Structural Design and Behavior of Two Smith Trusses

Stephen Buonopane, *PhD, PE*
Associate Professor
Rooke Chair in the Historical and Social Context of Engineering
Bucknell University
Lewisburg, PA US
stephen.buonopane@bucknell.edu

Sarah Ebright
formerly undergraduate, Bucknell University
Structural Designer, KL&A, Inc., Basalt, CO US

Alex Smith
formerly undergraduate, Bucknell University
Structural Engineer, ARUP New York, NY US

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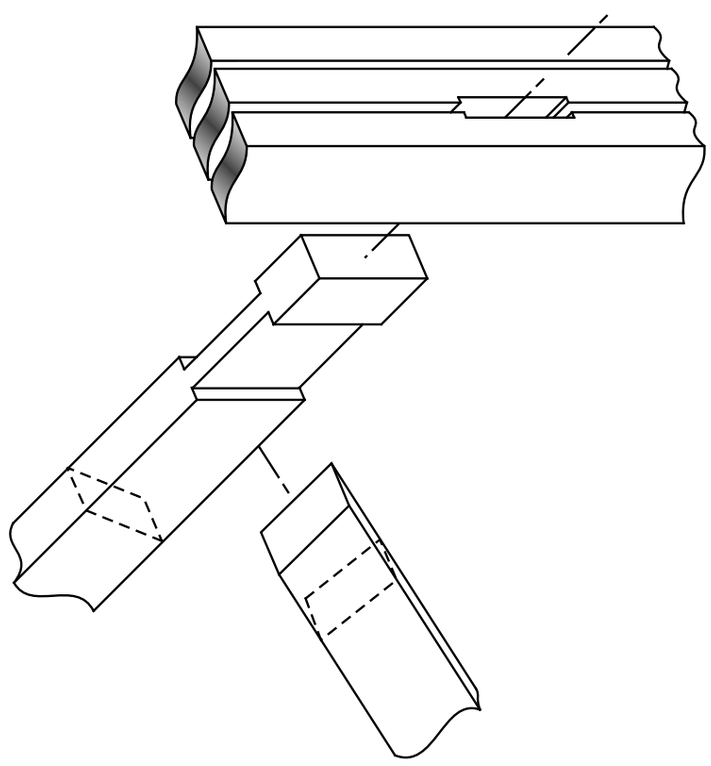

Acknowledgements

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Emily Daniels formerly of Bucknell University
Rooke Chair in the Historical and Social Context of Engineering

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(HAER PA-622)

Objective

Overview

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- Study Smith trusses as engineering and historic artifacts.

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- Not a structural analysis for repair or rehab.

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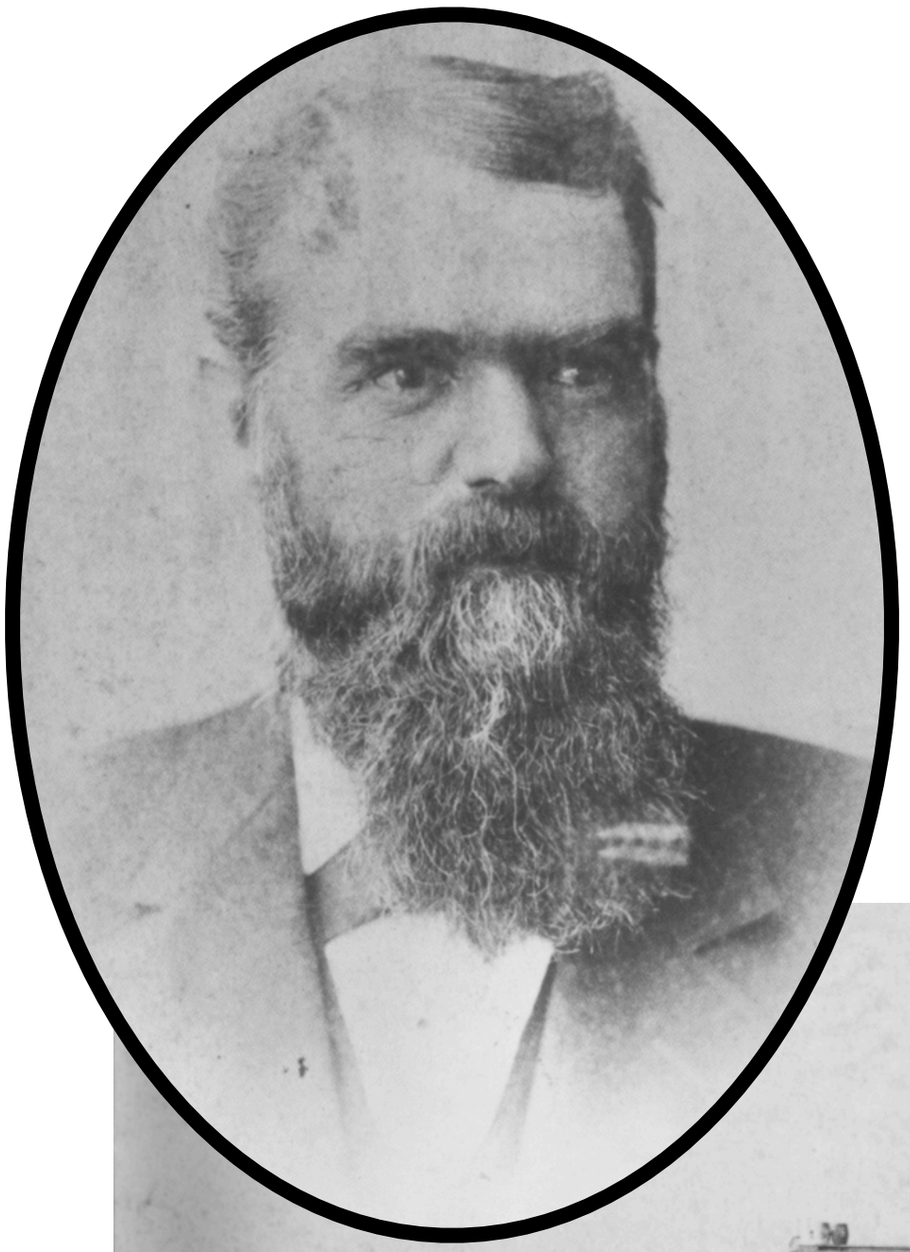
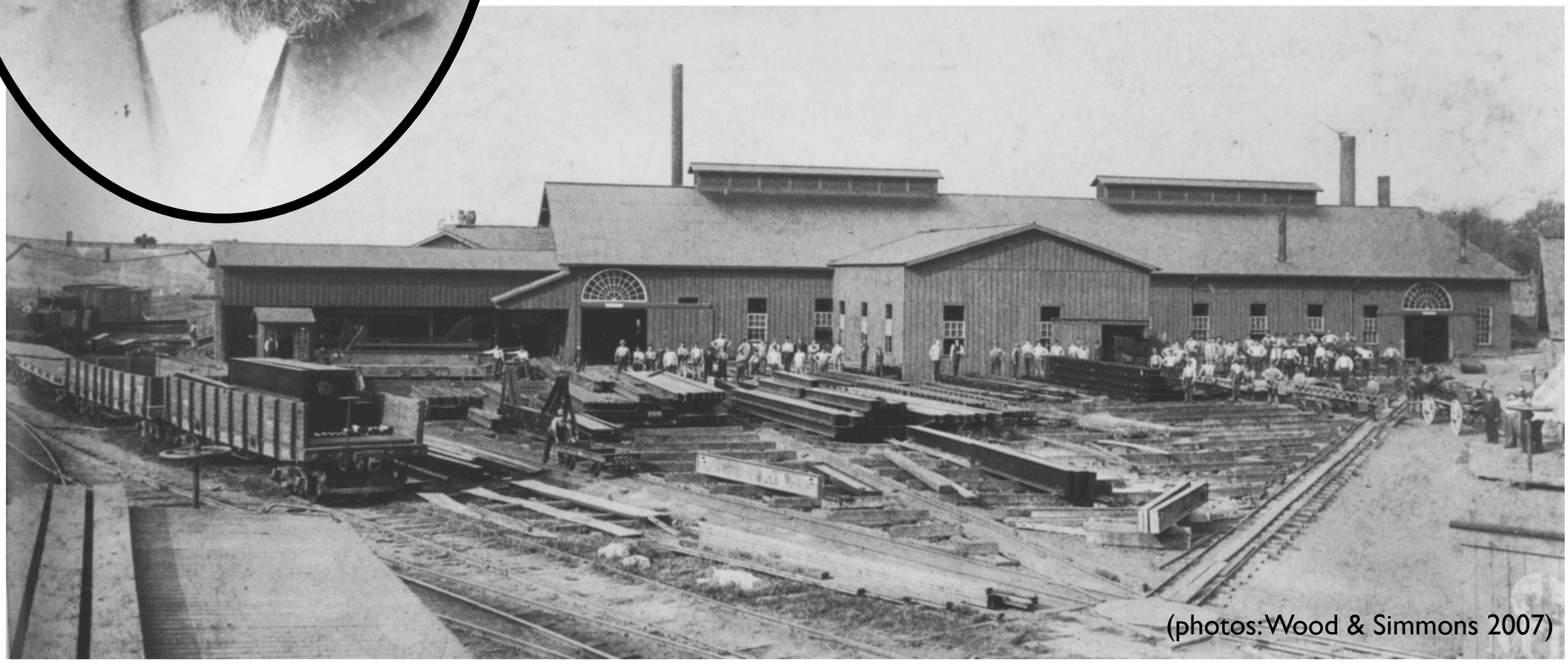
Overview

- Smith Bridge Company
- Historic engineering context with other truss types
- Smith truss types
  - unique aspects
  - evolution of form
- Structural analyses
  - member forces & stresses
  - deflections & camber
  - connections



Robert W. Smith (c.1833-1898)

Smith Bridge Company (1867-1890)

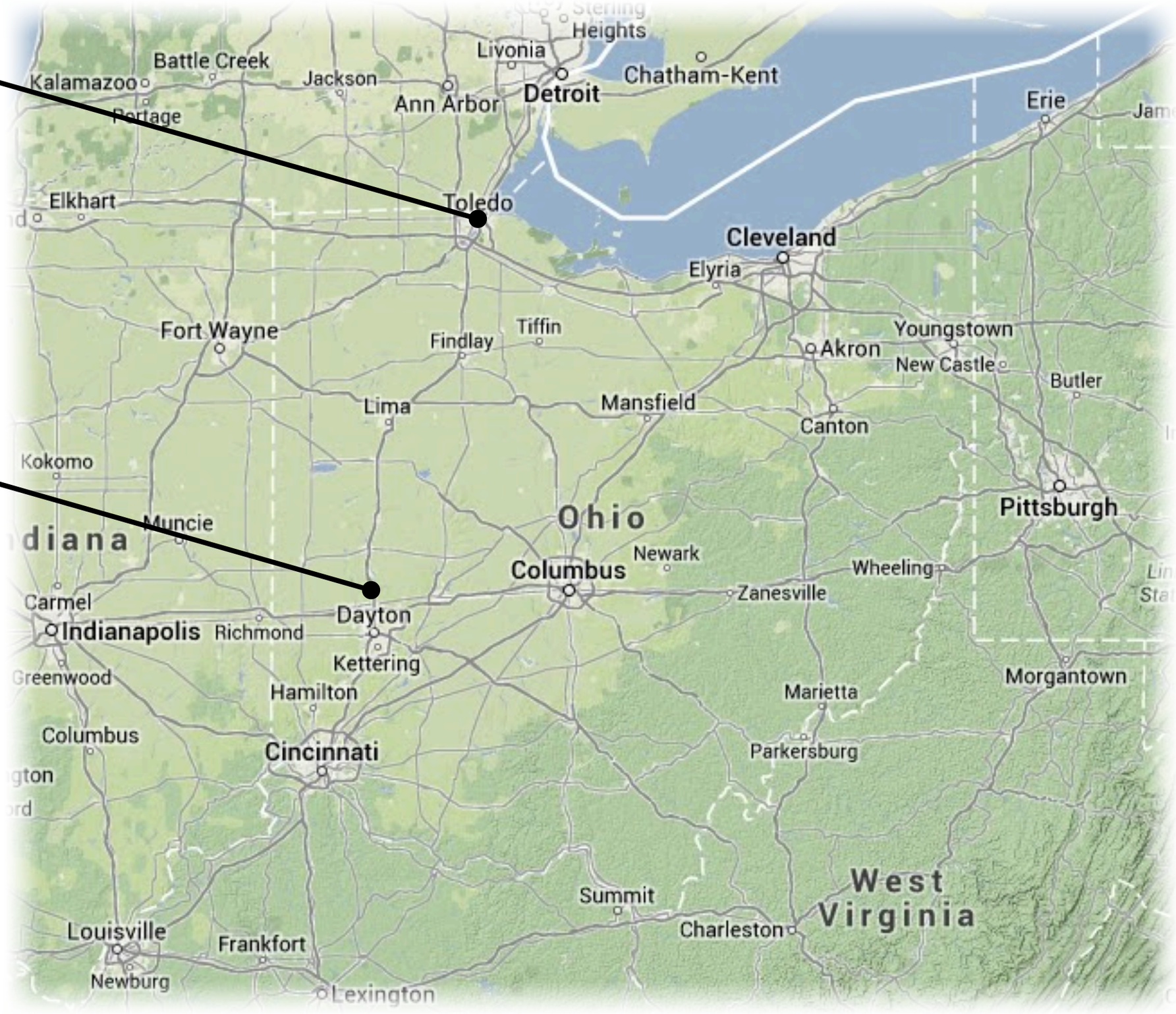


(photos: Wood & Simmons 2007)

Smith Bridge Company (1867-1890)

Toledo

Tippecanoe City



R. W. Smith's Patent Truss Bridge

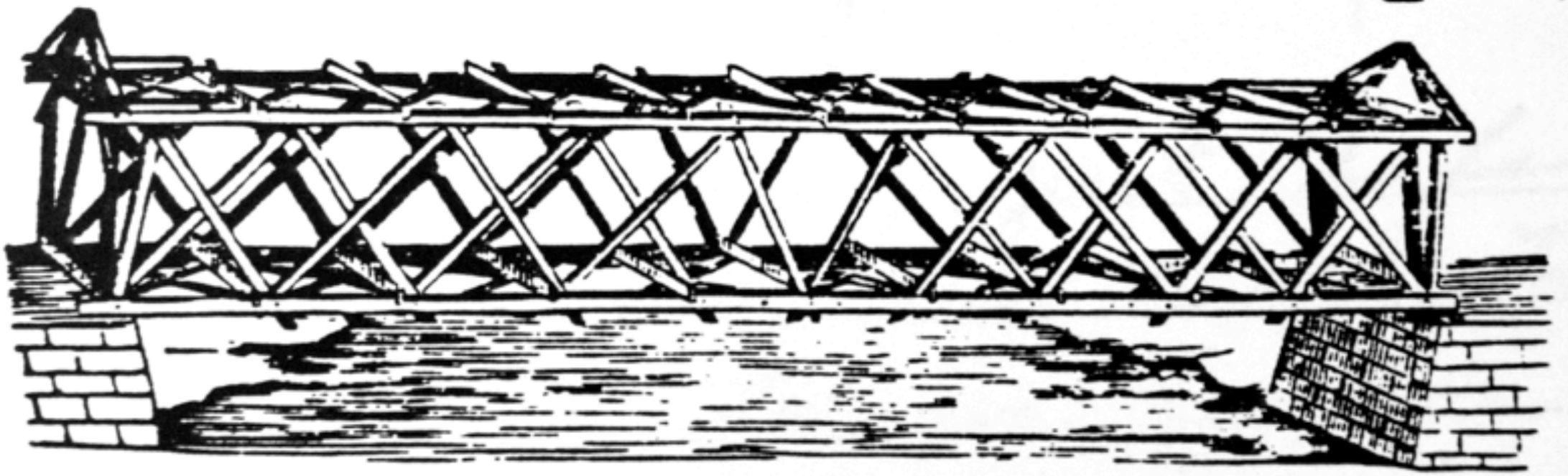
TIPPECANOE CITY MIAMI CO. OHIO.

STRIGRIDGE & CO. LITH. CINCINNATI O.

Pacific Bridge Co.

MANUFACTURERS AND BUILDERS OF ALL KINDS OF

Wooden and Iron Bridges,



And Heavy Frame Work; Also Agents for

Smith's Patent Truss Bridge,

Works at South Point Mill, Berry St.. bet. 3d and 4th, San Francisco.

Office in Wilcox Block, Oakland.

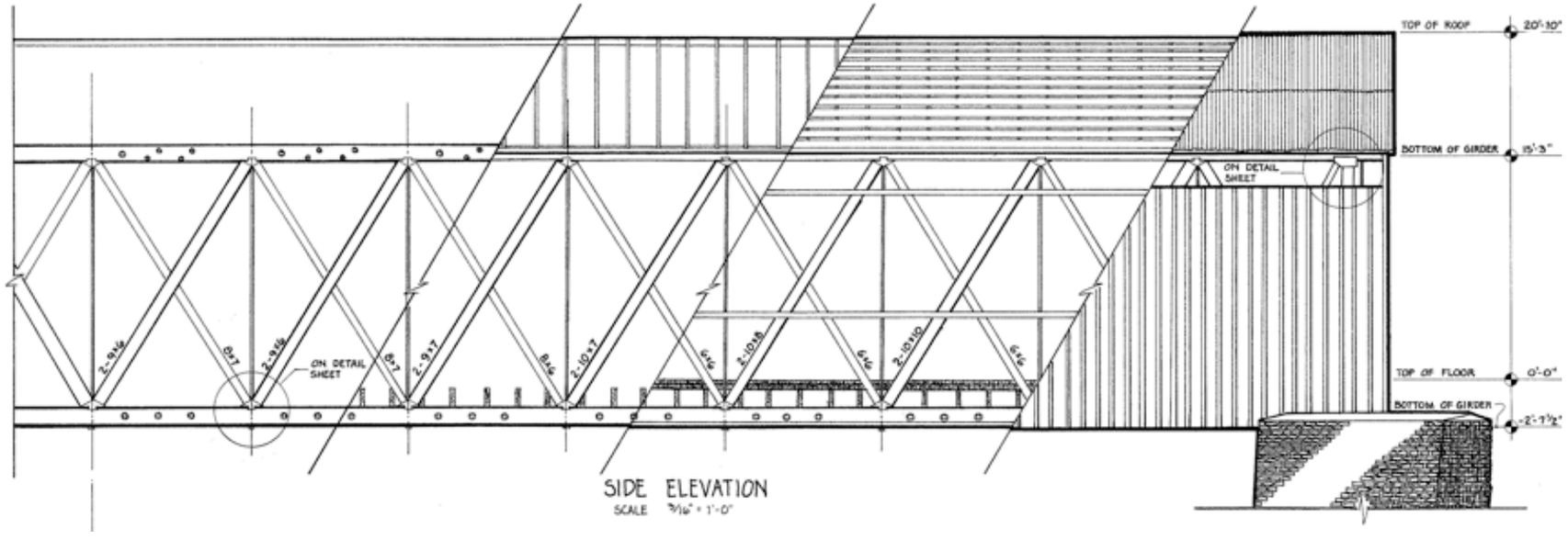
W. H. GORRILL, President. C. H. GORRILL, Sec'y & Treas.

