LANGLEY COVERED BRIDGE REHABILITATION: Practical Solutions for Rehabilitation of a Historic Covered Bridge

National Covered Bridge Conference

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Langley Covered Bridge
Centreville, Michigan

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OUTLINE

- Project background, history of bridge
- Assessment of rehabilitation needs, findings of structural analysis
- Rehabilitation construction process, lessons learned

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BACKGROUND

- Project began 2005, completed 2009
- Project participants:
  - St Joseph County Road Commission
  - Preservation architect
  - Structural/preservation engineer
  - MDOT historian
  - Contractor

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Significance of Langley Bridge

- Constructed 1887, timber Howe trusses
- One of four remaining historic covered bridges in Michigan
- One of the longest historic covered bridges in US
- Forms part of local identity
- Still in active use as county road

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Project Location

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The Langley bridge 1887

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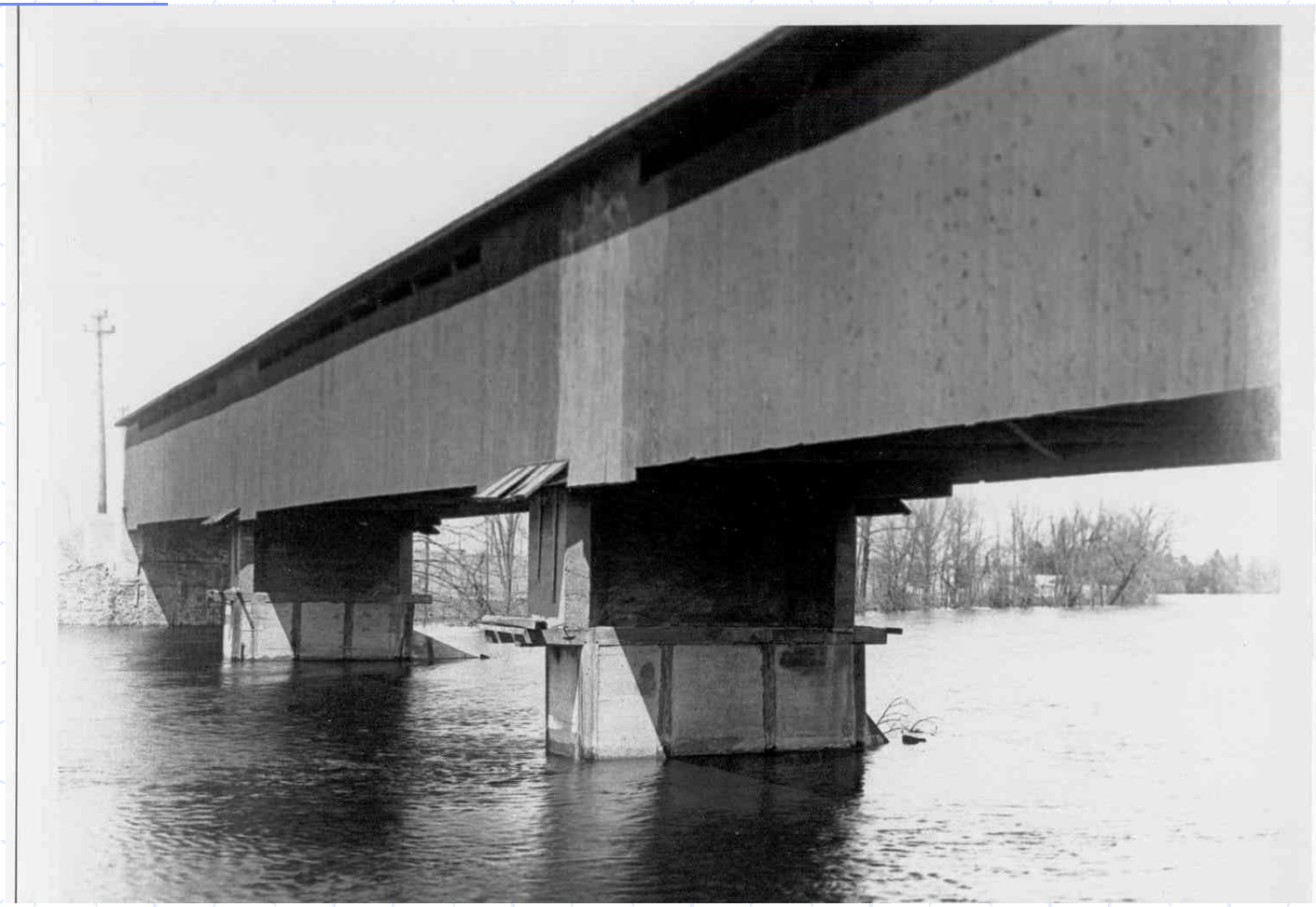
Raising the bridge for dam 1910



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New causeway to connect bridge across floodplain

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Later changes: deck, piers and abutments replaced 1950s

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Roof raised and replaced

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Sway bracing modifications

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The fishing window

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The Structure

- Heavy timber Howe through trusses

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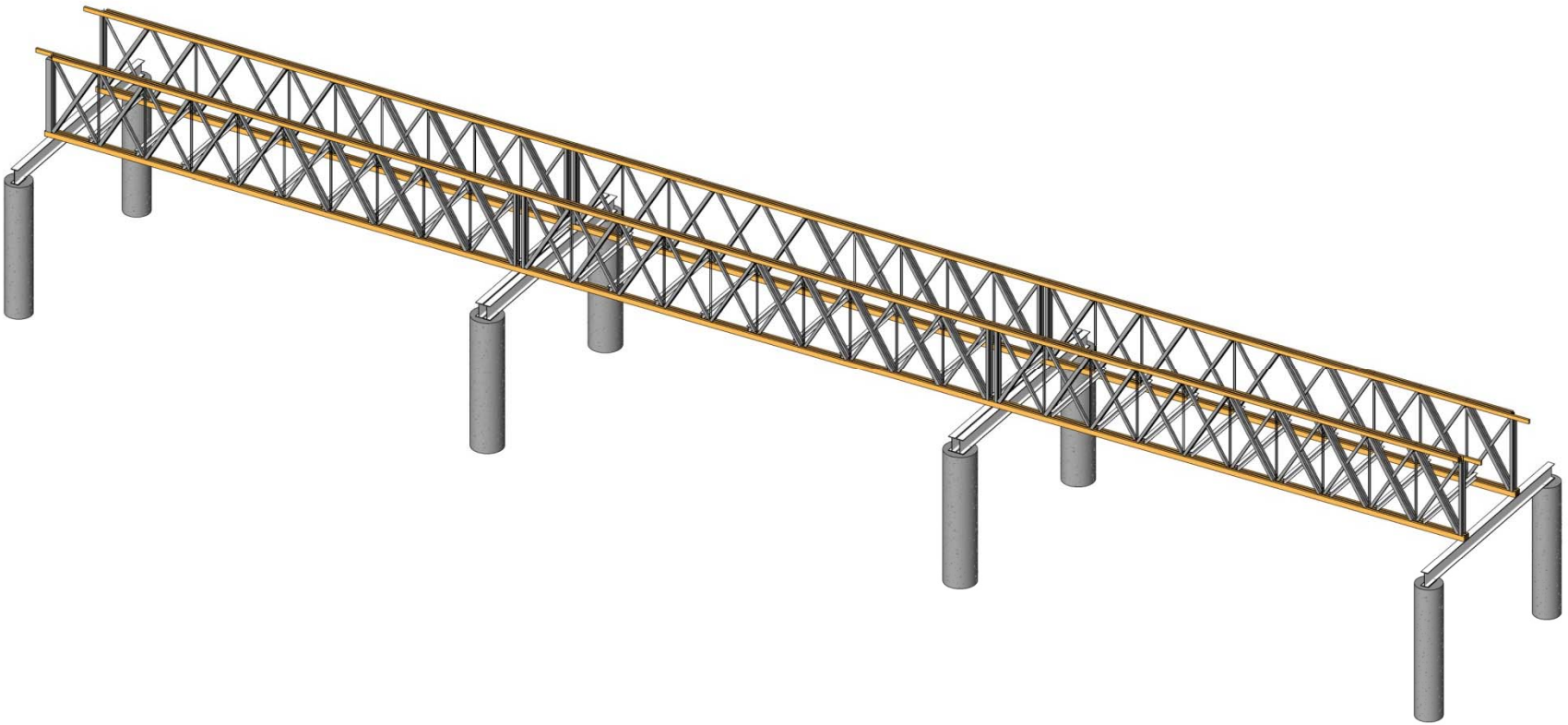
The Howe trusses here are the historically significant feature



