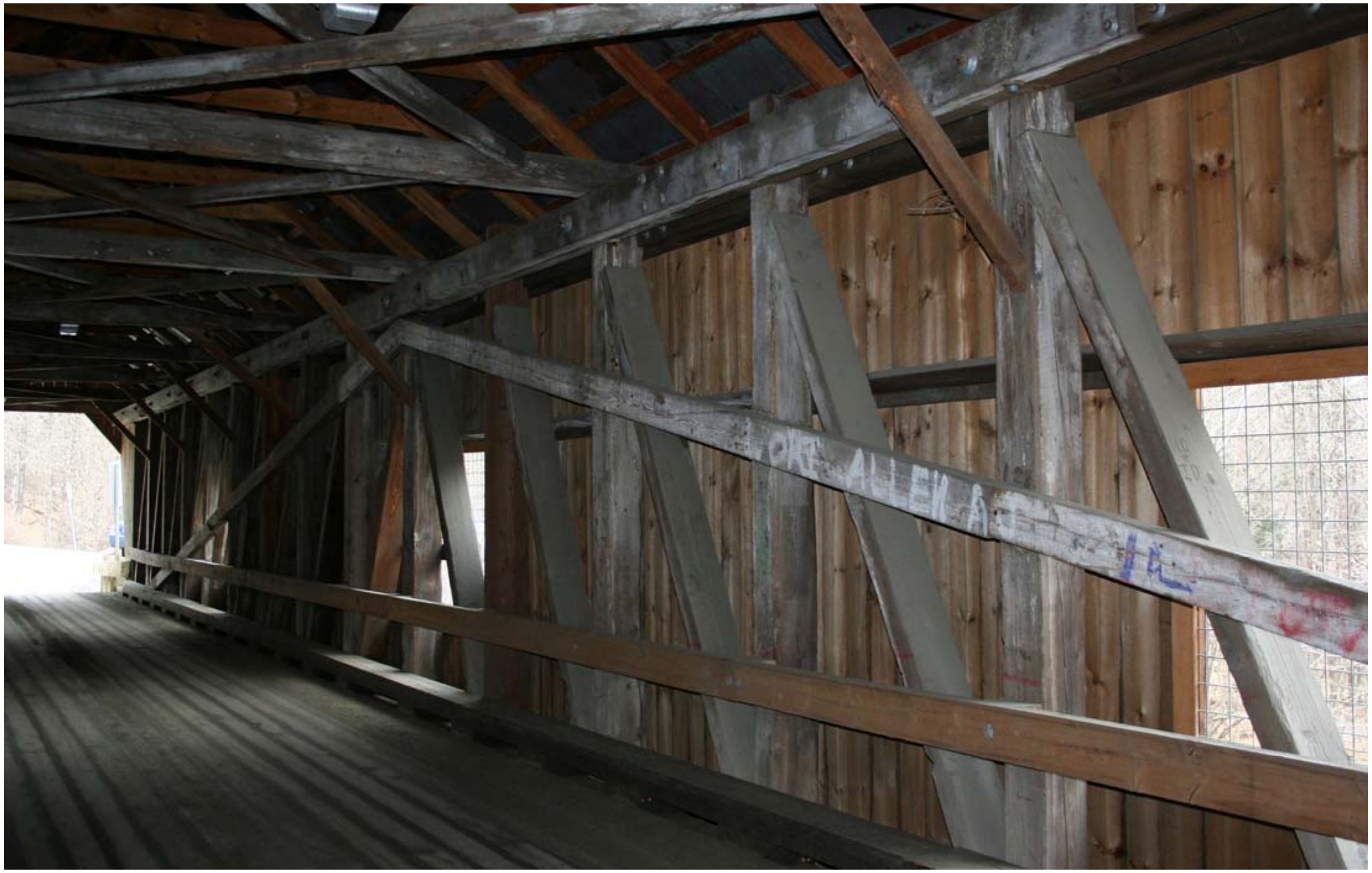


Built 1867

Goal: support the Town's fire Apparatus (H20)