(David Simmons collection)

Not All Smith Bridge Co. Bridges are Smith Trusses

(http://bridgehunter.com/oh/montgomery/feedwire-road/)

Feedwire Road Bridge
(1870)
Montgomery Co., OH

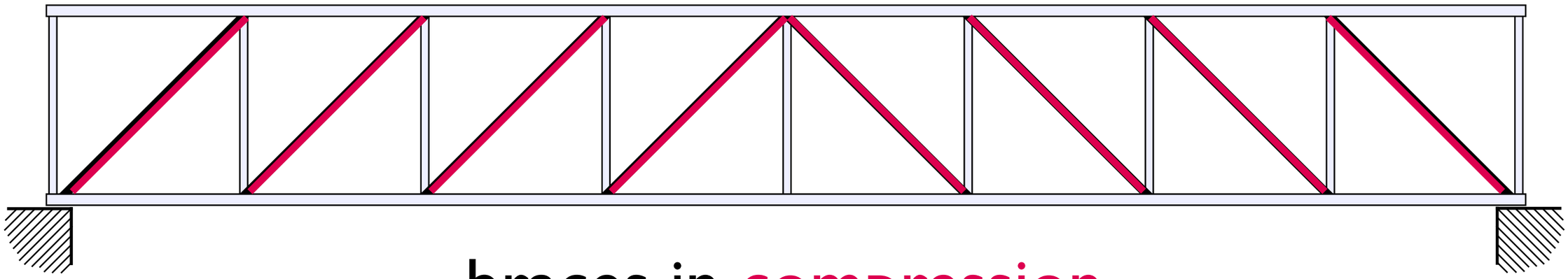


(HAER IN-50)

Cumberland Bridge
(1879)
Grant Co., IN

Truss Types

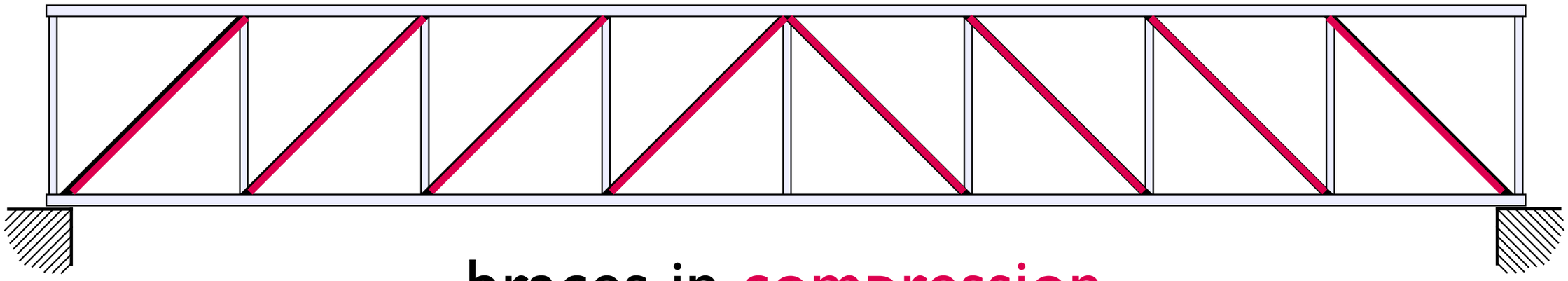
Multiple Kingpost



braces in compression

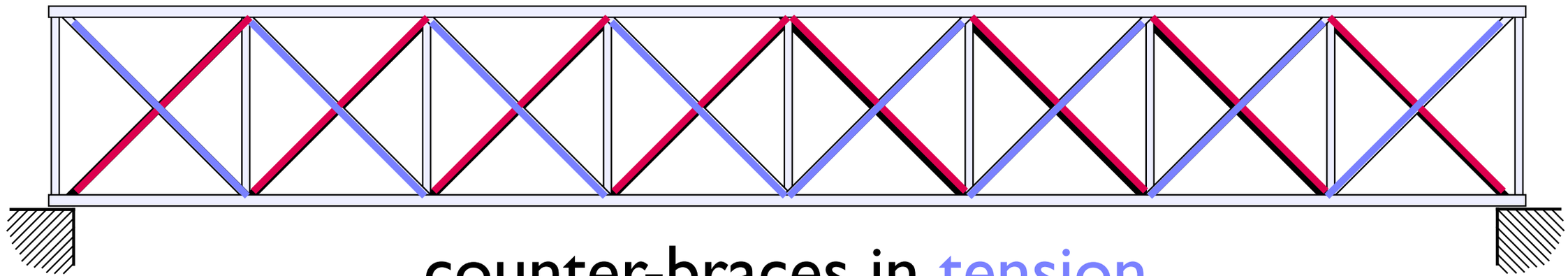
Truss Types

Multiple Kingpost



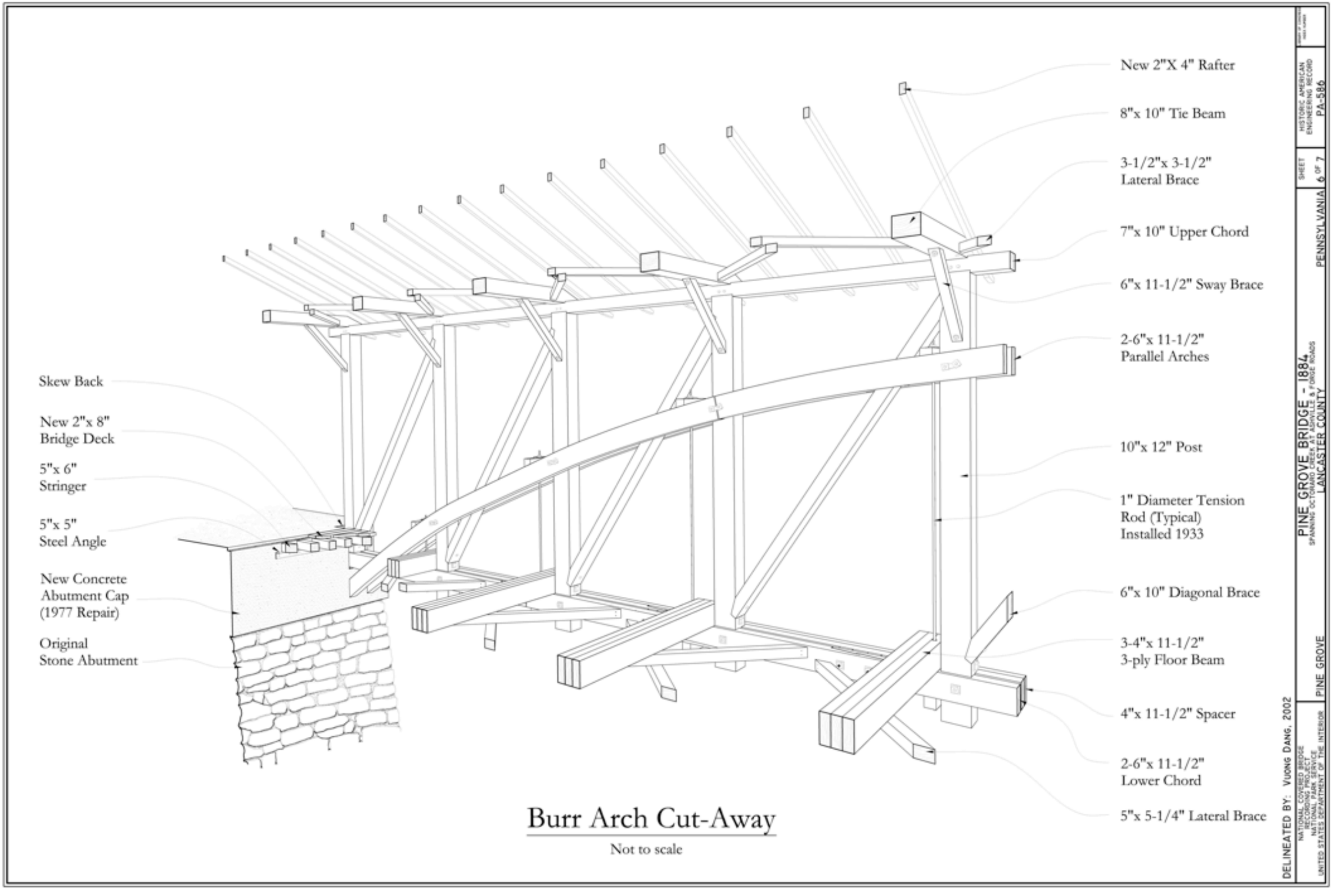
braces in compression

Multiple Kingpost with Counter Braces



counter-braces in tension

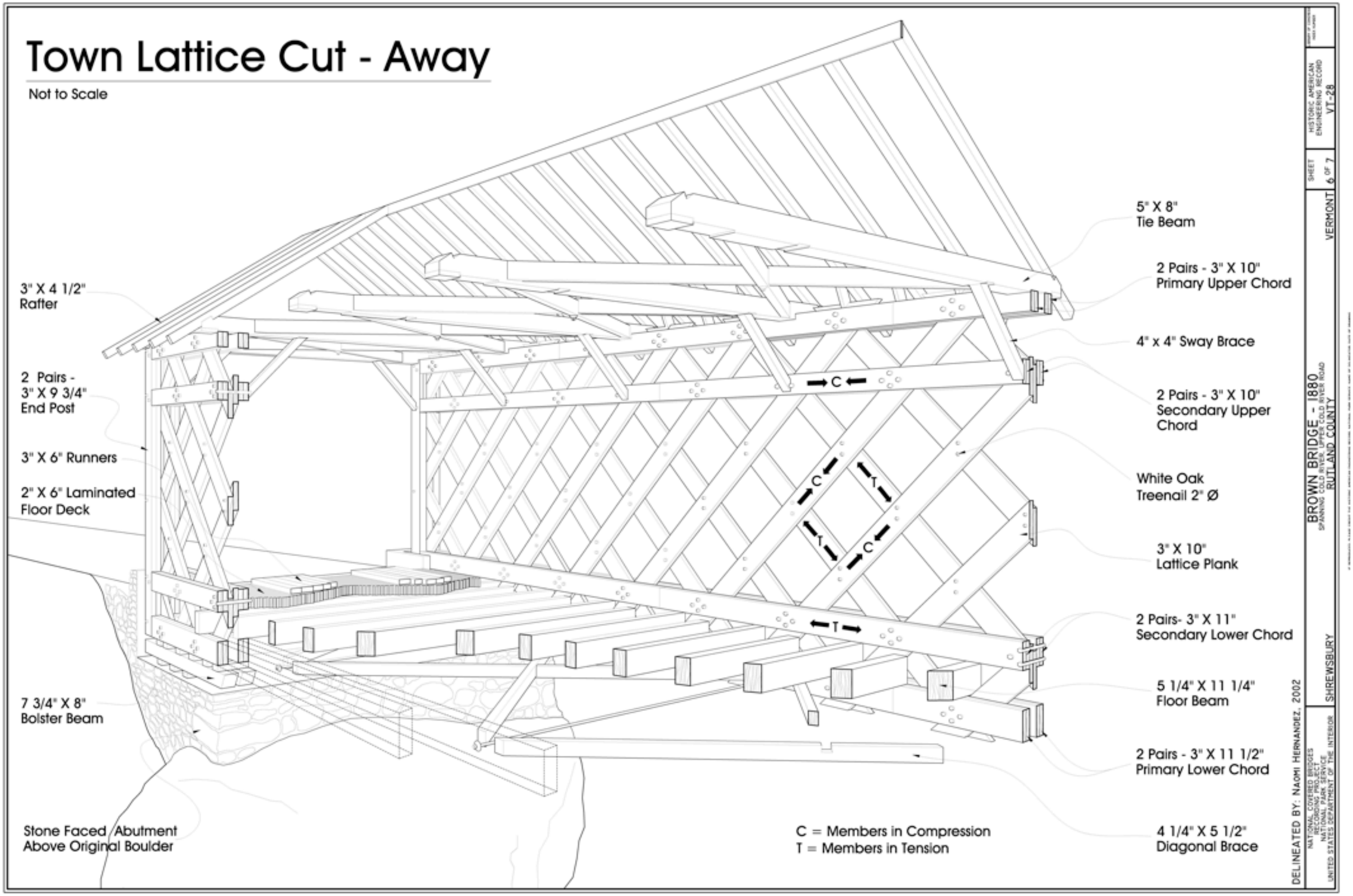
Burr Arch-Truss



Pine Grove Bridge (1884) Chester Co., PA

(HAER PA-586)

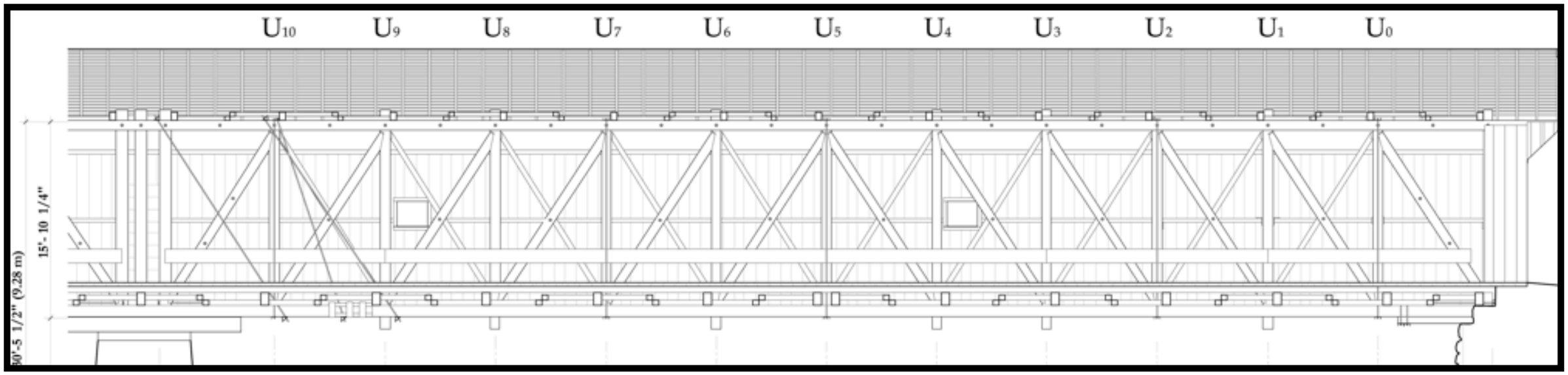
Town Lattice

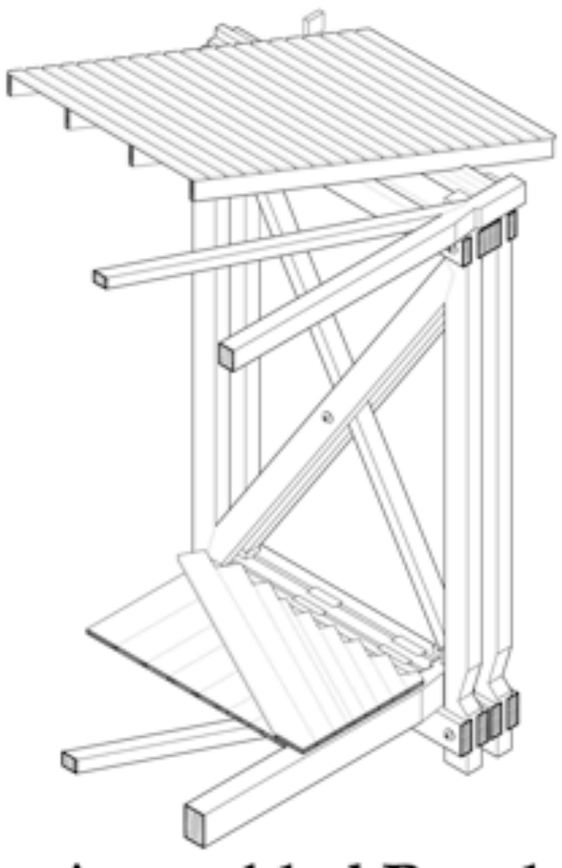


Brown Bridge (1880) Rutland Co., VT

(HAER VT-28)