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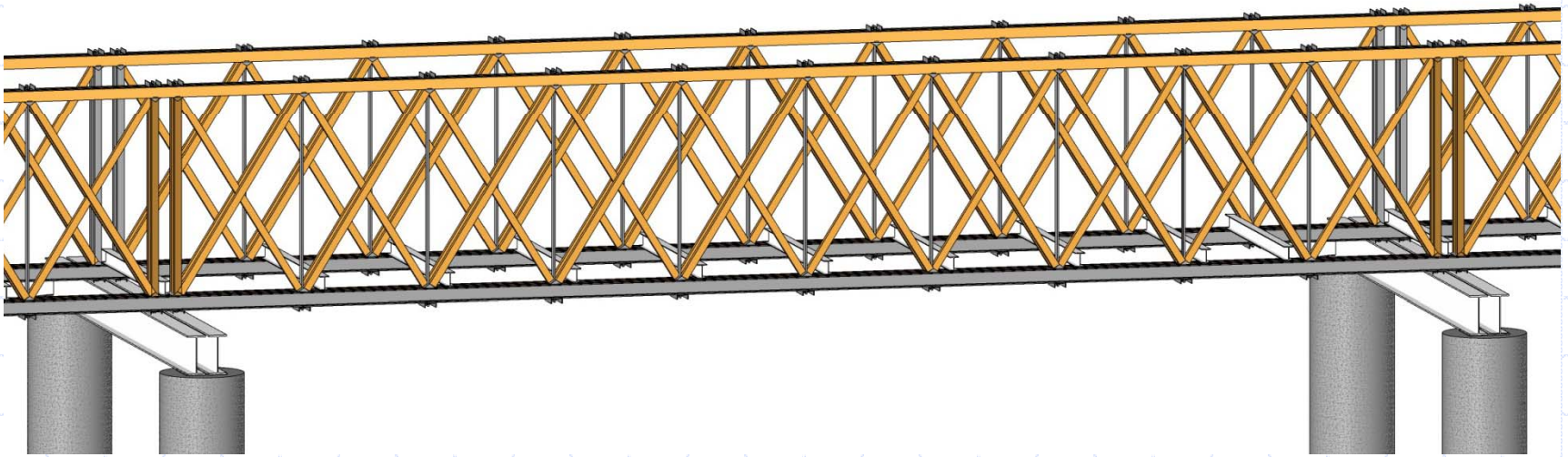
The Langley Bridge trusses

- Each truss 94 ft long, 16 ft tall, h/L=6
- 10 panels per span, 9'-2 ¾" each
- Diagonals slope 60



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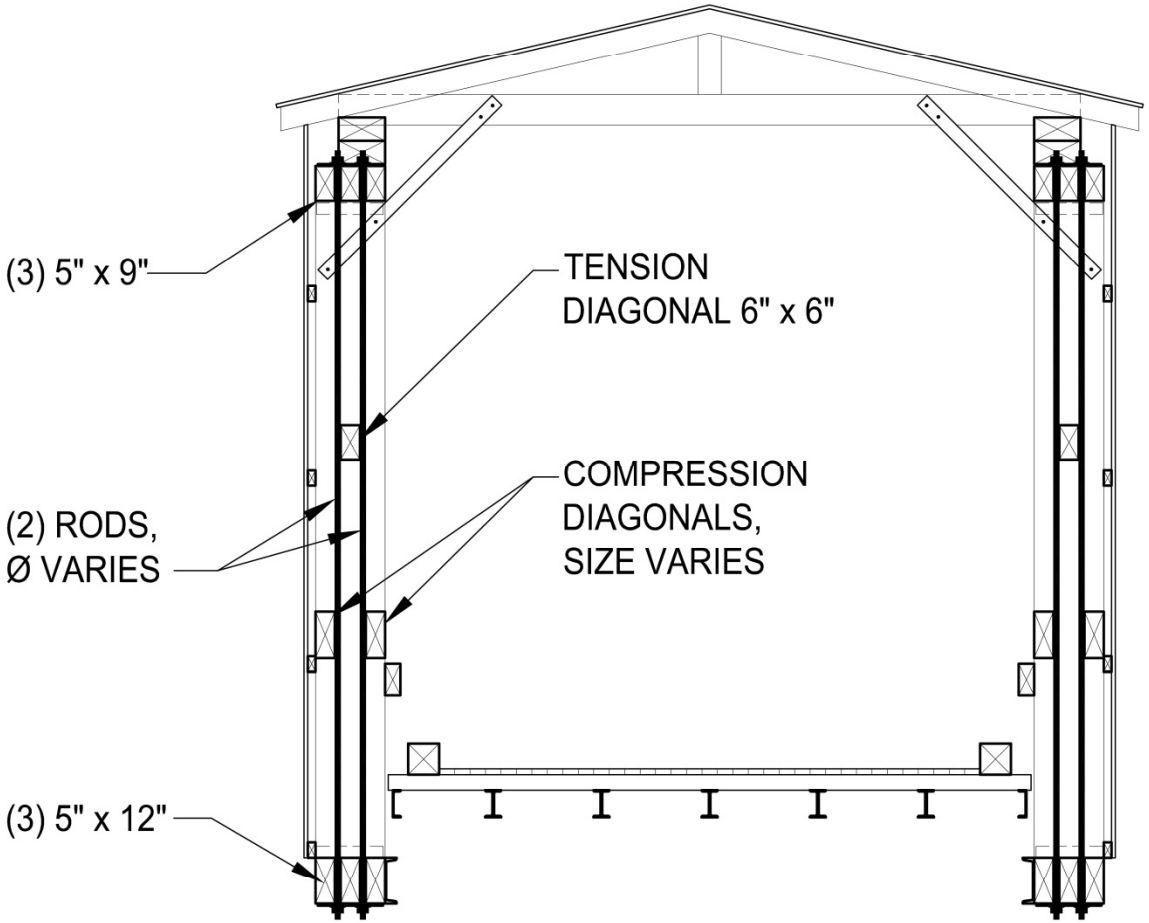
Trusses built up from sawed timber, three laminations at chords



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Iron castings at nodes, tension rod bearing directly on chords

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ASSESSING REHABILITATION NEEDS; FINDINGS OF STRUCTURAL ANALYSIS

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Issues

- Bridge was posted for 3 T load limit
- Load and speed limits regularly ignored
- Last major repairs and maintenance 1970's
- Previous modifications and repairs addressed functional requirements only, little regard for historic preservation

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Recent Vehicle Impact

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Issues with roof: framing and covering