Case Study – Union Village Covered Bridge, Thetford, VT

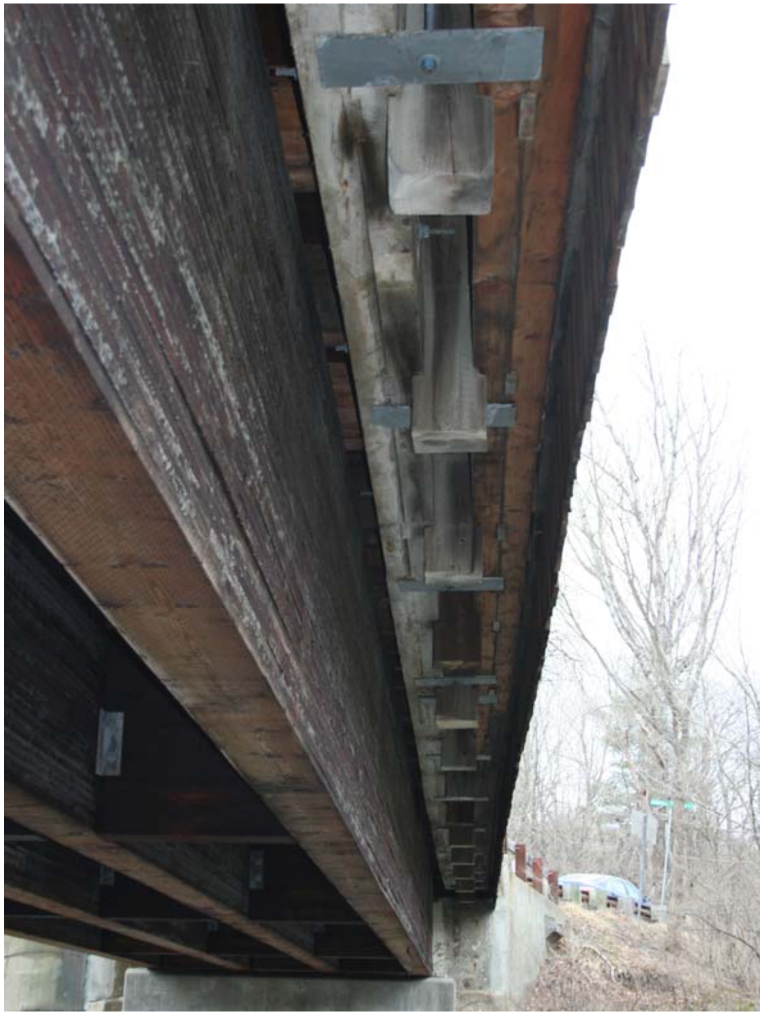


Existing Capacity:

Trusses: H6.5
Deck: H4
Floorbeams: H5

Haupt Truss

Case Study – Union Village Covered Bridge, Thetford, VT

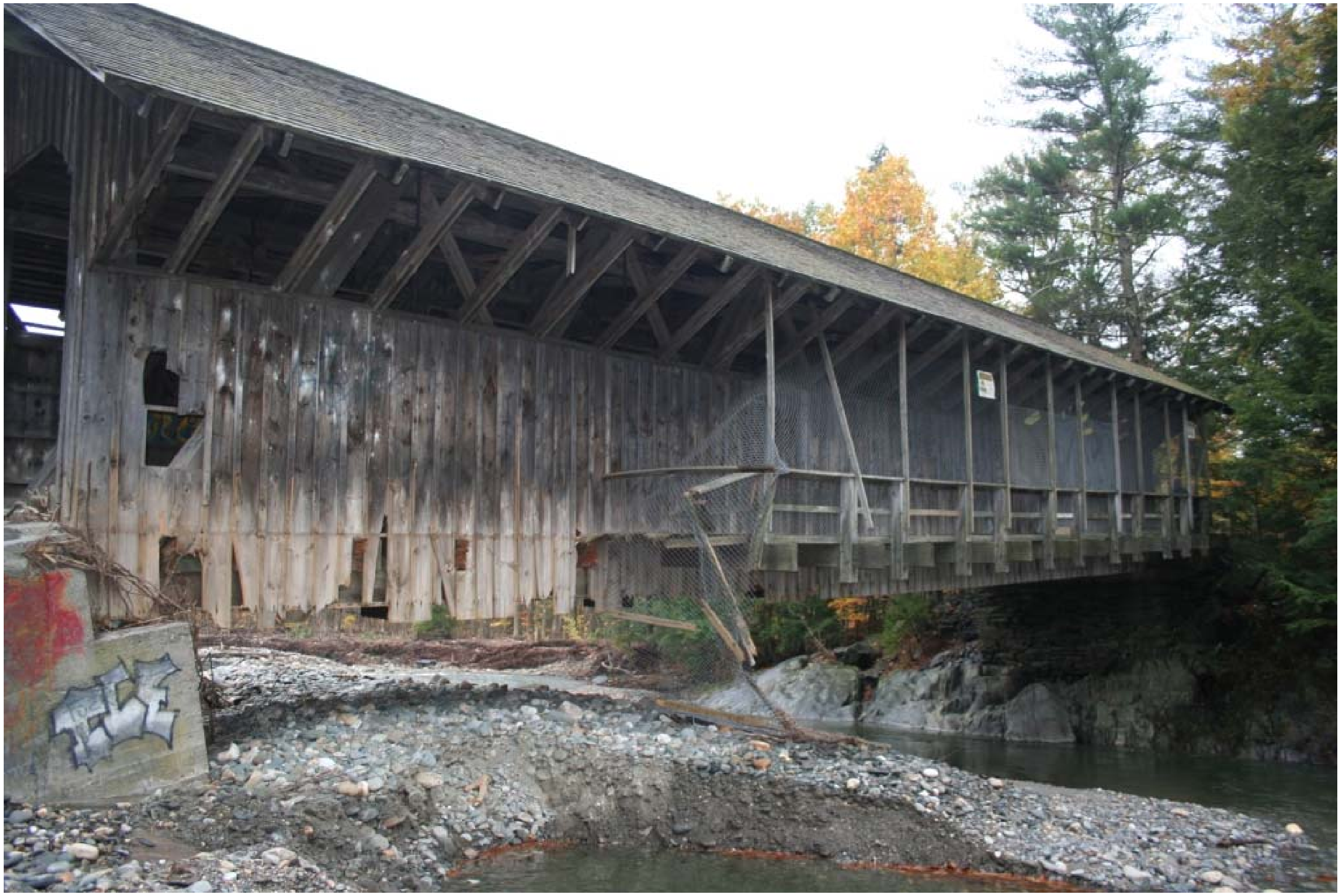


Co-functional glulam beams added

Summary

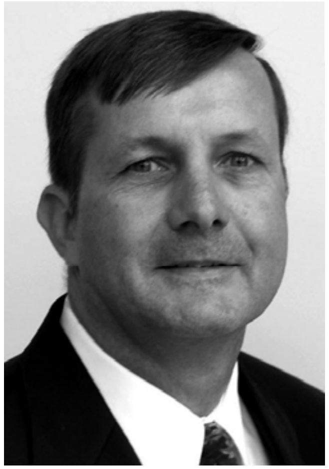
- Funding sources are shrinking
- Project costs are increasing
- Standards that apply to covered bridges allow pragmatic solutions:
  - Use of modern materials and commercially available products and materials are cost-effective.
    - Modern hardware
    - Commercially available Douglas Fir or Southern 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

Questions?



Green River Bridge Rehabilitation, Greenfield, MA

Contact Information



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