Long Truss

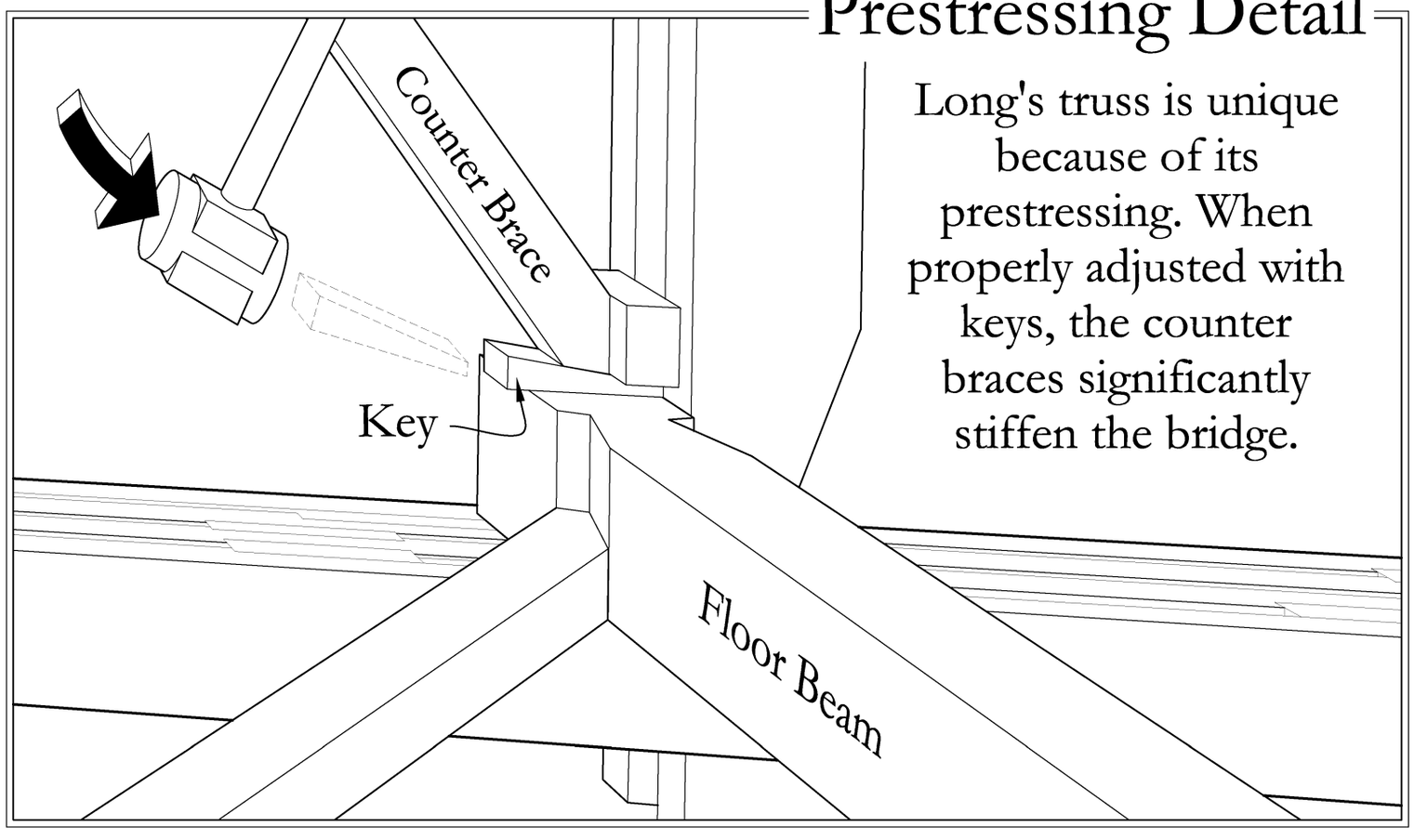




Assembled Panel

Prestressing Detail

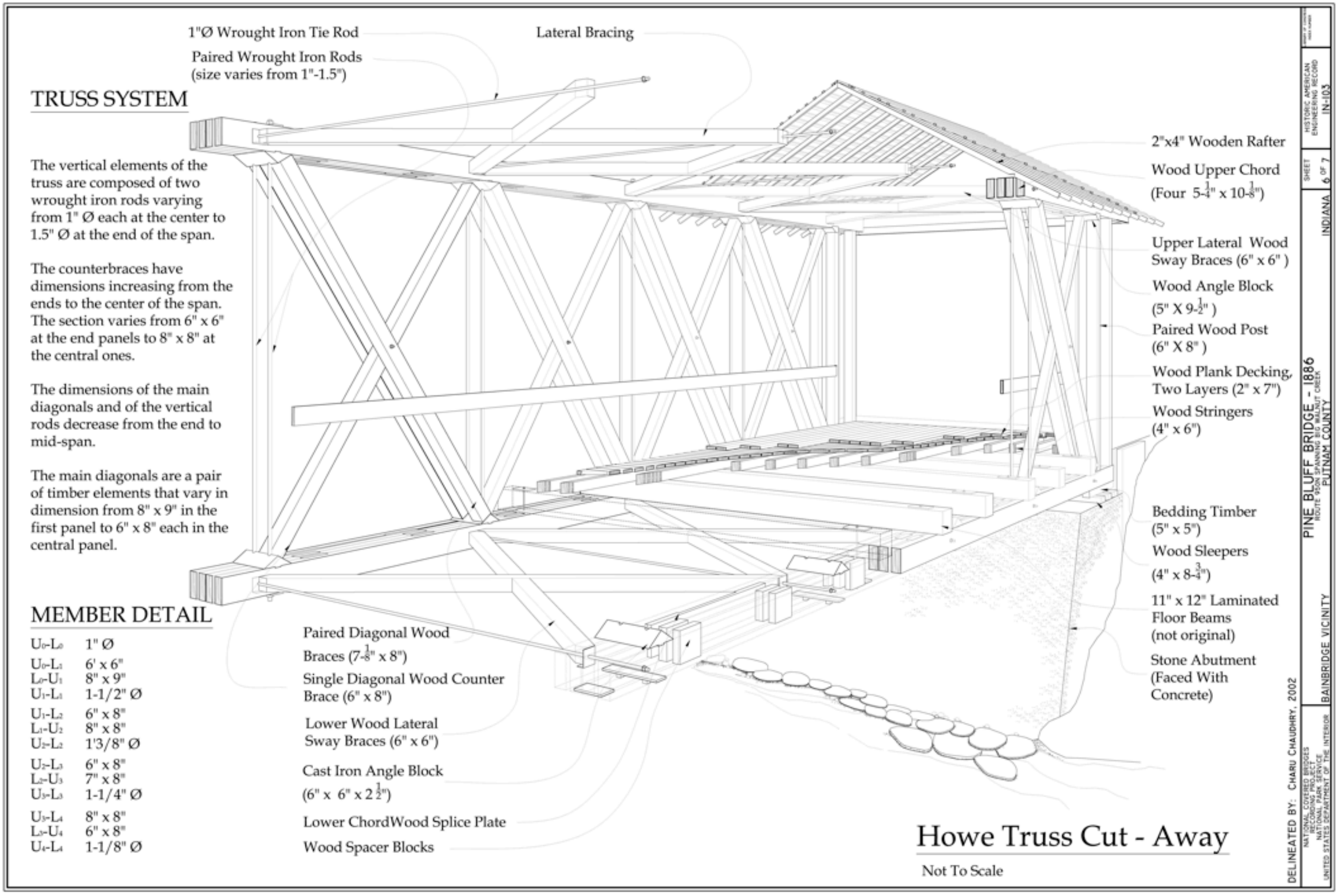
Long's truss is unique because of its prestressing. When properly adjusted with keys, the counter braces significantly stiffen the bridge.



Eldean Bridge (1860) Miami Co., OH

(HAER OH-122)

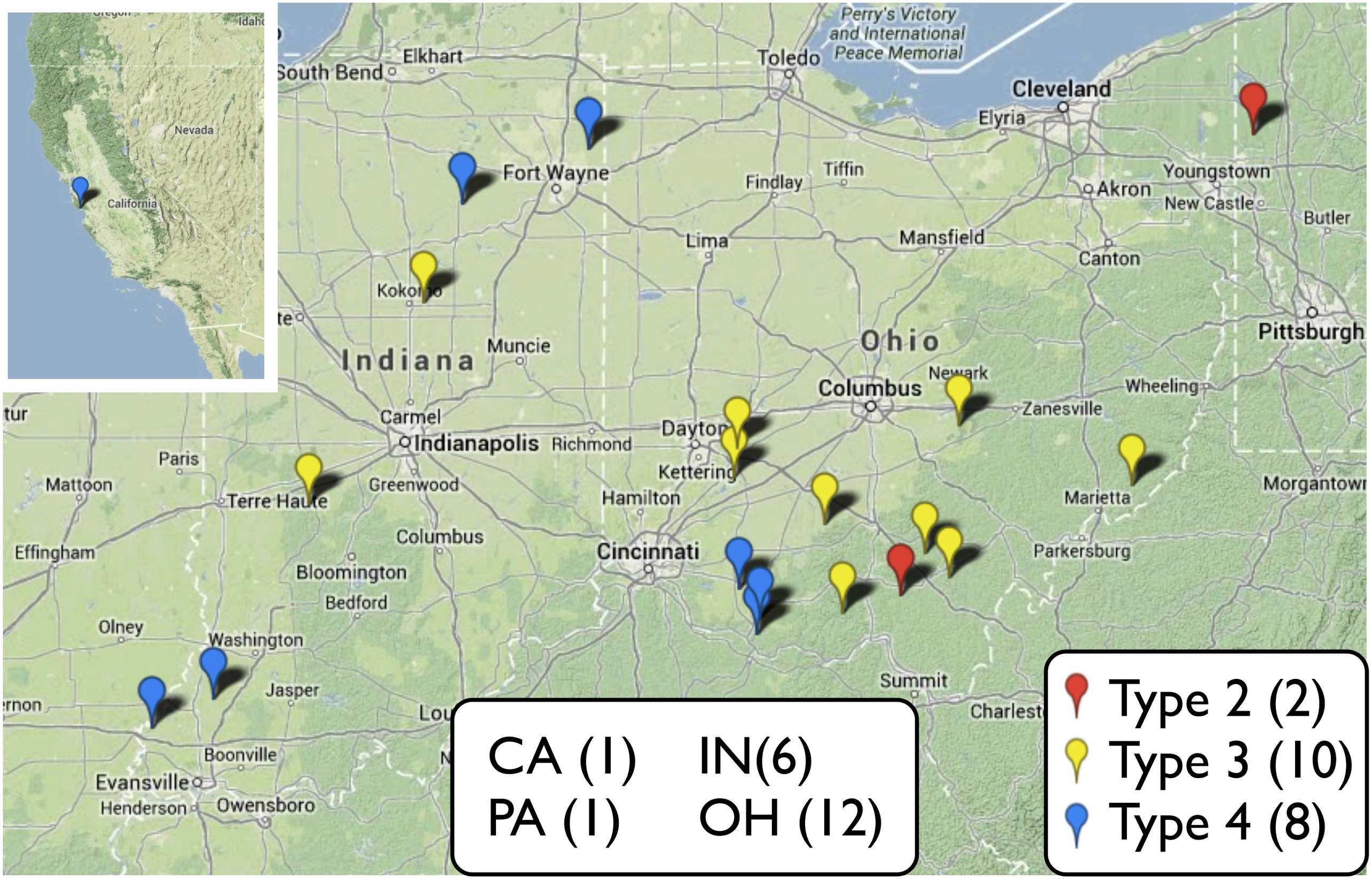
Howe Truss



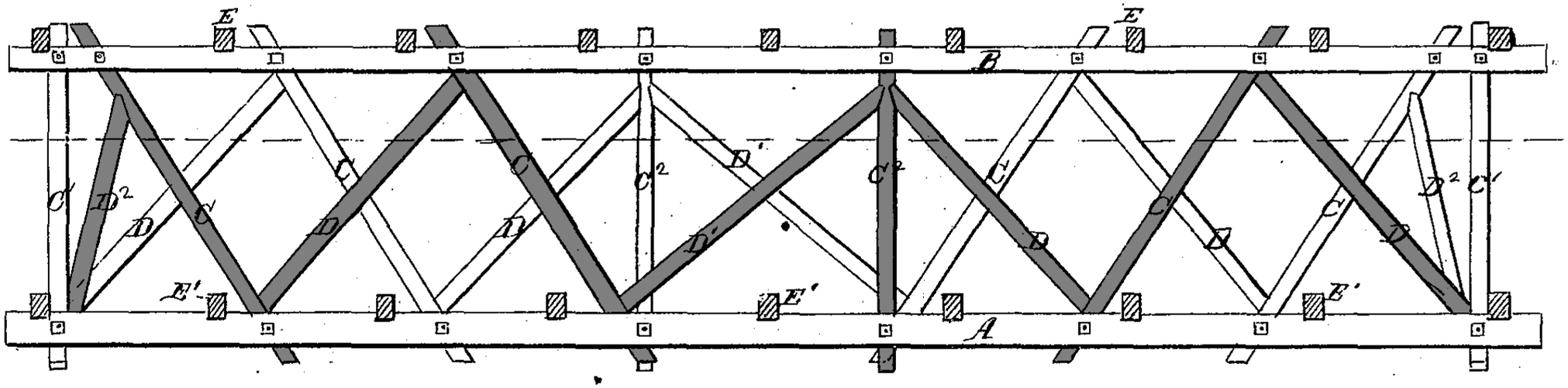
Pine Bluff Bridge (1886) Putnam Co., IN

(HAER IN-103)

Twenty Surviving Smith Trusses (1868-1879)



Smith Truss Patents & Types



Type 1
1867 patent

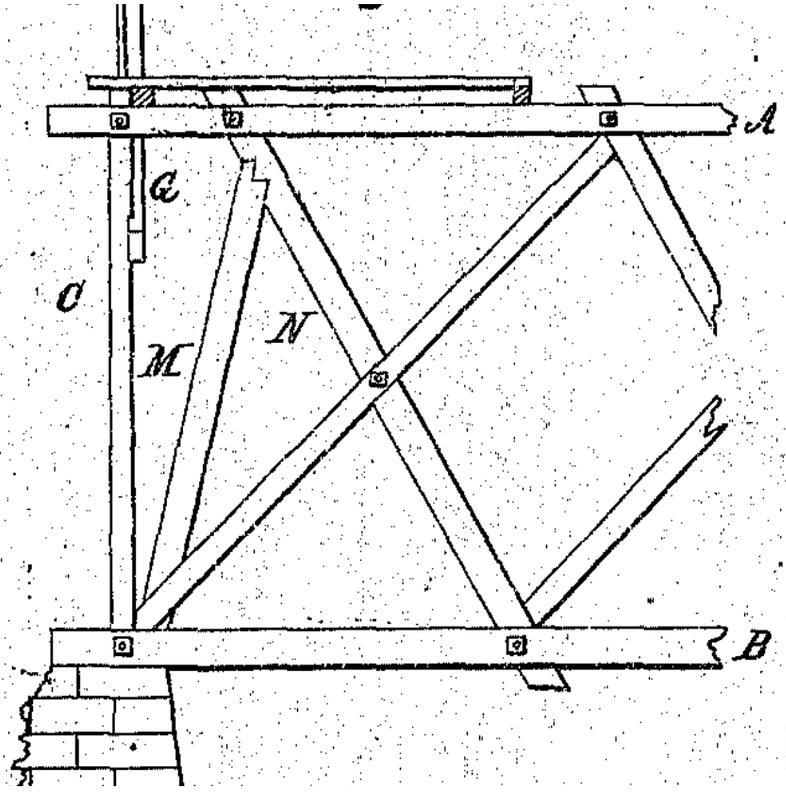
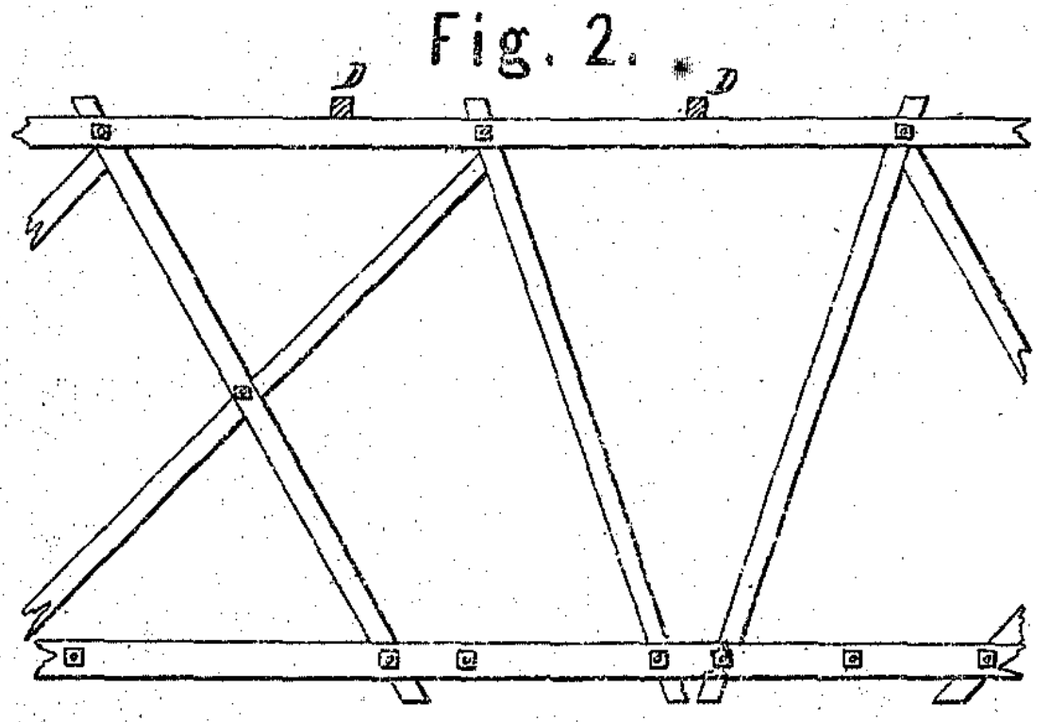
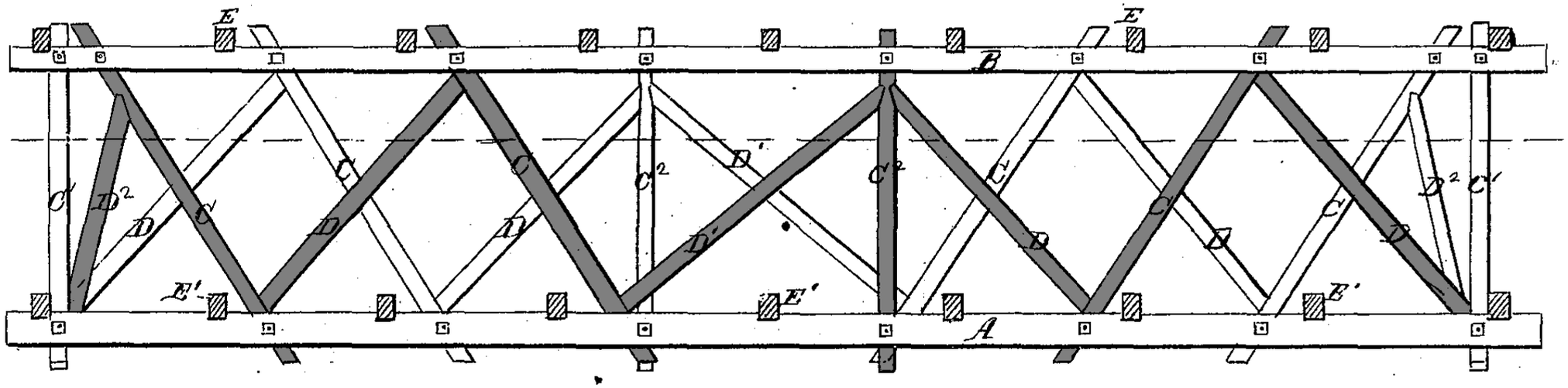


Fig. 2.