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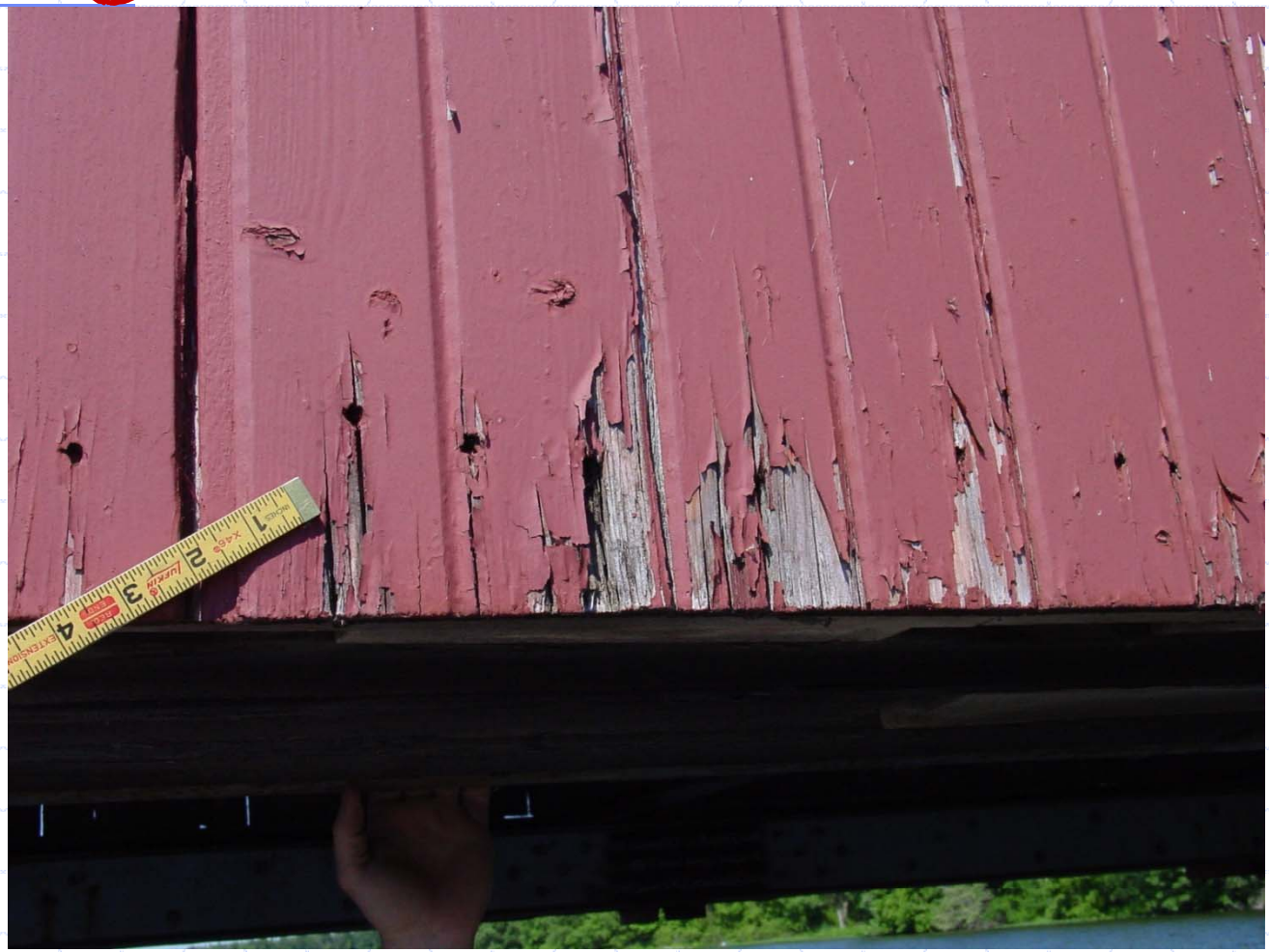
Issues with siding: rot, lead paint peeling into the river



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1950s steel deck framing, corroded, lead paint peeling

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Truss bottom chord reinforcing corroded, south span sagging

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Low clearance an advantage during condition audit

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Hands on, piece by piece

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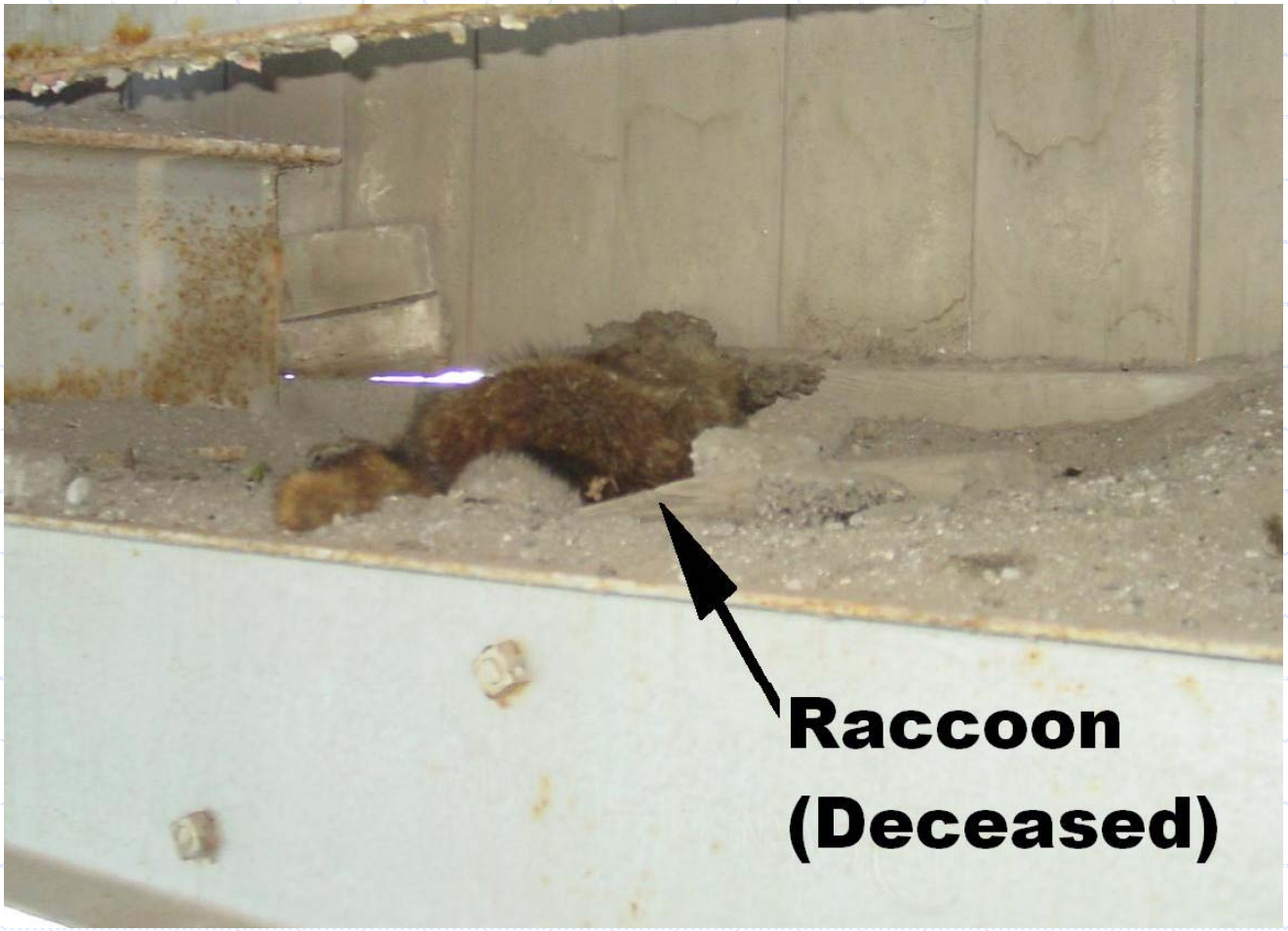
Rotting of bottom chord



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Rotting and crushing of compression diagonals

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Crushing of tension rod bearings, at top chord...