Type 2
1869 patent

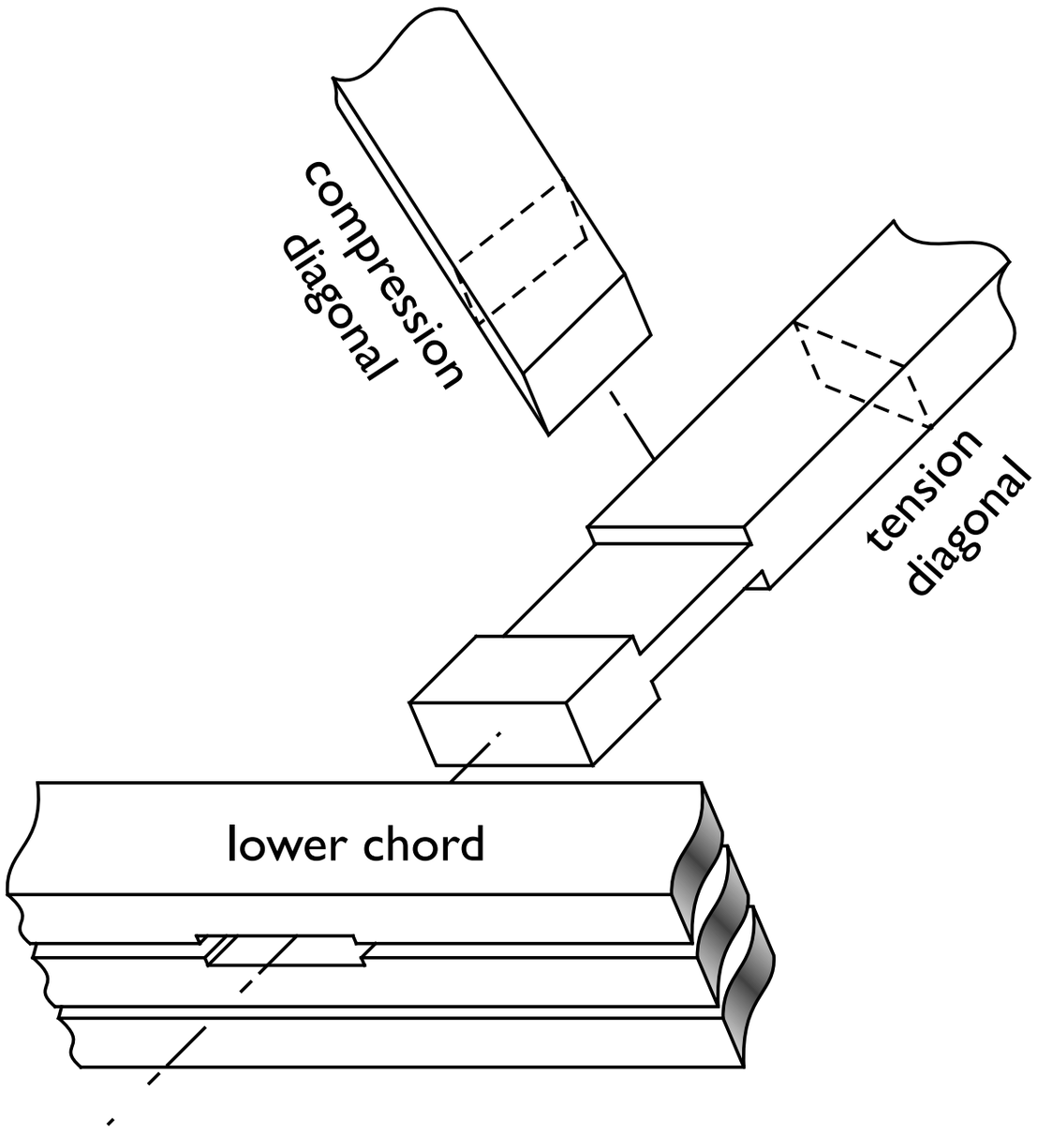
Smith Truss Characteristics

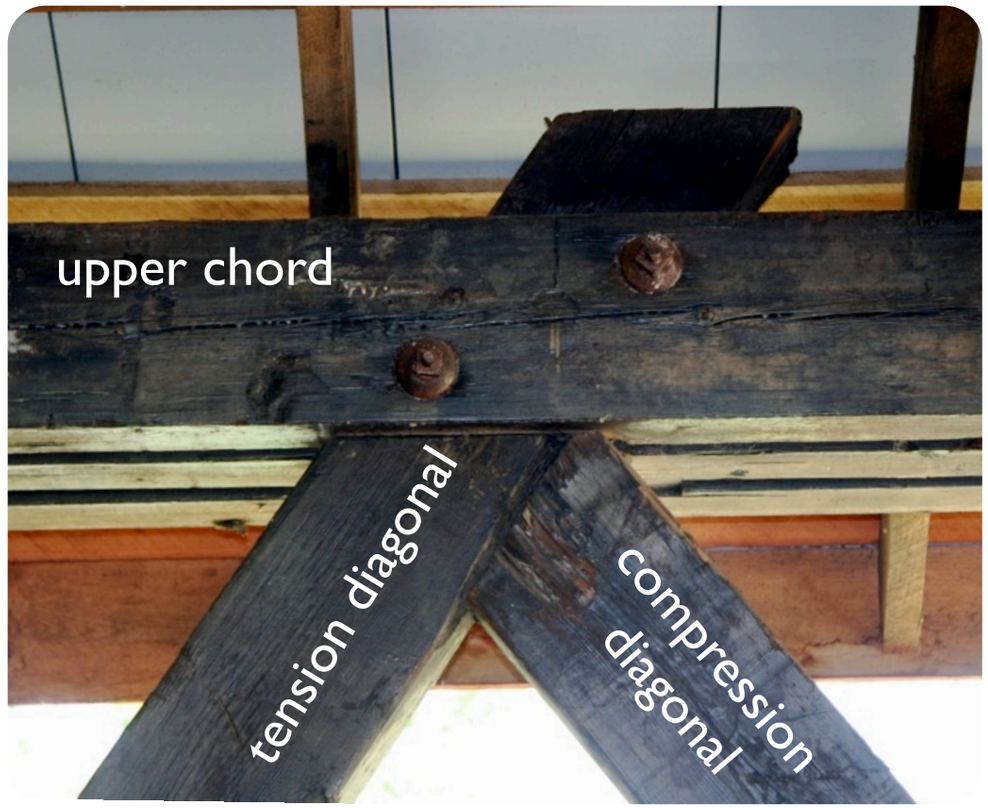


Type 1
1867 patent

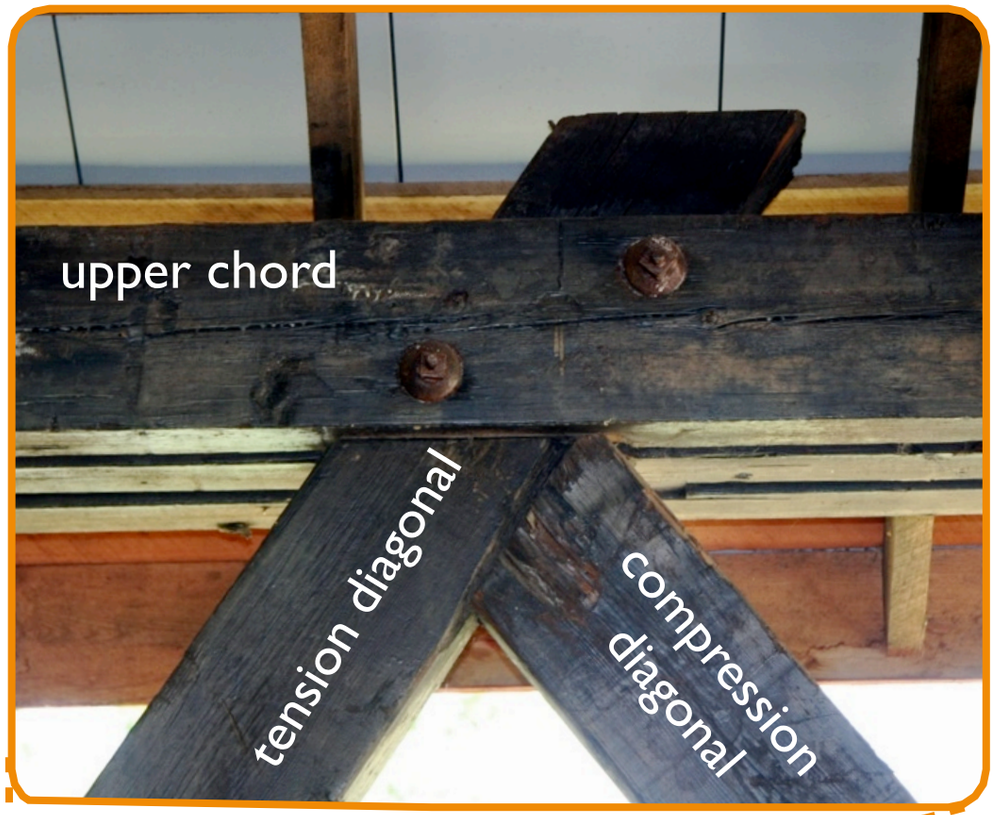
- No iron members
- Timber tension members
- Few or no vertical members
- Compression diagonals inclined at ~45°, Tension at ~60°
- Large diagonal timbers (e.g. 7”x11”)
- Compression diagonals bear against tension diagonals
- Requires independent planes of diagonals
- Critical tension diagonal to chord connection

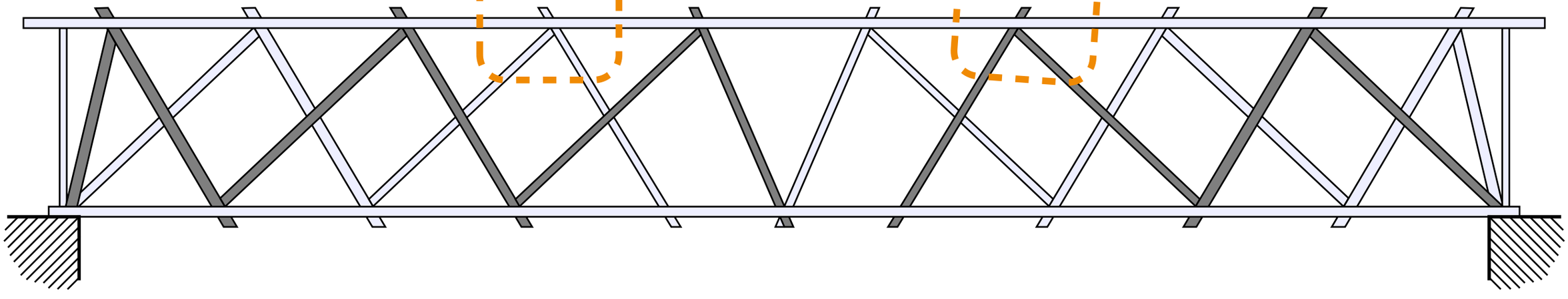
Typical Connection



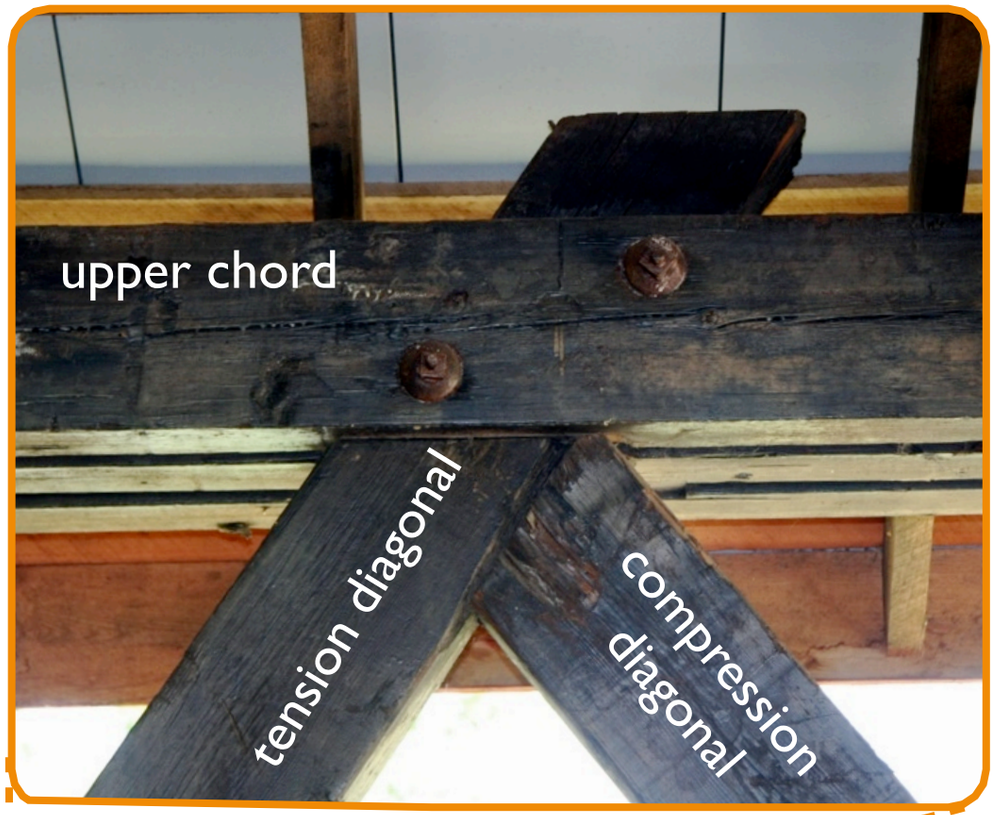


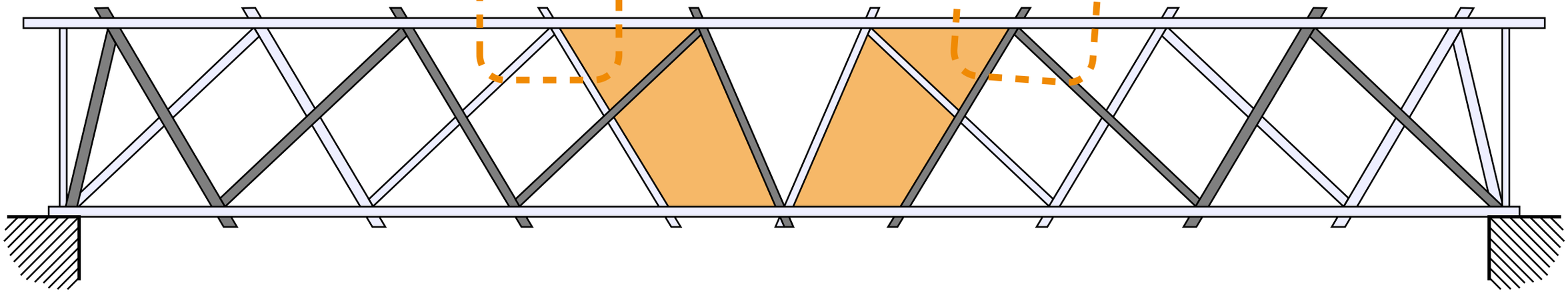
Smith Truss: Type 2





Smith Truss: Type 2





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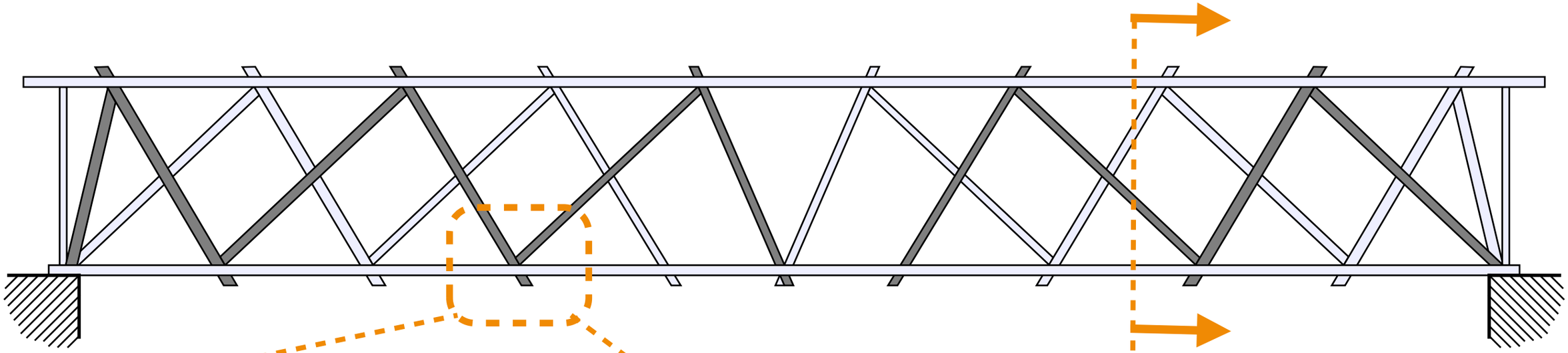
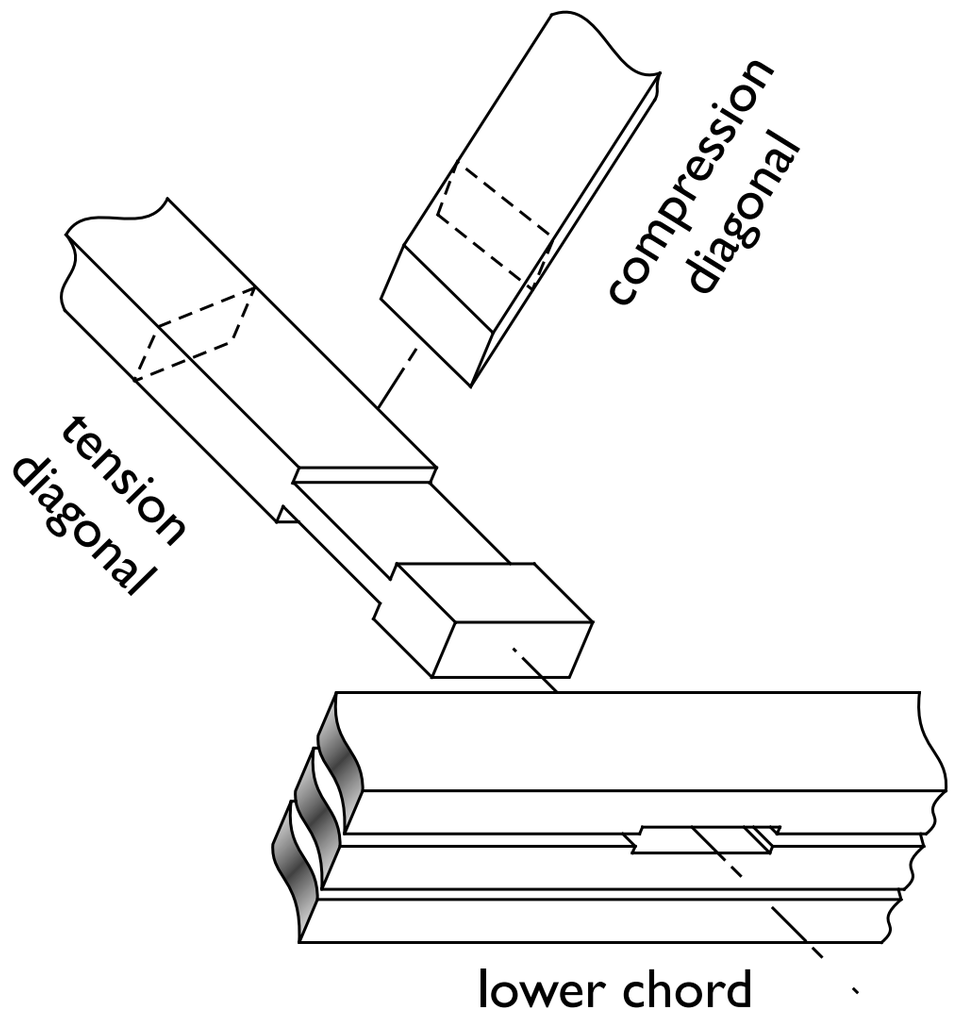
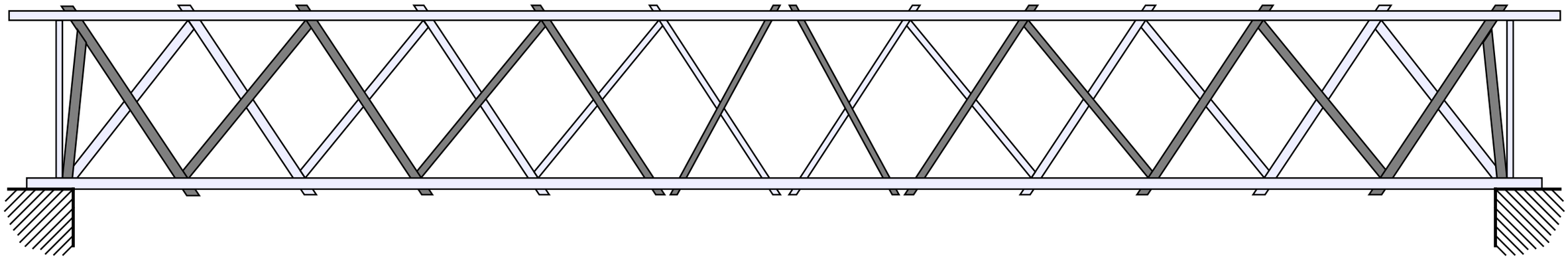
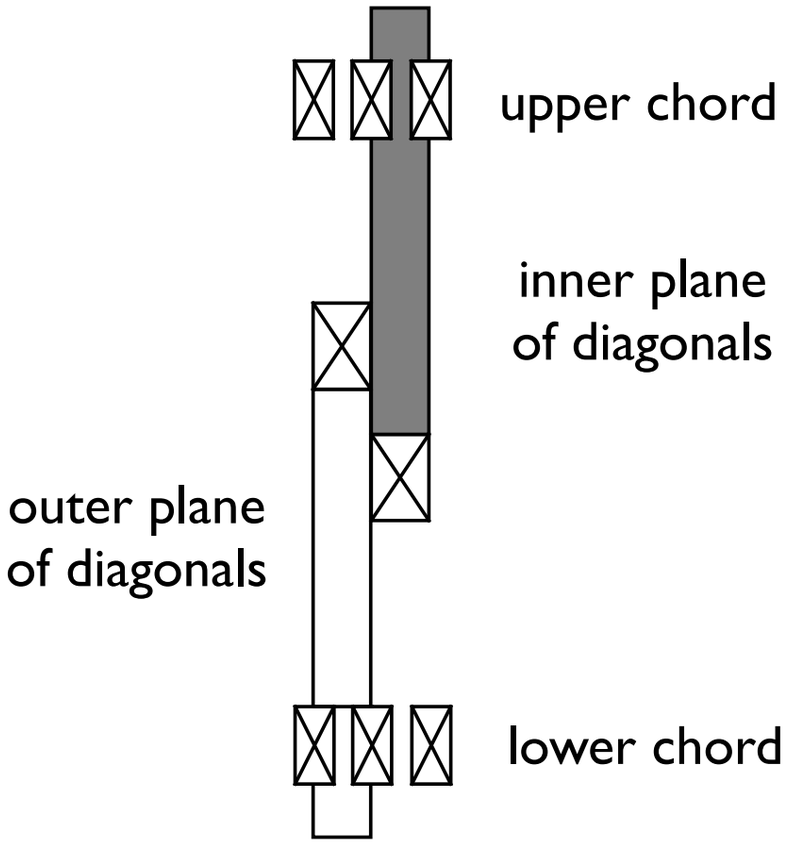




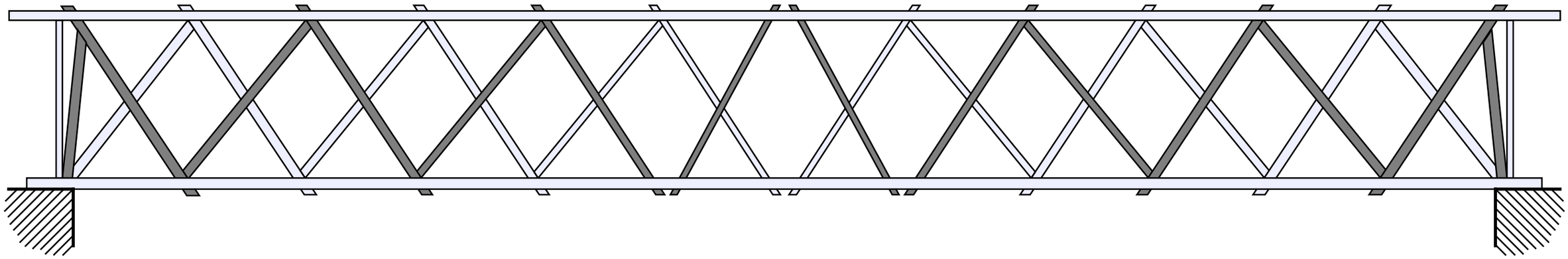
Smith Truss: Types 3 & 4



Type 3:
3 chord timbers



Smith Truss: Types 3 & 4



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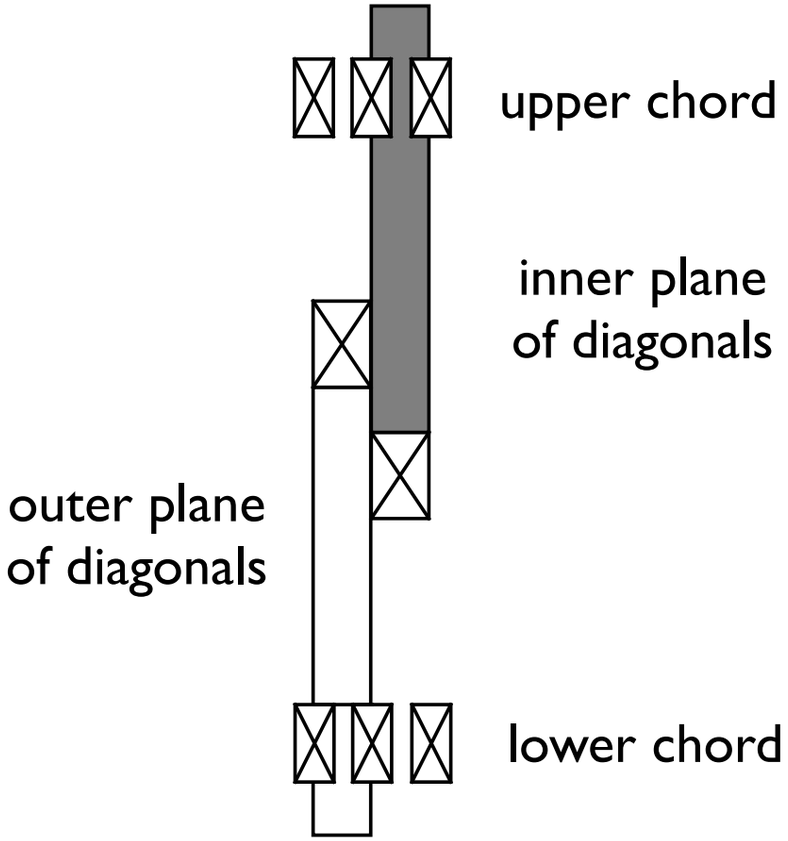
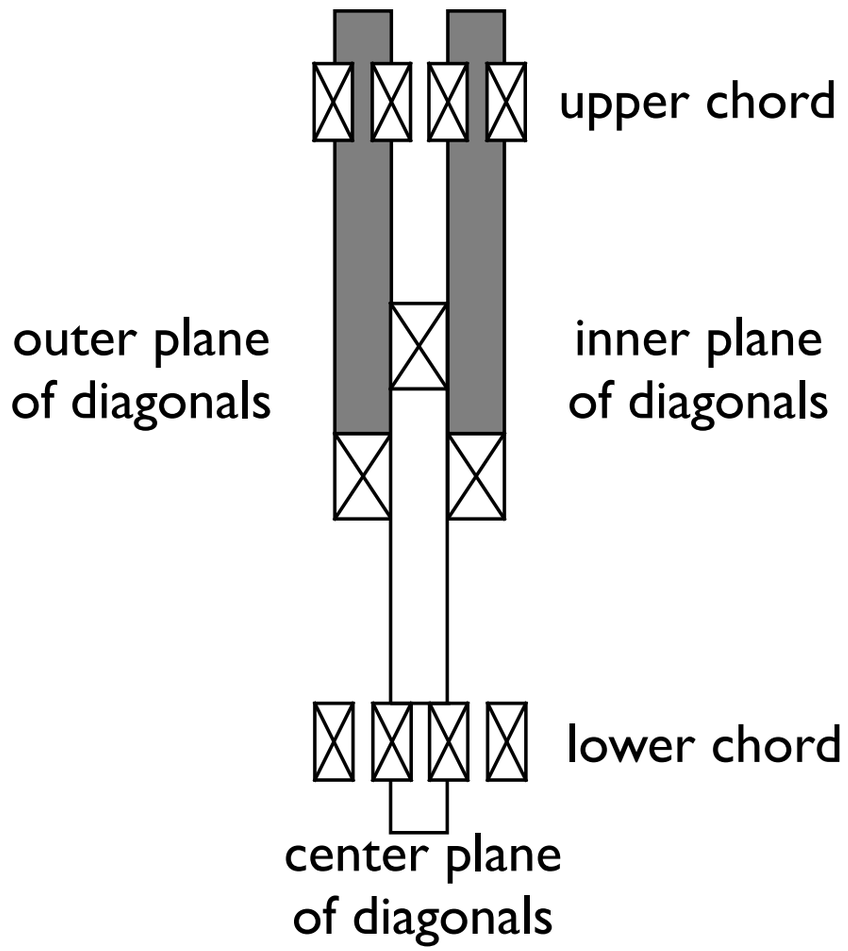
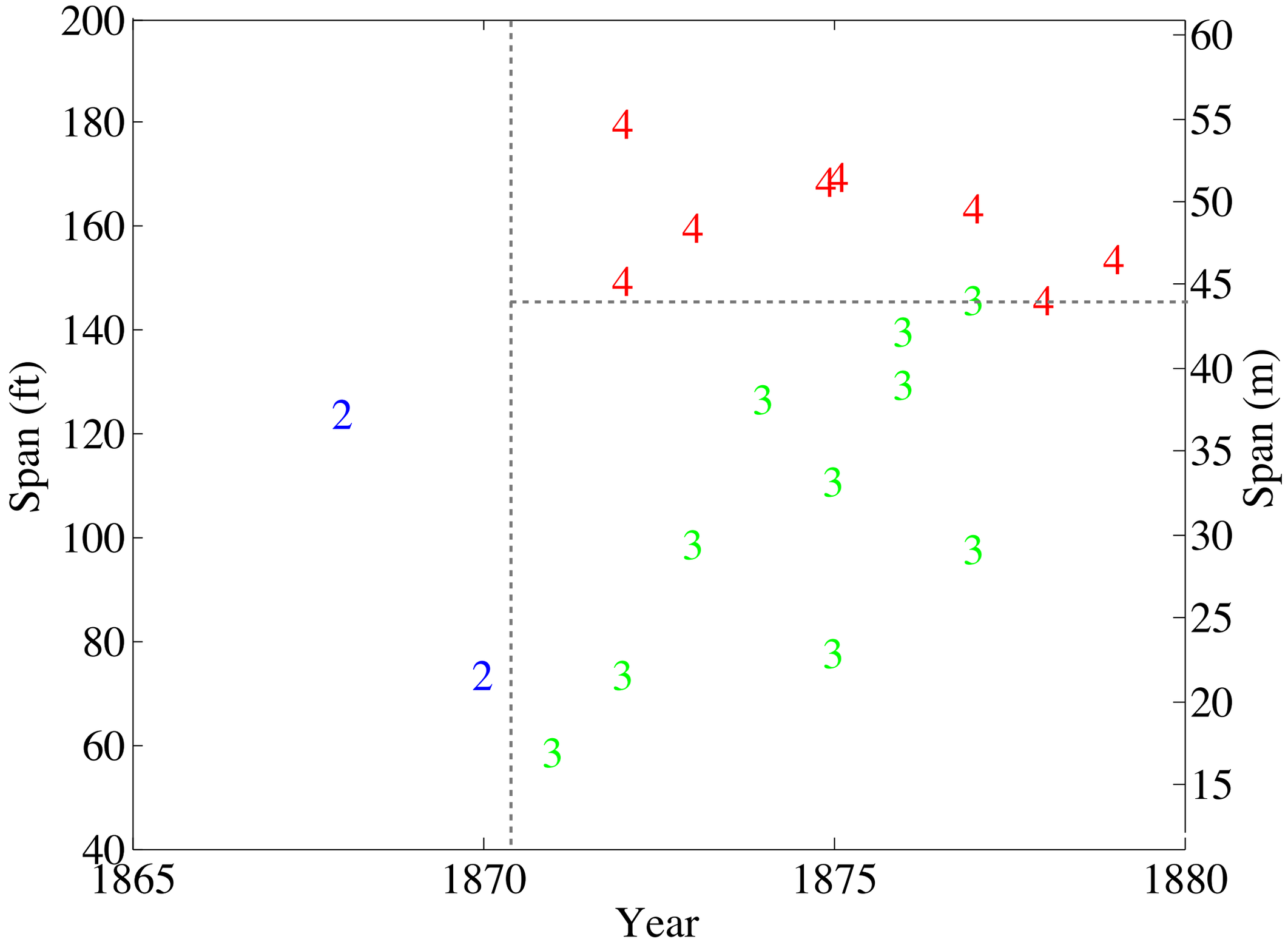
3 chord timbers



Type 4:
4 chord timbers



Twenty Surviving Smith Trusses (1868-1879)