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And bottom

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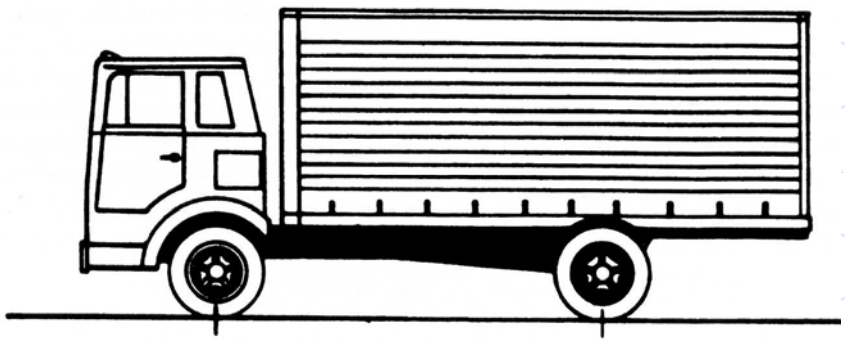
Purpose and Need: Defining the Loads

- We recommended public meetings held to discuss conversion to pedestrian and bicycle use only
- That idea not endorsed by community
- Community wanted to maintain crossing over river as a county road

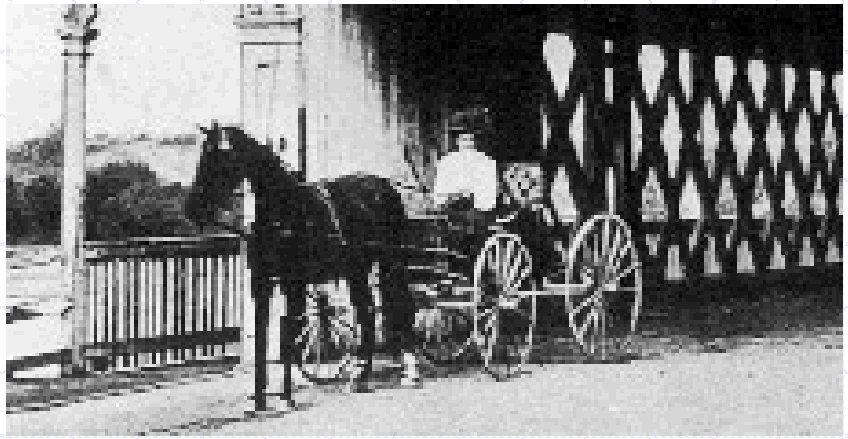
Loads

- Modern loads per AASHTO vs horse-drawn carriages and wagons: 30,000# vs 7,000#

HIGHWAY BRIDGES



H 20-44	8,000 LBS.	32,000 LBS.*
H 15-44	6,000 LBS.	24,000 LBS.



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Structural analysis to assess repair and strengthening needs

- We examined roof framing, deck framing, trusses, girders and substructure, no work below the waterline
- Want to discuss here three issues:
  - Tension capacity of bottom chords
  - Load transfer at castings
  - Role of counterbraces in Howe trusses

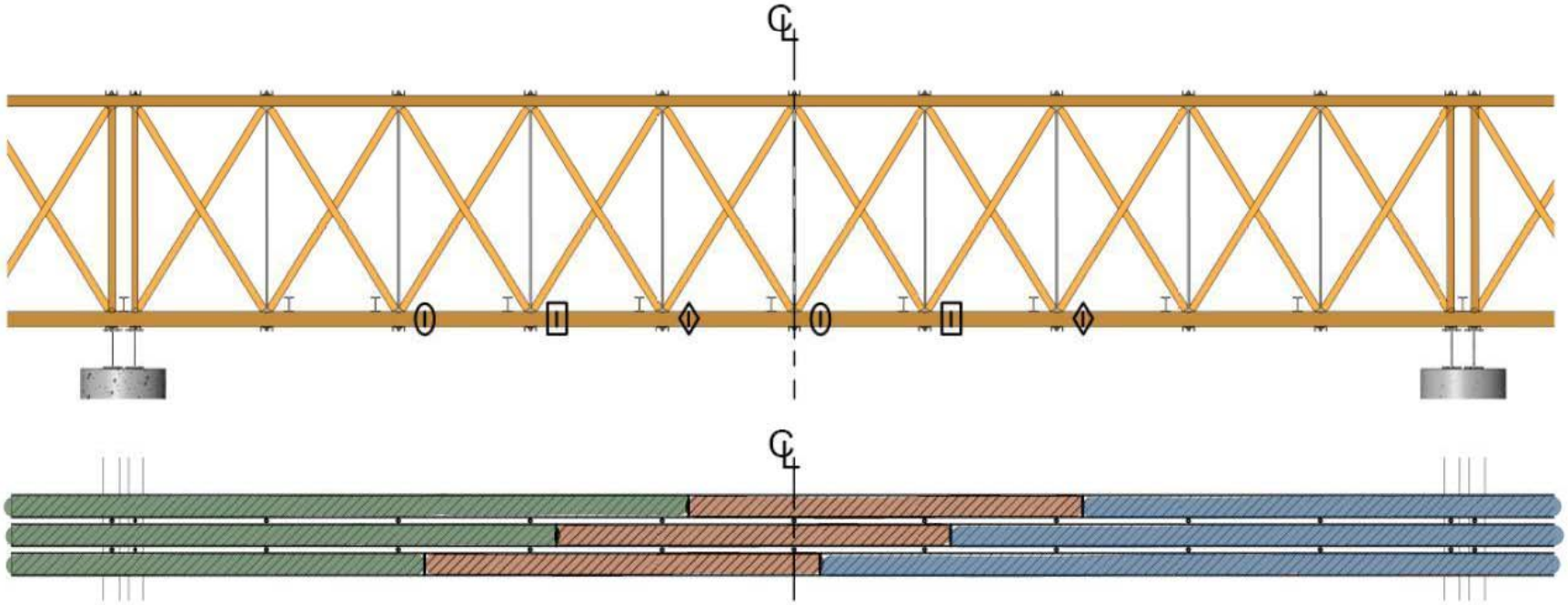
Findings

- Timbers stresses within reasonable limits for No. 1 white pine, though at high end
- Tension rods also well within allowable stresses, ok for fatigue

Findings (cont)

- Max bottom chord tension on gross area of timbers appeared acceptable
- But tension chord members were spliced in original construction