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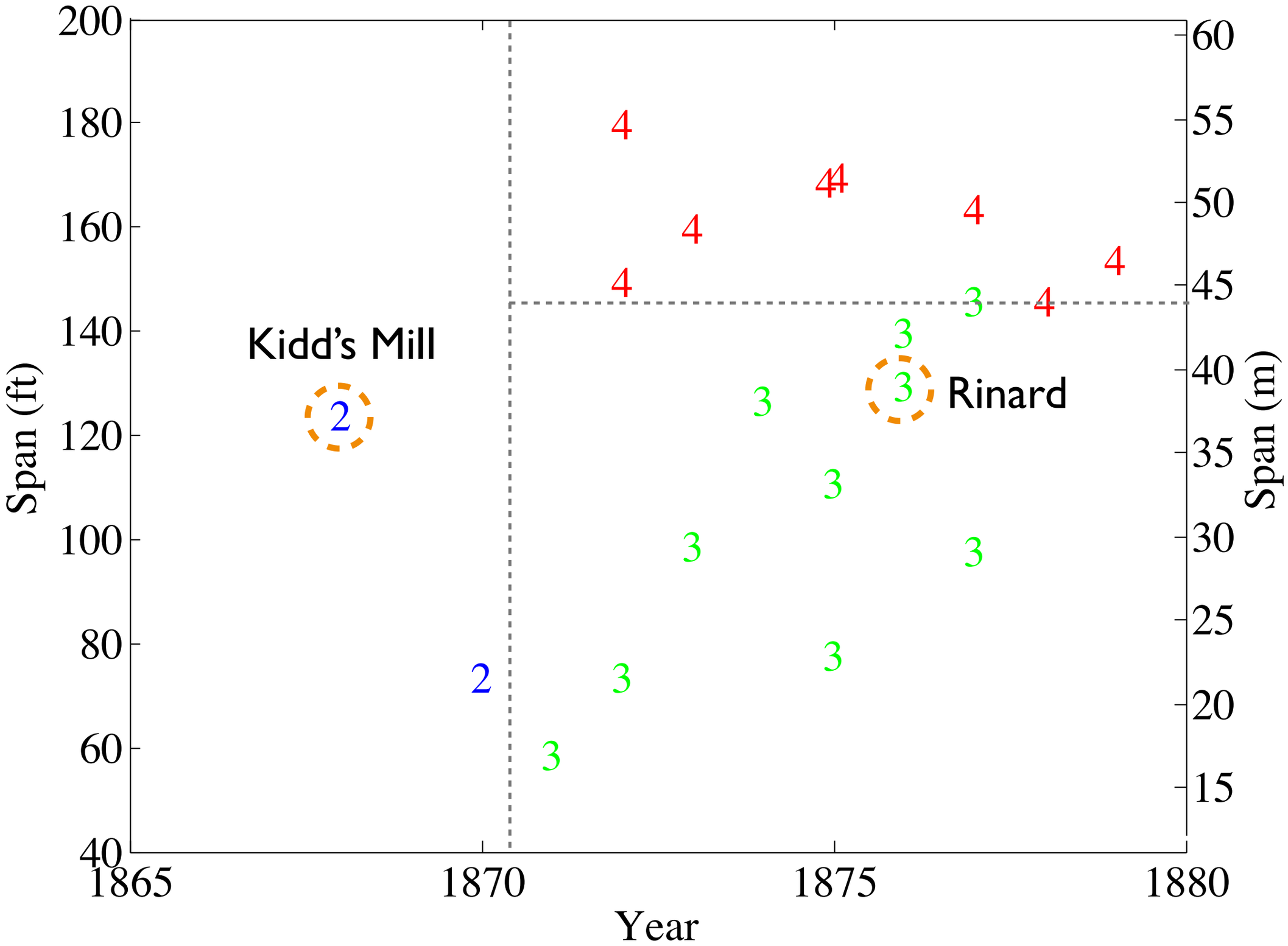


Type 2 (2)
Type 3 (10)
Type 4 (8)

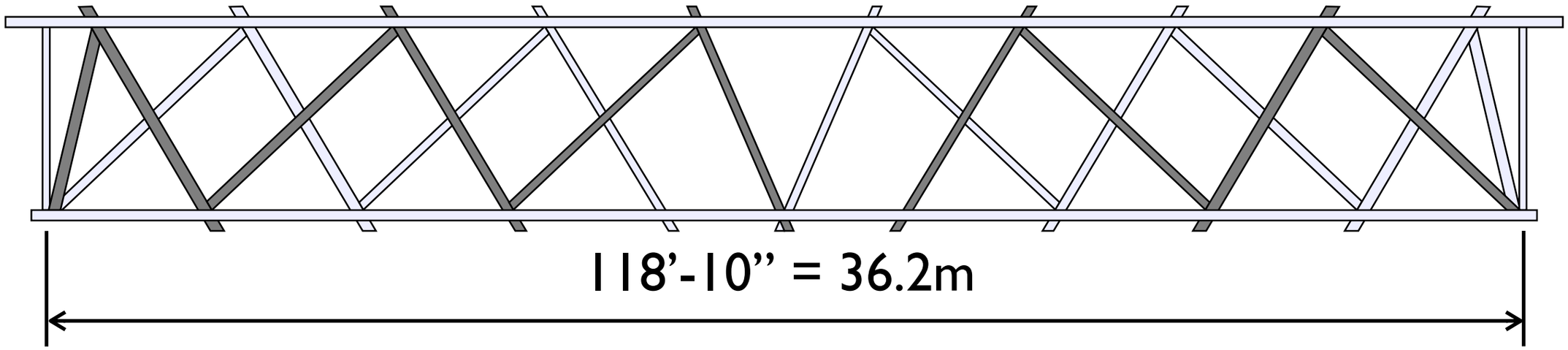
Kidd's Mill Bridge
Type 2, 1868

Rinard Bridge
Type 3, 1876

Kidd's Mill Bridge (1868, Type 2)

Kidd's Mill Bridge (1868, Type 2)

(HAER PA-622)



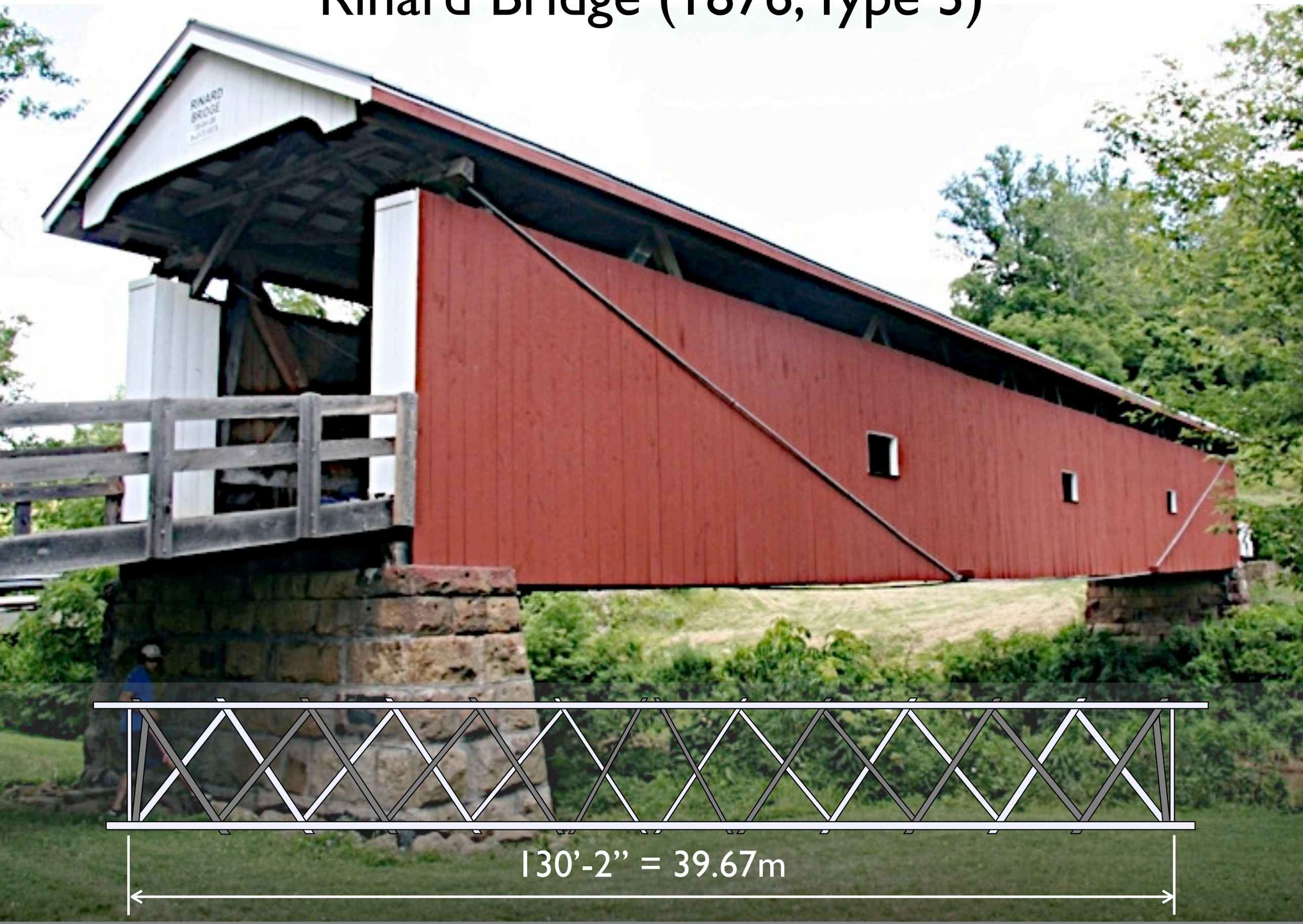
Rinard Bridge (1876, Type 3)

1933 photo

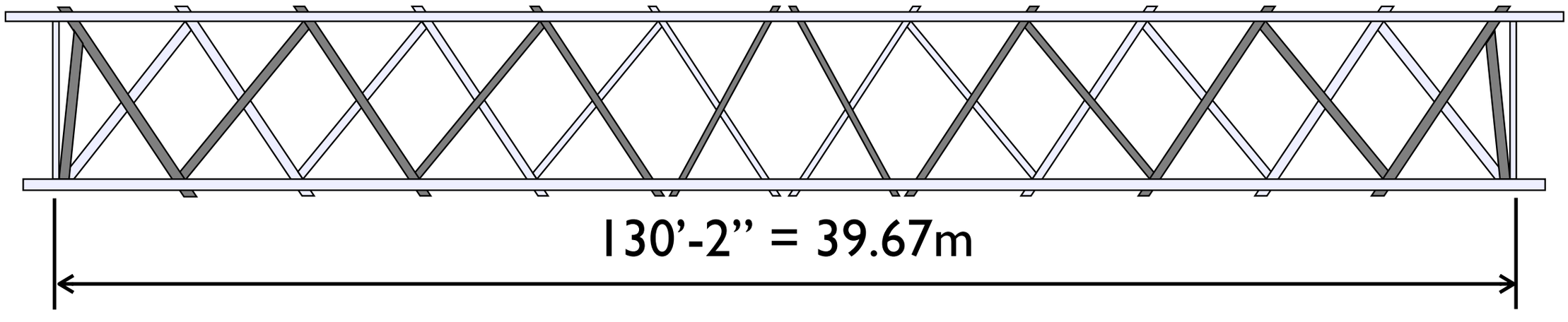
130’-2” = 39.67m

(Washington Co. OH Historical Society)

Rinard Bridge (1876, Type 3)



Rinard Bridge (1876, Type 3)

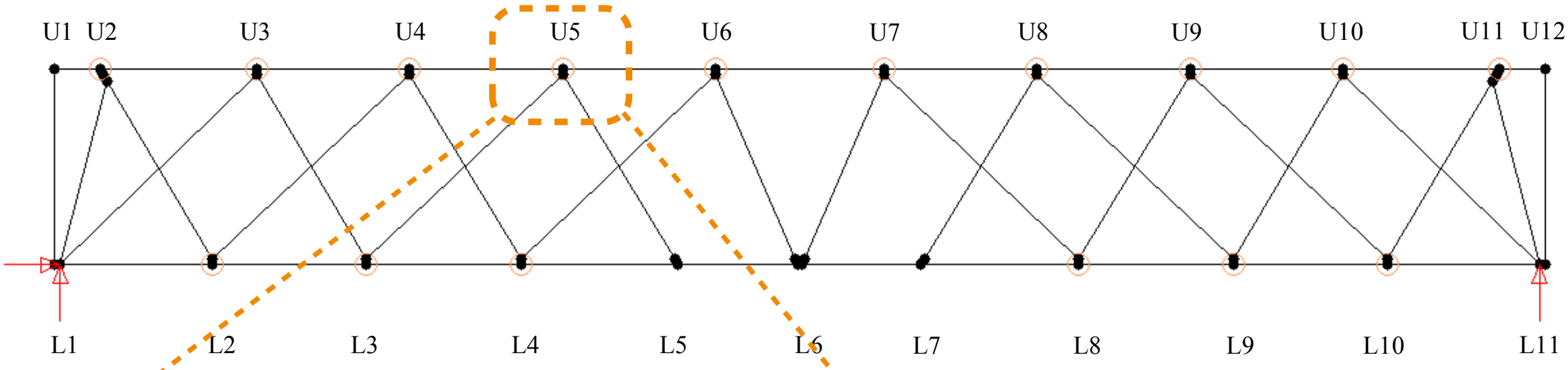


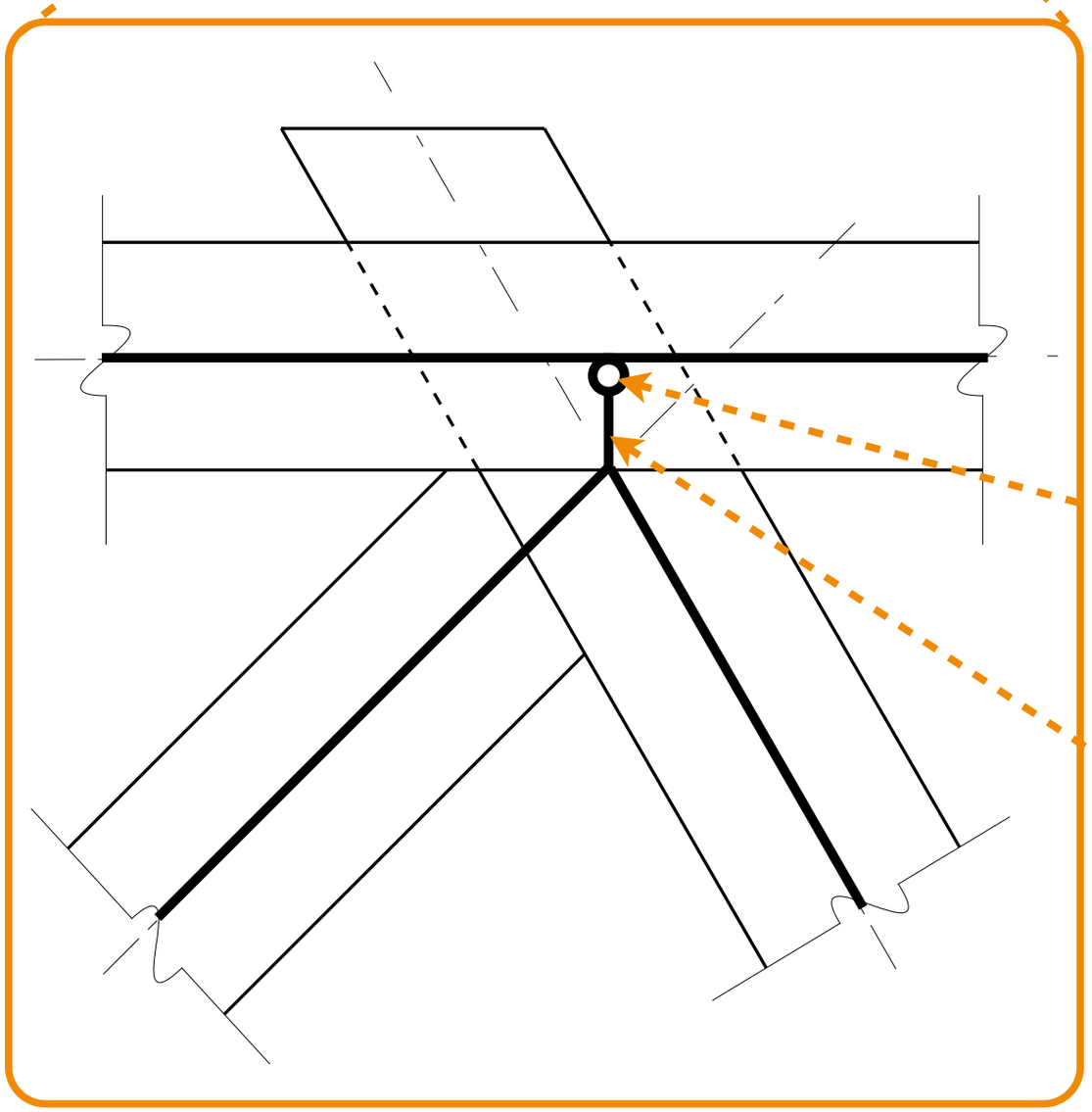
Structural Analysis Details

- Loads
  - Truss self-weight
  - Additional dead load
  - Uniform live load (65 psf, ~0.5 k/ft per truss)
  - Concentrated live load (10t vehicle, 5t per truss)
- Allowable stresses of 800 psi axial and bending

- Linear elastic truss analysis
  - Member forces and stresses
  - Deflections & Camber
- Connection forces