Bottom chord splice locations



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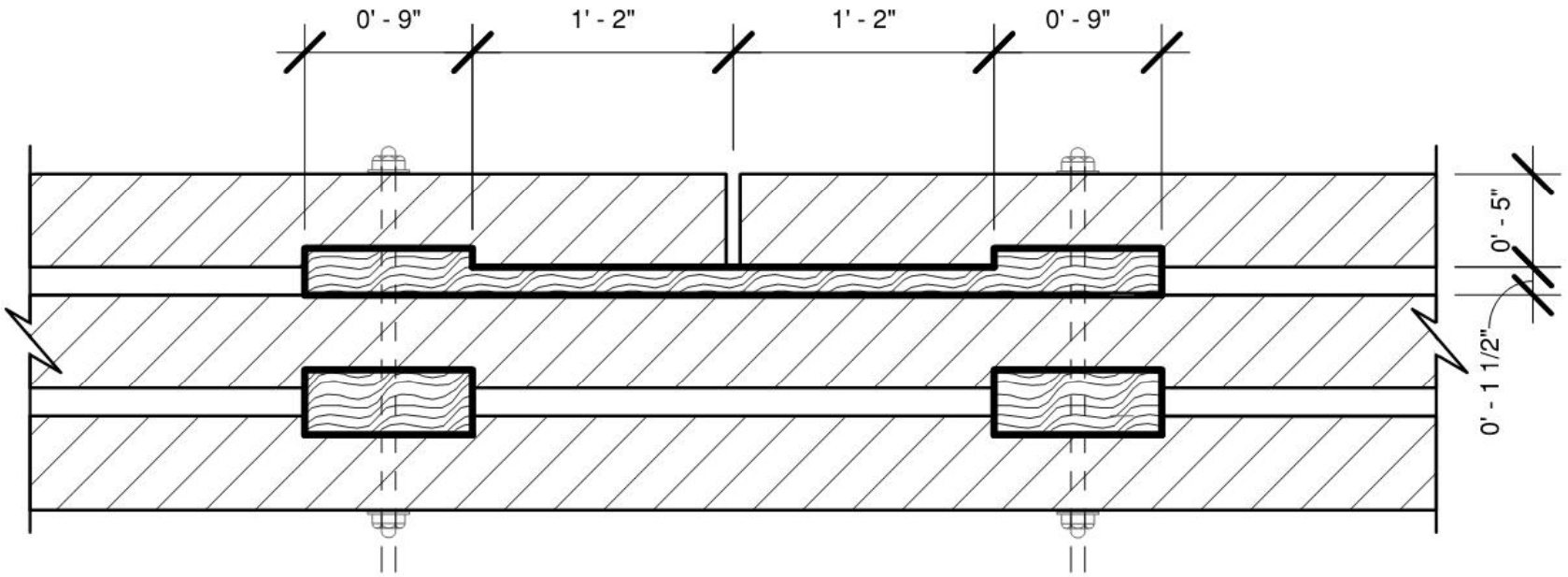
Fishplate detail



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Bottom chord splices

- Evaluate tension on net area and shear parallel to grain in the timbers and fishplates, and compression on the bearing surfaces
- To support wagon loads, need 13,000# of load transfer through each fishplate if we rely on them alone to do the job

Assessing bottom chord tension capacity

- Per current code limits on bearing stress, bottom chord fishplate capacity is 5,200#, not adequate even to carry self weight of bridge
- Might then assume all tension carried by remaining two laminations (ref S. Patrick Sparks, APT Journal 2005), but they too are spliced
- Need to consider development of tension capacity of bottom chord as a whole, all three laminations

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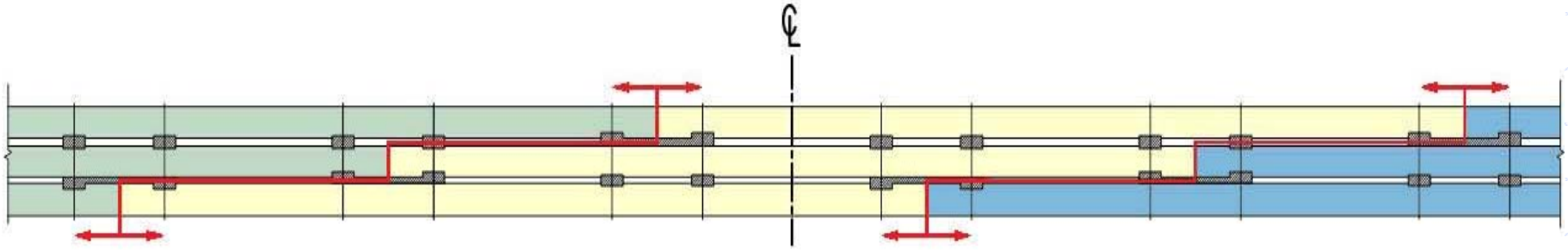
The weak links



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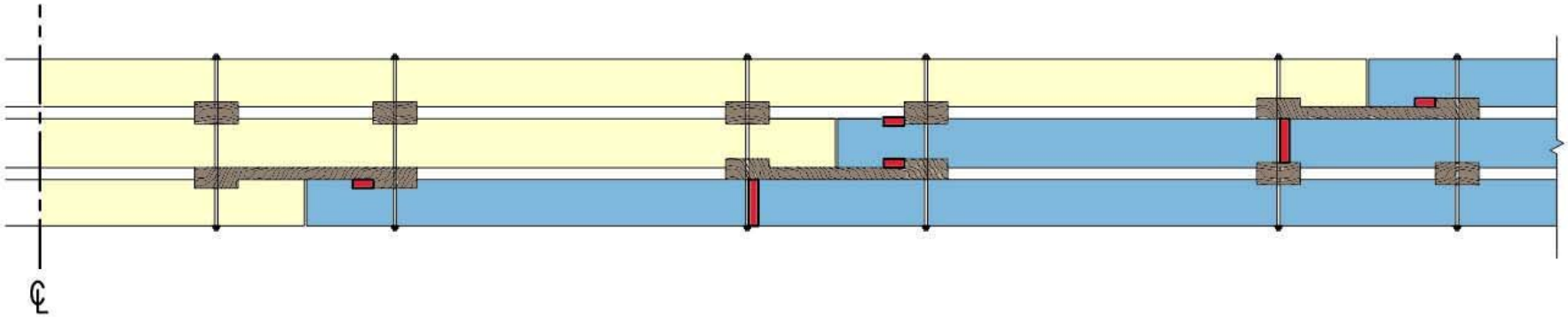
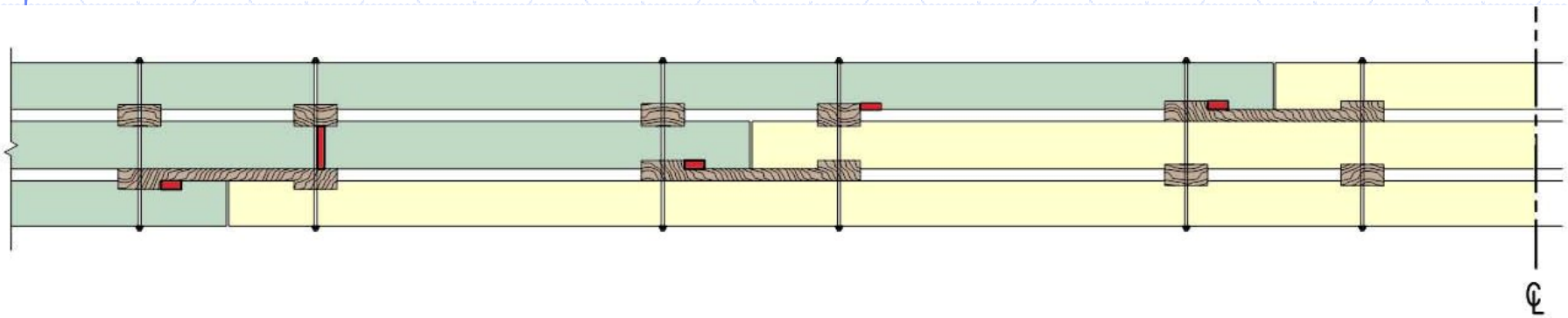
Fishplates, keys, bolts acting