Kidd's Mill Bridge Truss Model



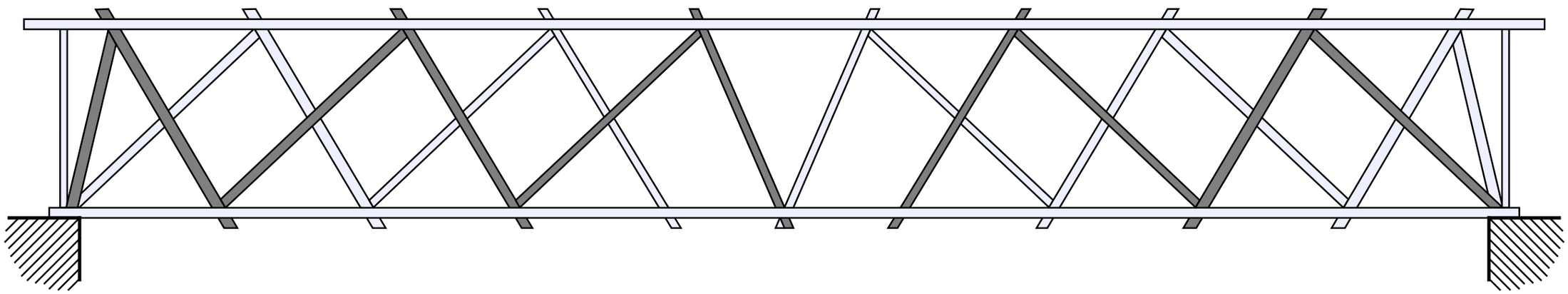


for calculation
of member forces

moment release

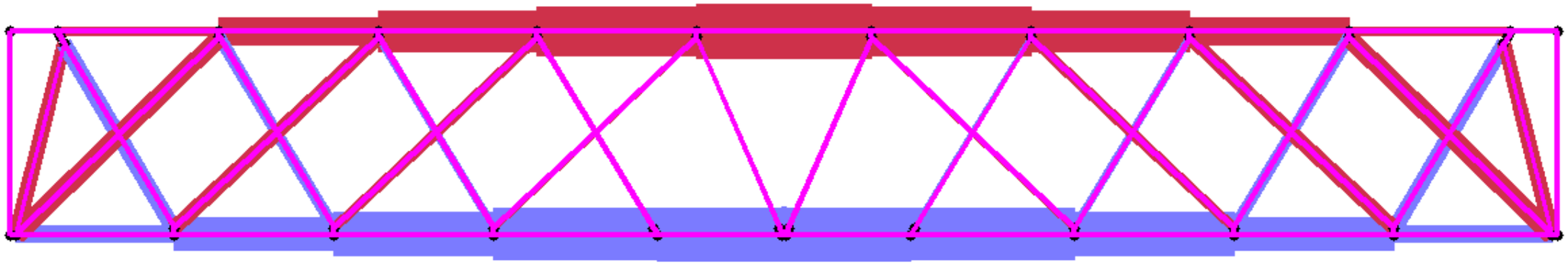
rigid offset

Kidd's Mill Bridge: Dead Load



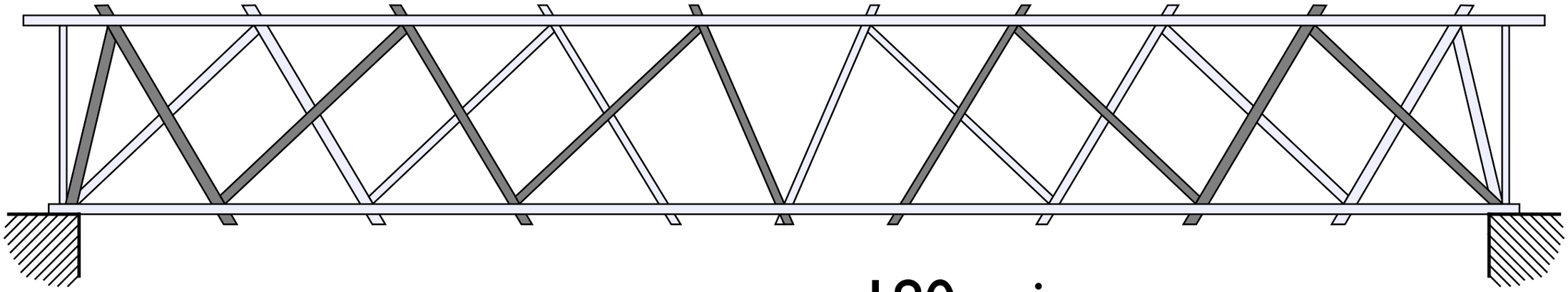
Diagonals vary in width

Axial

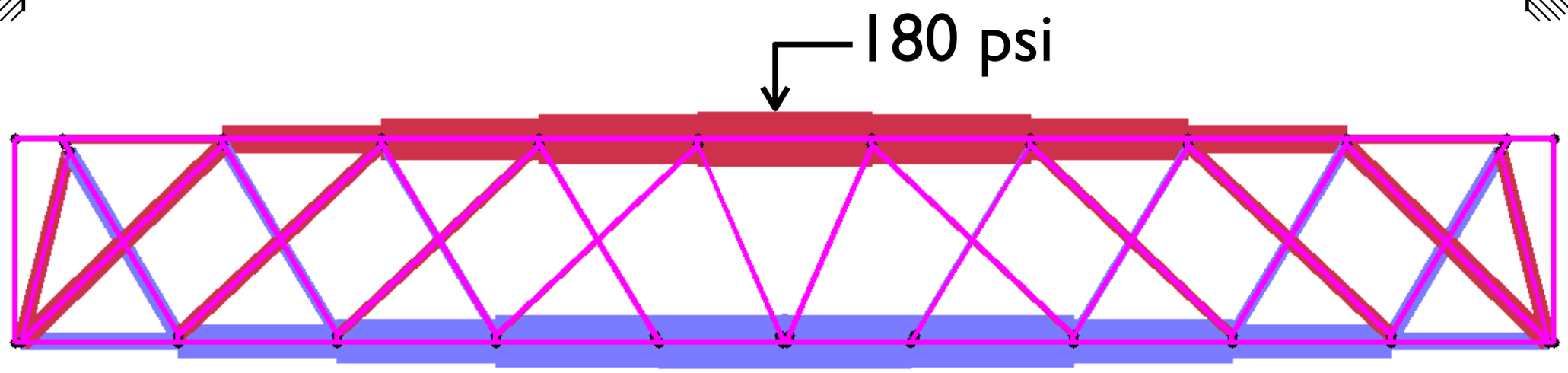


compression tension

Kidd's Mill Bridge: Dead Load

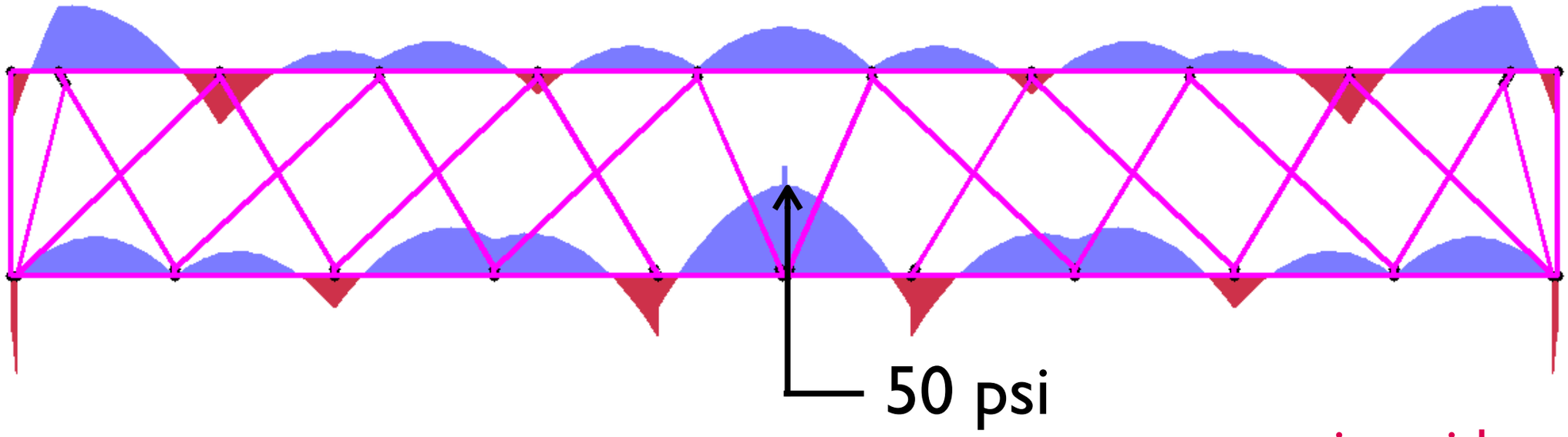


Axial



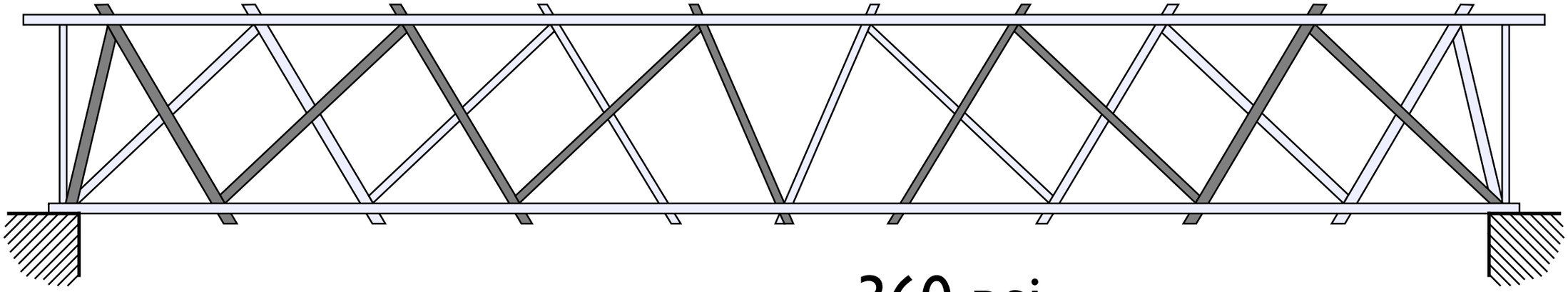
compression tension

Bending

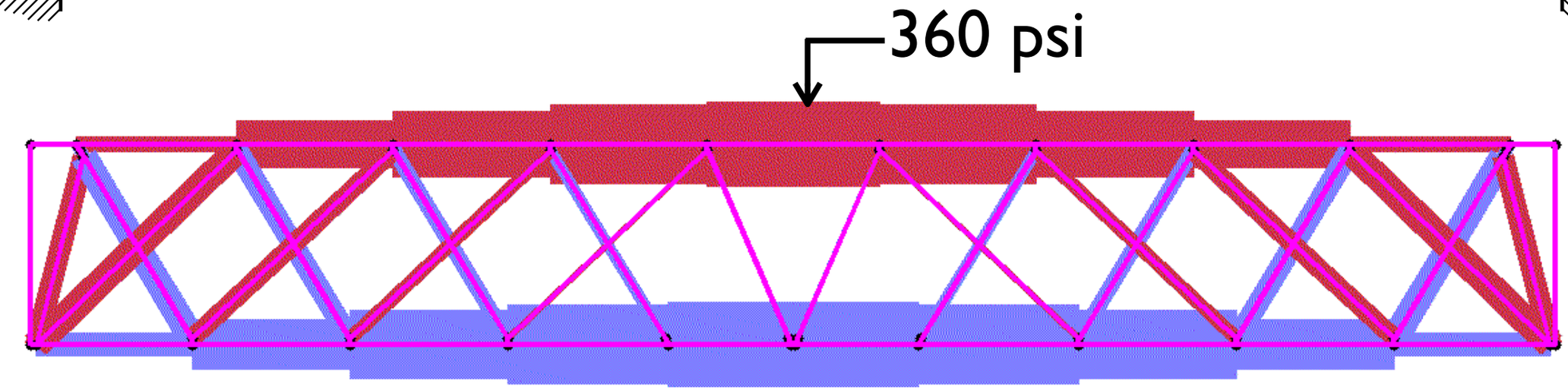


compression side

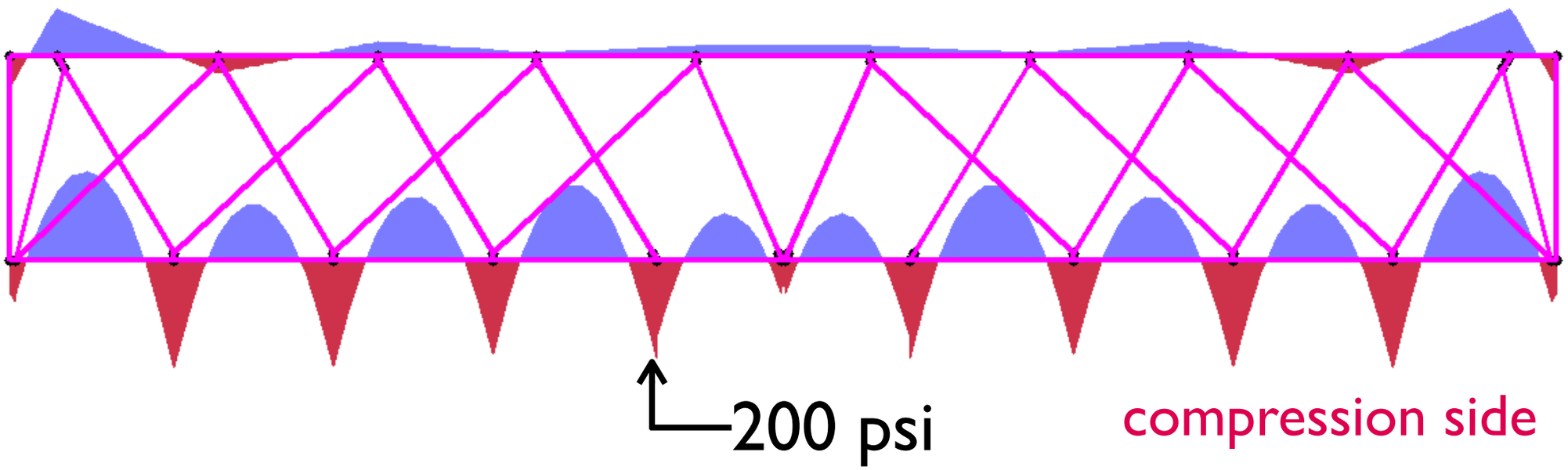
Kidd's Mill Bridge: Uniform Live Load



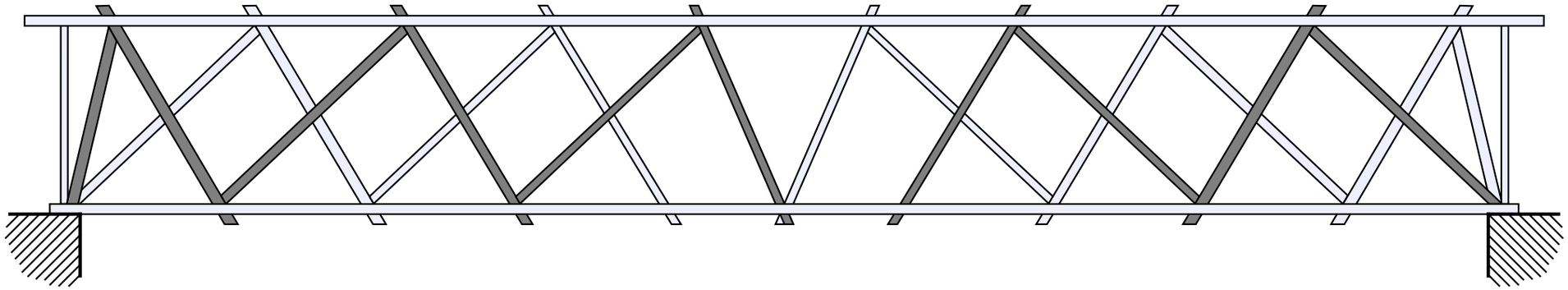
Axial



Bending



Kidd's Mill Bridge

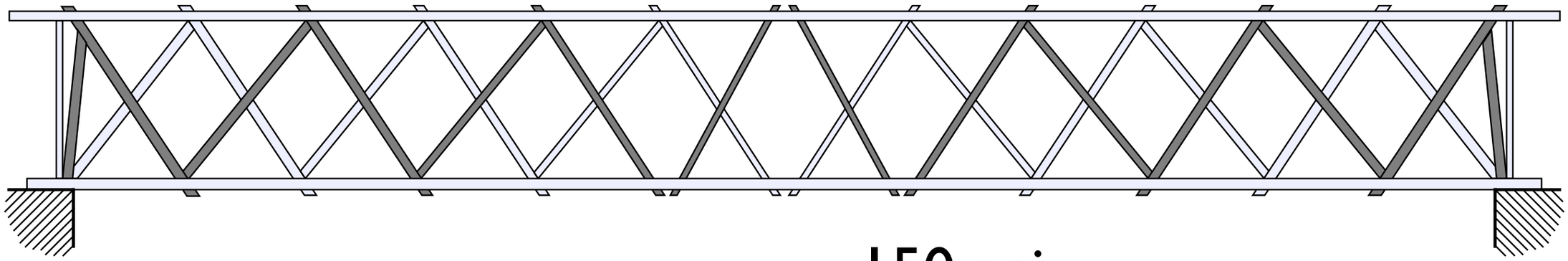


Maximum Chord Stresses at Midspan (psi)

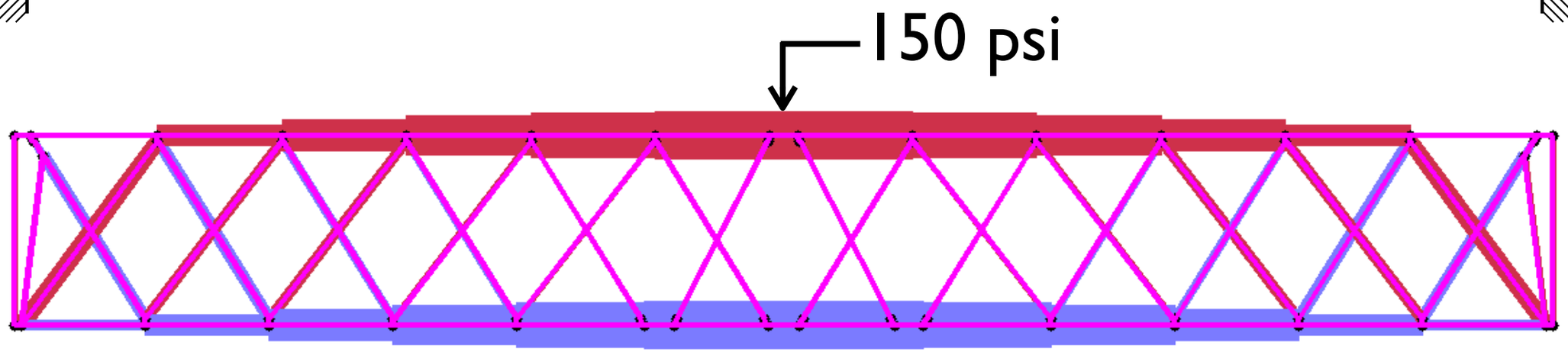
	Dead	Live	Total
Axial	180	360	540
Bending	50	200	250
Total	230	560	790 psi