Fishplates, keys, bolts acting

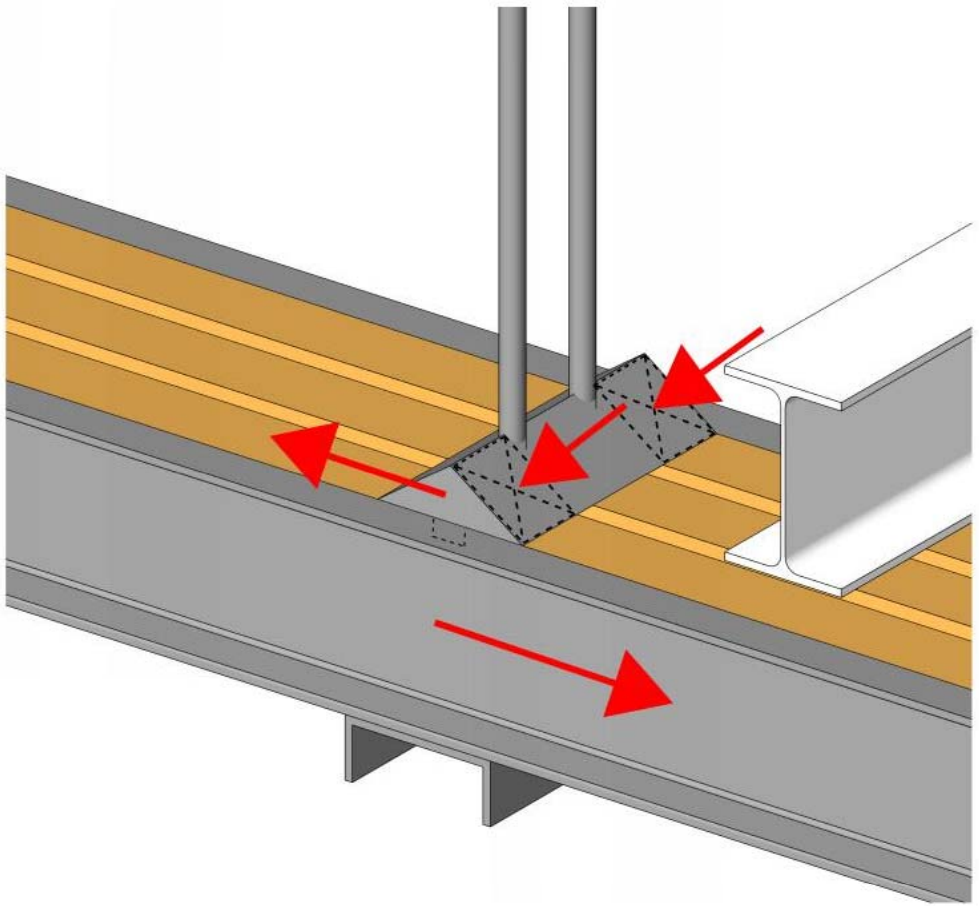


Tension capacity using keys and fishplates

- Four bearing surfaces and one or two bolts in single shear at critical path
- Total capacity = 26,000 # per current NDS, including C_d and 0.75 F'_c limit
- (or 33,000# per pre-2001 NDS)
- Acceptable for wagon loads, not H15 on trusses with deteriorated and cobbled chords

Bottom chord strengthening

- Steel channels each side of each chord, hidden by siding
- Provided good bearing for deck beams and tension rods



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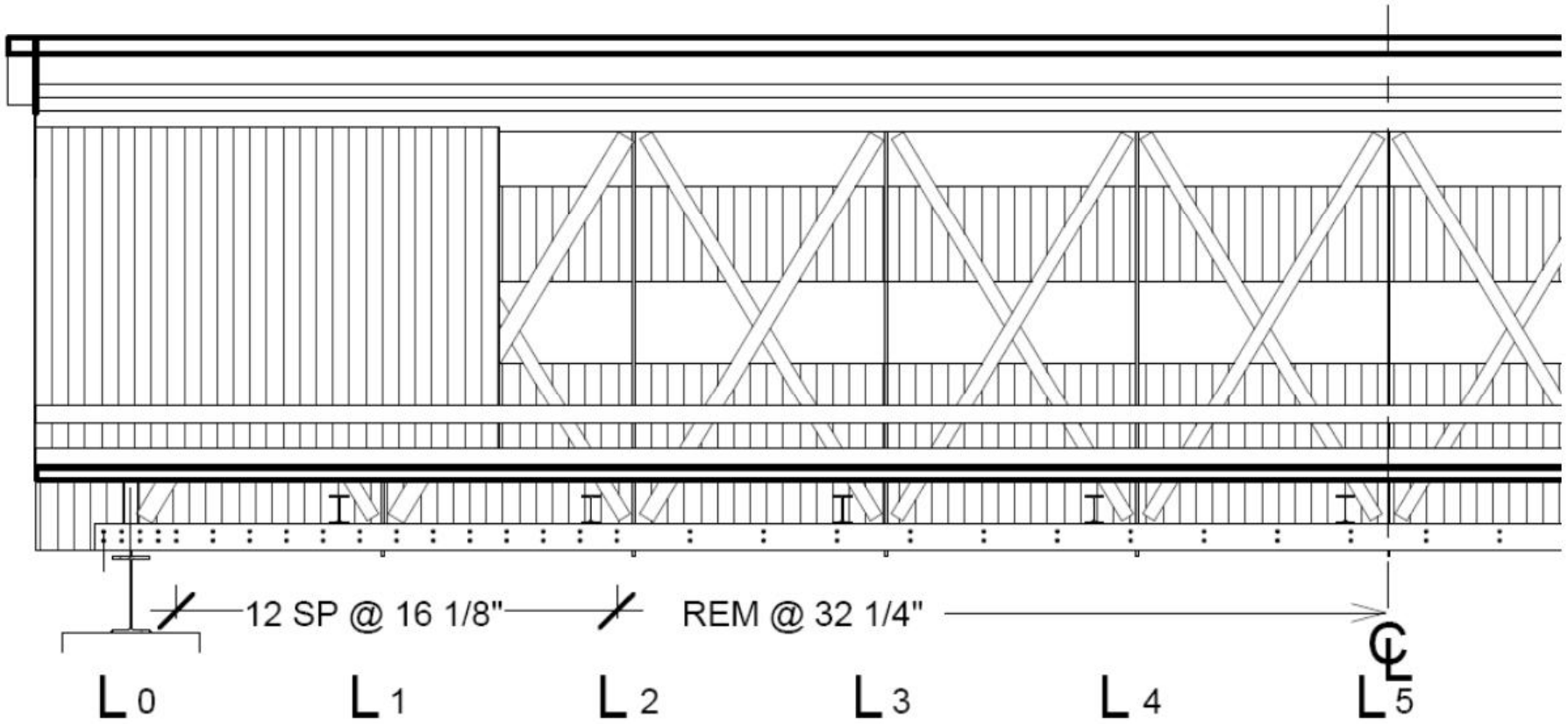
Bolting pattern to develop tension in steel channels, not to splice wood lams



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Load paths at castings

- Max vertical = 31k, fc = 200 psi (wagons)
- Max horizontal component = 18k
- fc// on lug bearing surface = 1950 psi! but F'c// for EWP SSP&T = 834 psi

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Force transfer at castings

- In recent times, max horizontal load carried may have been = 28k, so fc// = 3000 psi
- Tension rods don't bear on wood, no dowel bearing to help out
- Friction?
- Is C_D of 1.15 too conservative?
- Confined F'c// = 3000 psi, » 800 psi?

No action taken

- Had supported higher loads in the past without damage
- Ductile failure mode

THE REPAIR PROCESS

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After lead abatement

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Braced internally

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Accessing the exterior

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Replaced all tension rods and bearing plates

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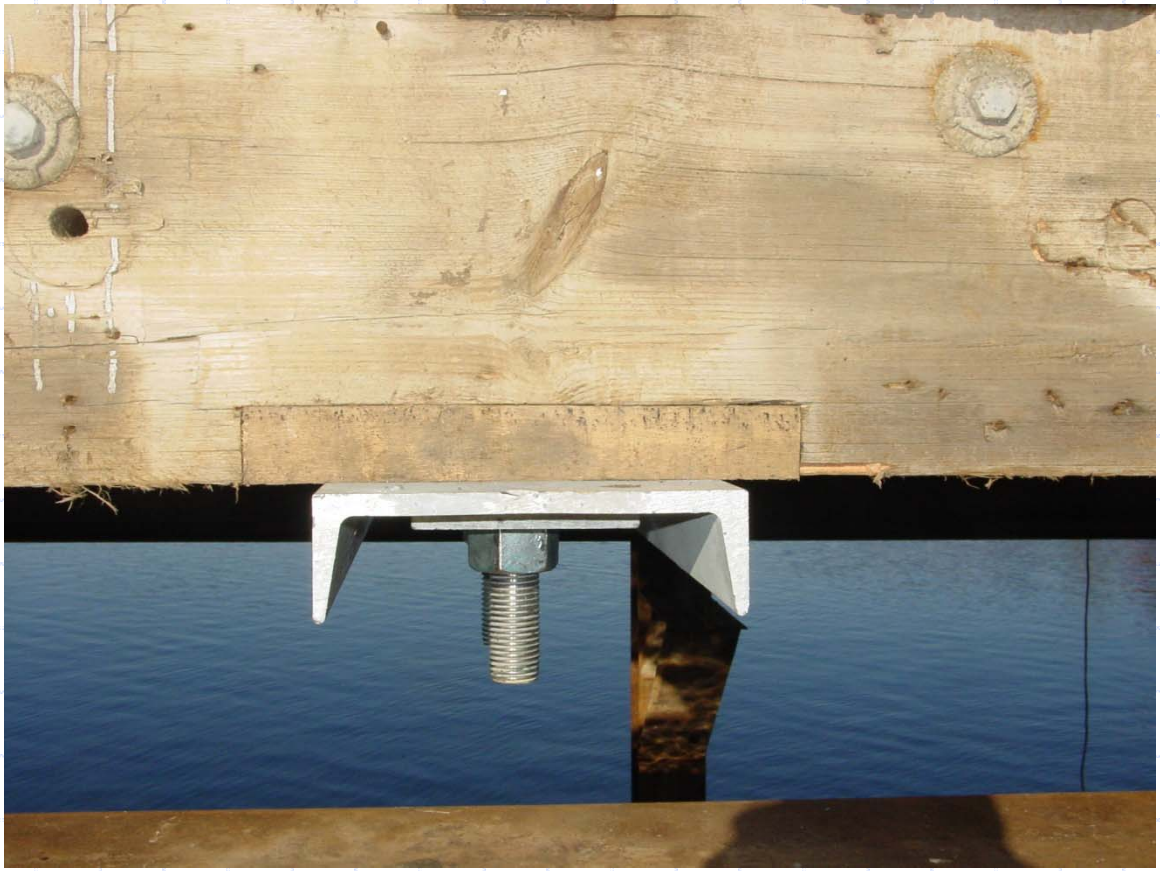
Repaired bottom chord bearing



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Replaced and supplemented tension chord reinforcing

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Spacers between wood and steel to promote durability

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Compression diagonals at fishing window

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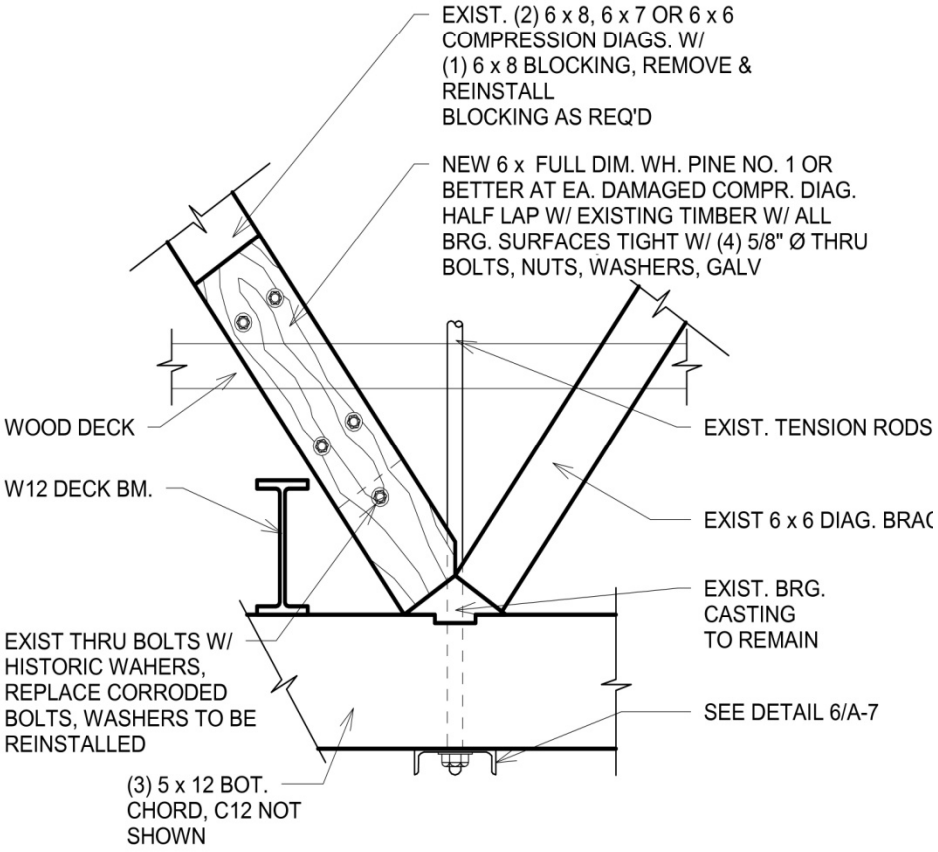
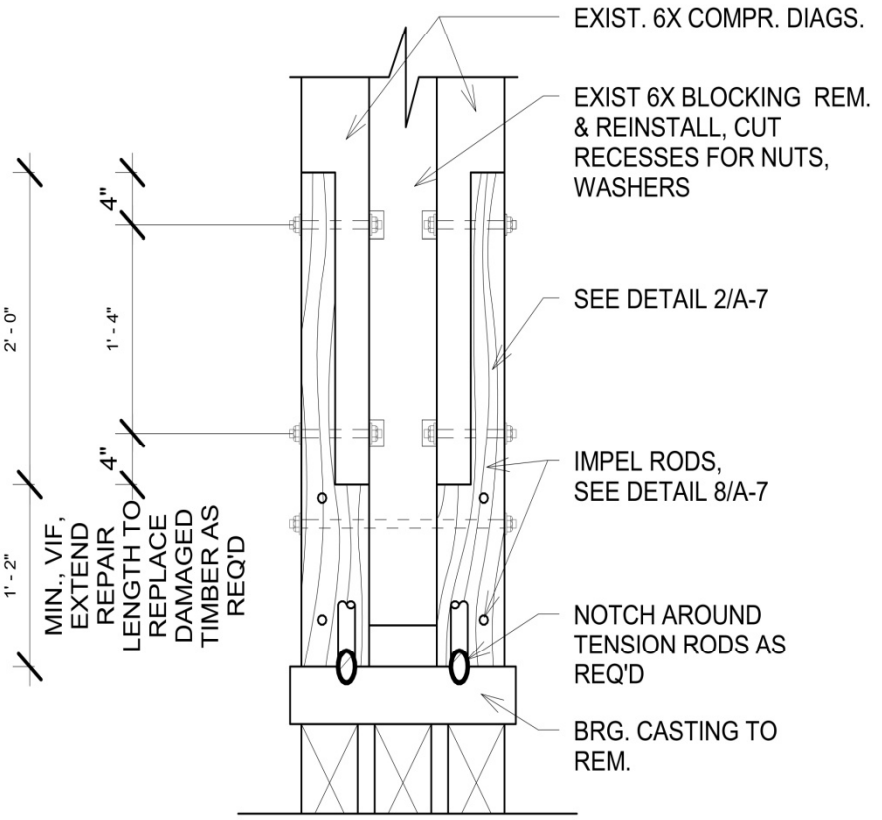
Compression diagonal repairs





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Reused timber washers

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Maintenance painting of steel

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Completed 2009

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Sag didn't get removed

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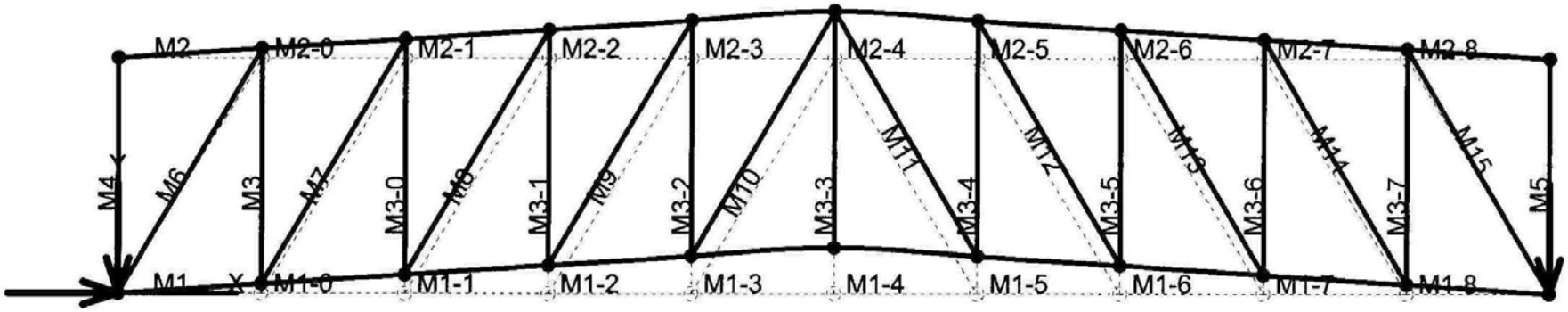
How to camber a Howe



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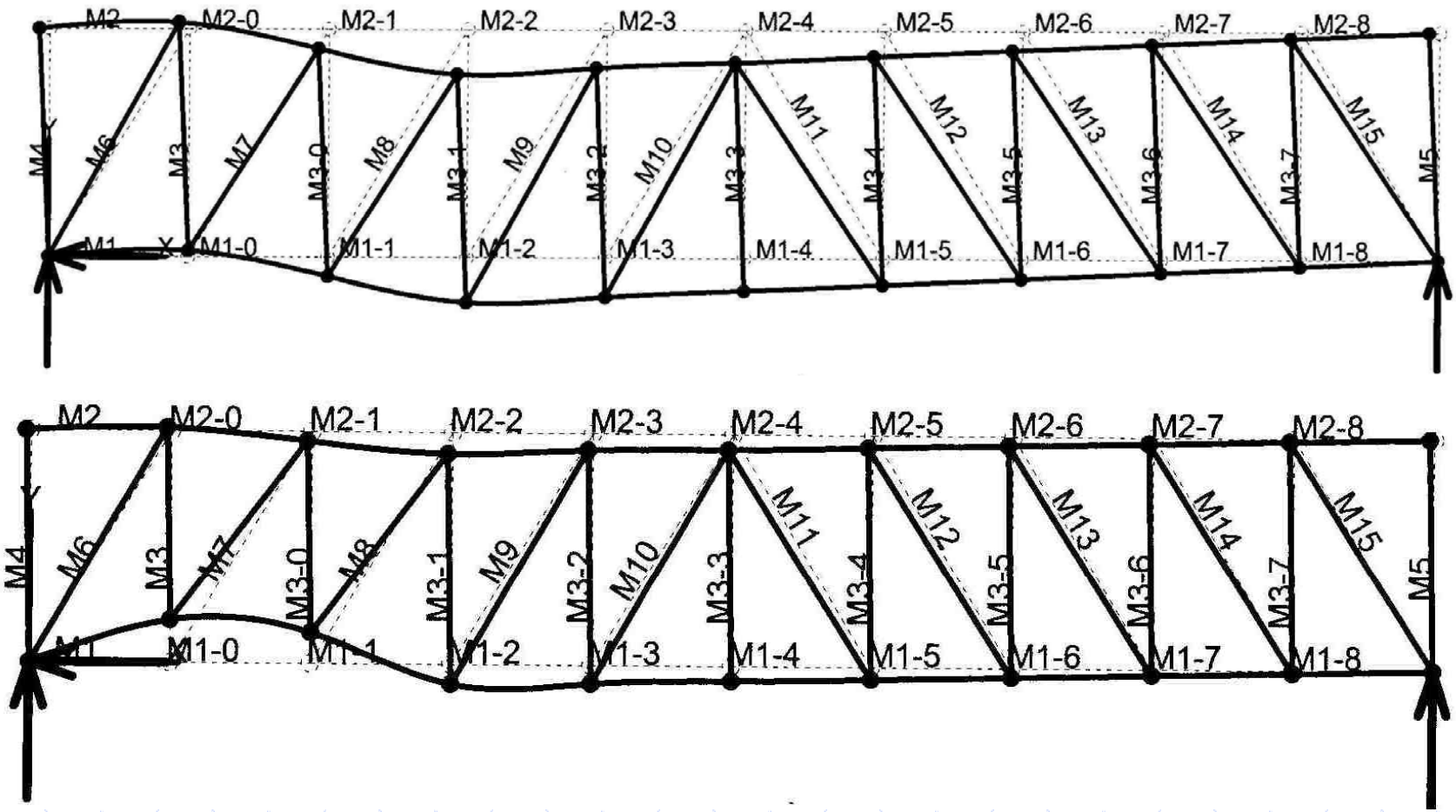
Effect of tightening rods alone



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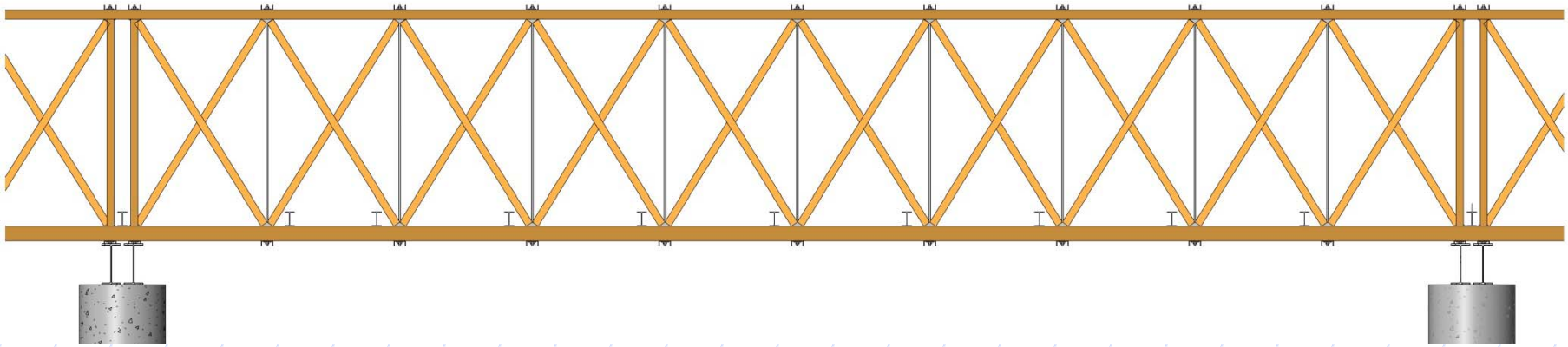
Function of the counter braces?



- Was prestressing the original concept? Can it practically be maintained?
- We found almost all to be loose; they don't brace the compression diagonals out of plane
- Assembly requirement only?

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Overall Satisfaction

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