Allowable Stress ≈ 800 psi

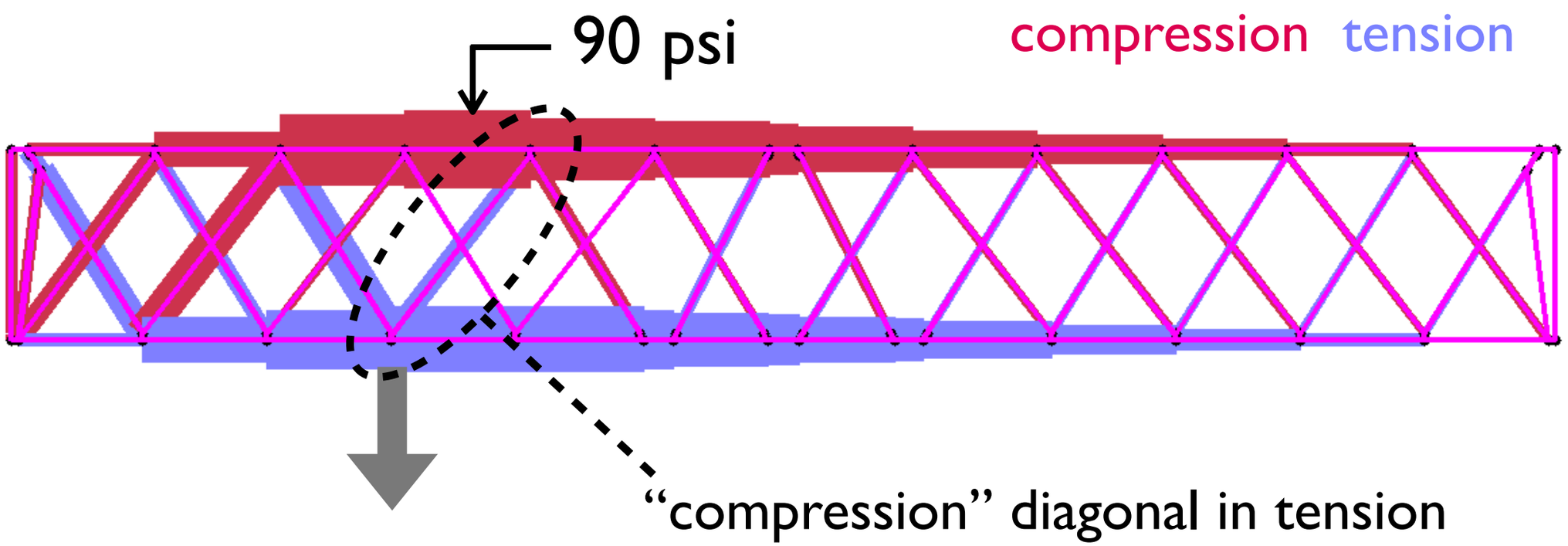
Rinard Bridge: Axial Forces



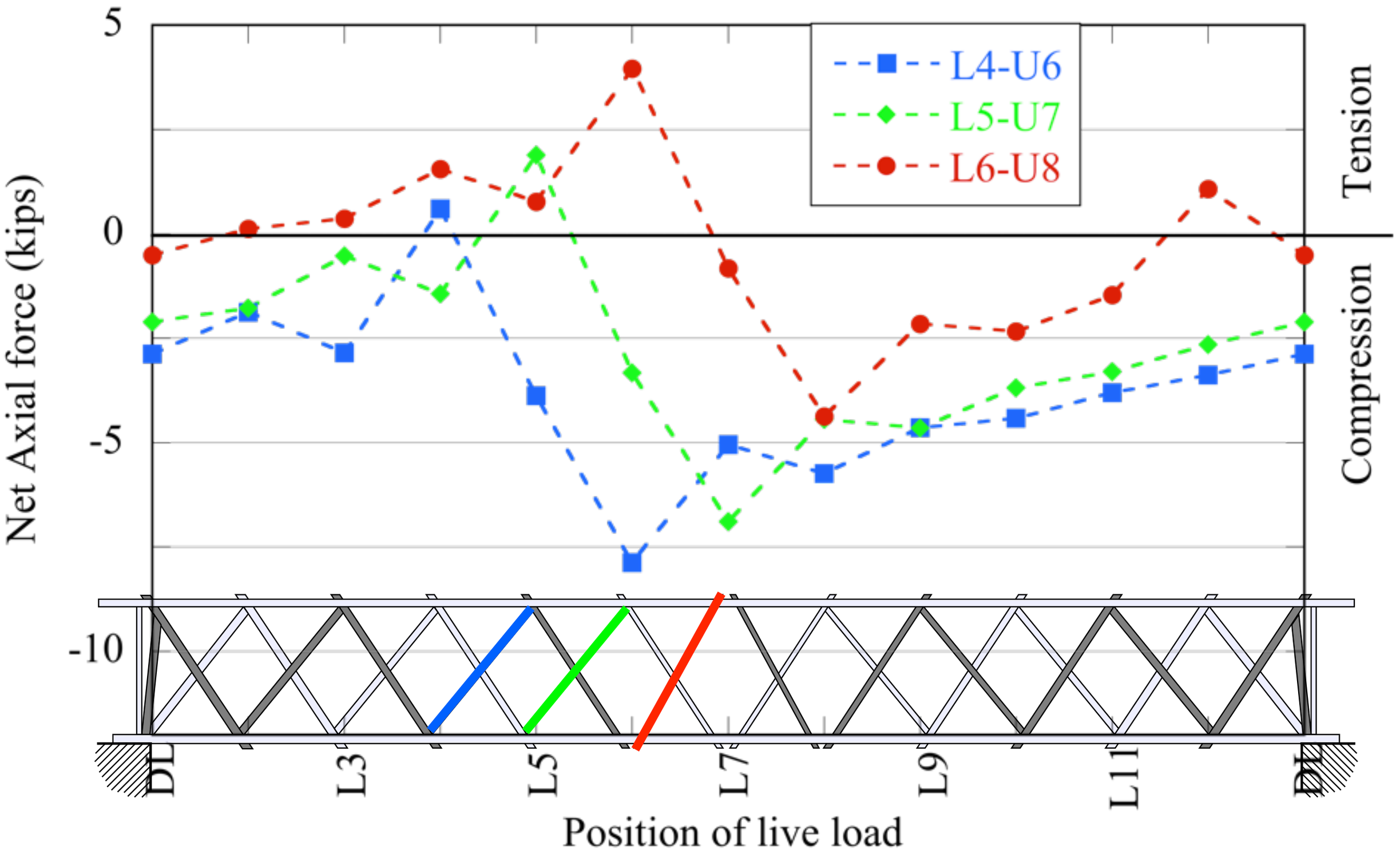
Dead Load



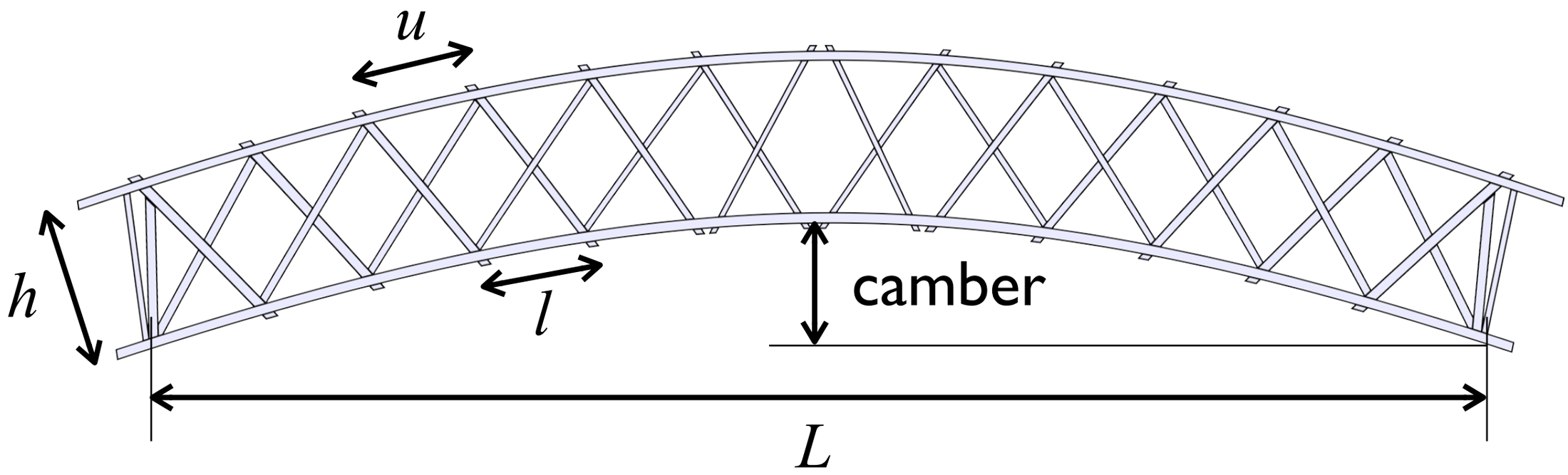
Live Load



Rinard Bridge: Influence Lines



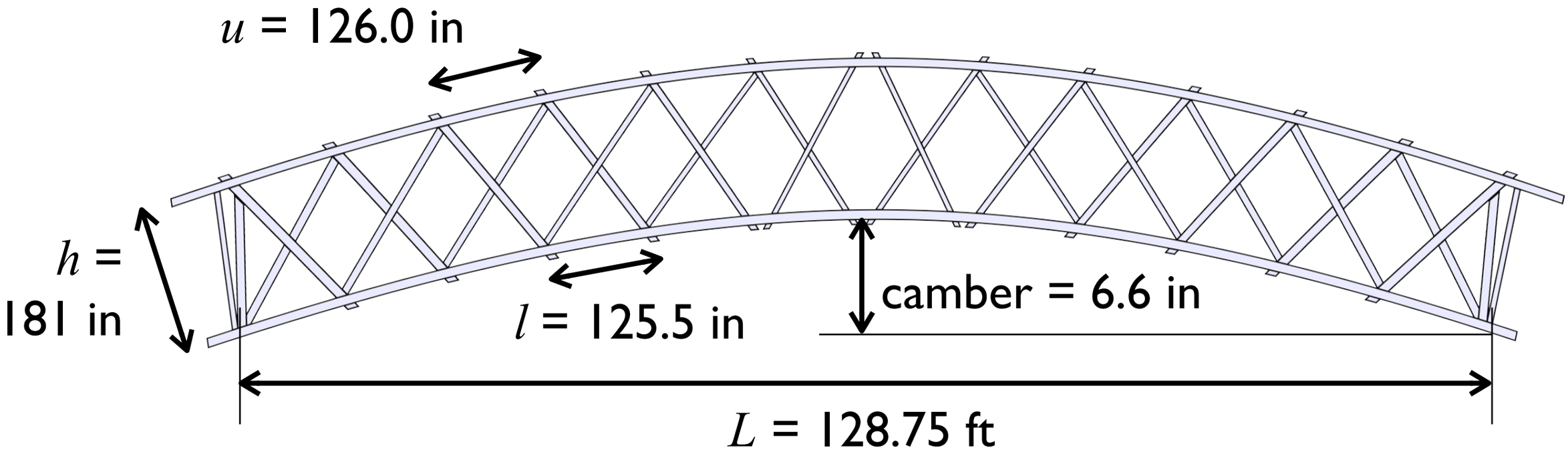
Deflections & Camber



Camber depends on

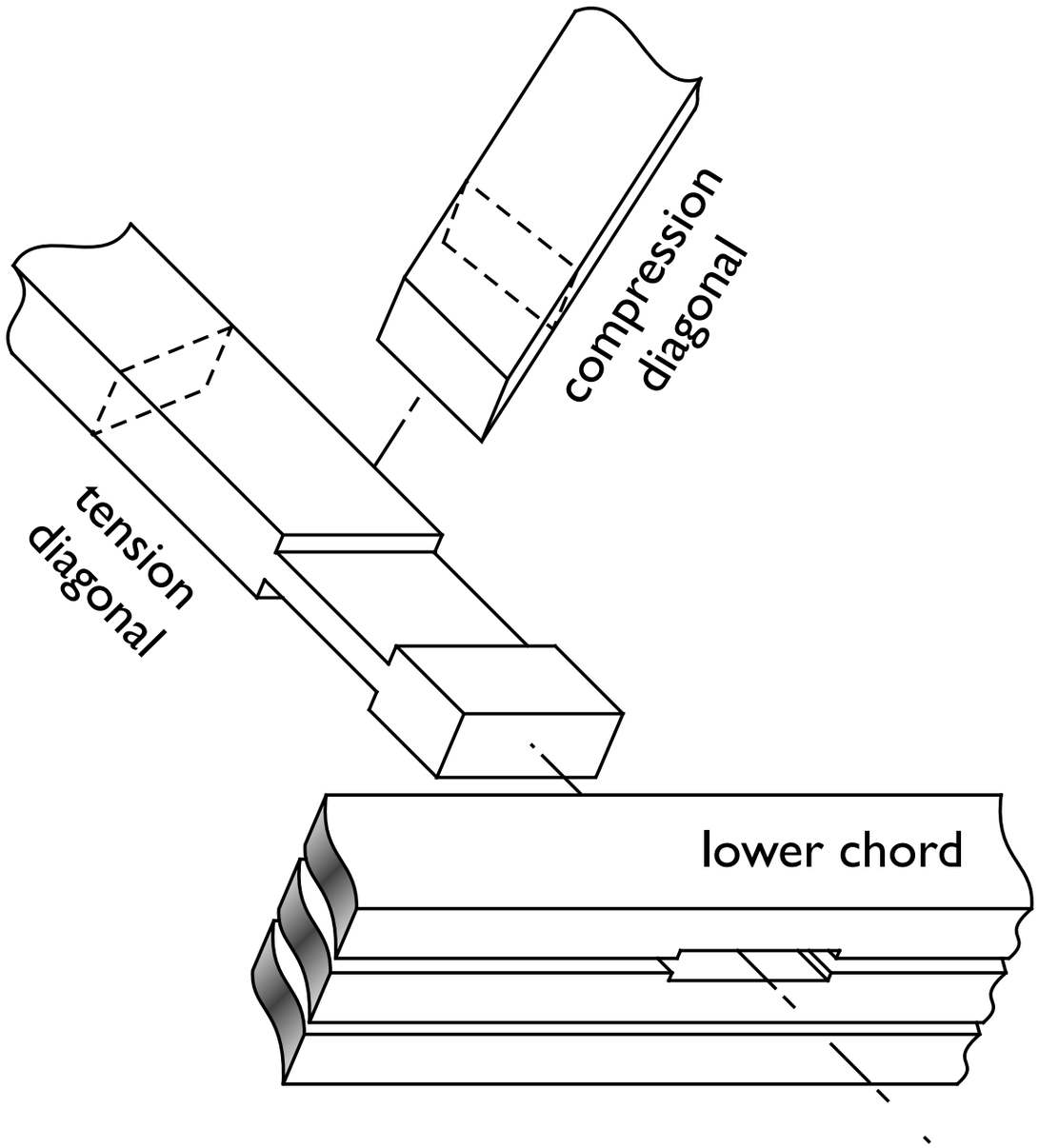
u = upper panel spacing
l = lower panel spacing
h = truss height
L = span

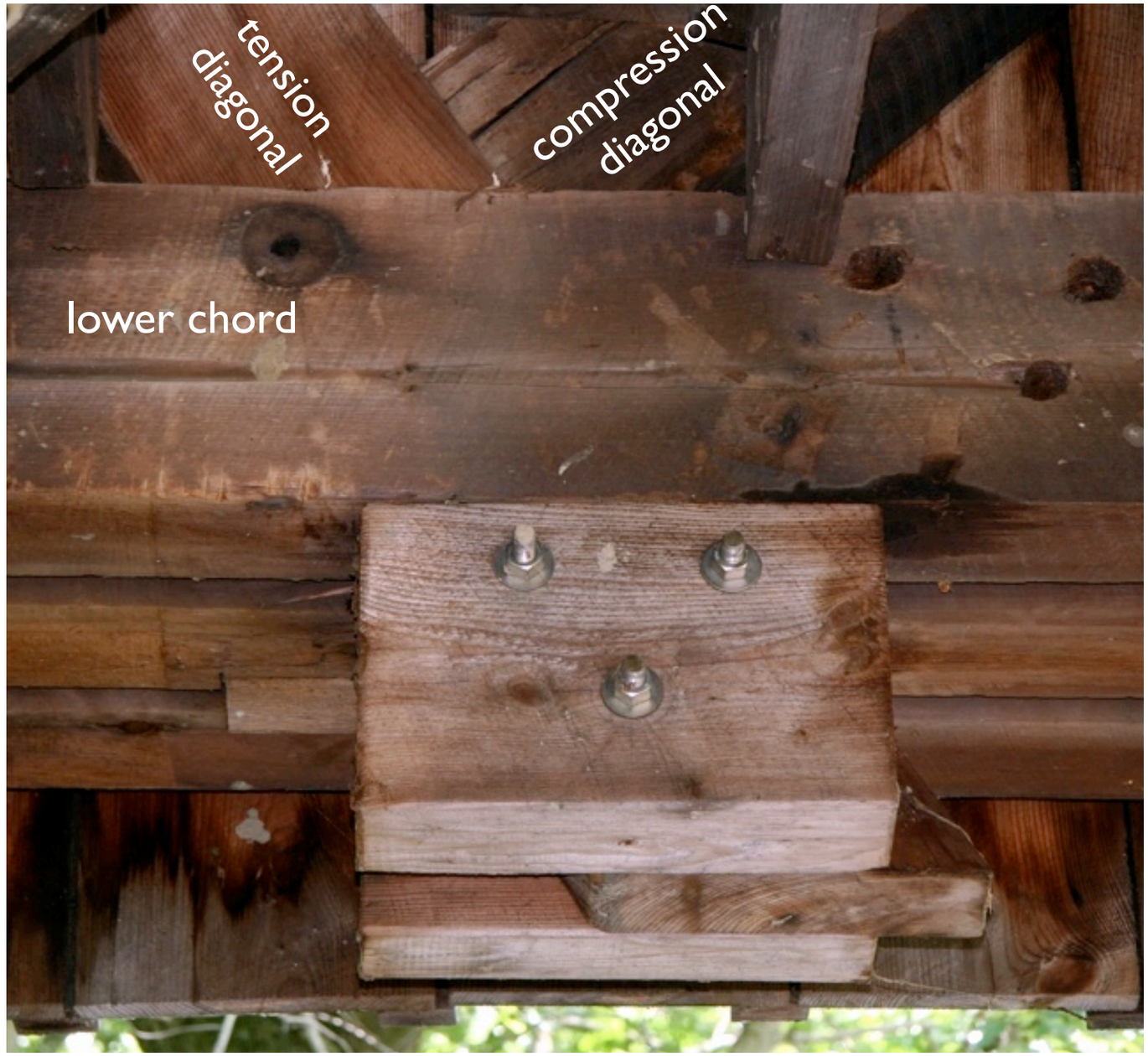
Rinard Bridge: Deflections & Camber



Deflections due to	in
Dead Load	0.5
Uniform Live Load	1.0
Concentrated Live Load	0.3

Connection Analysis





Kidd's Mill Bridge

Connection Analysis

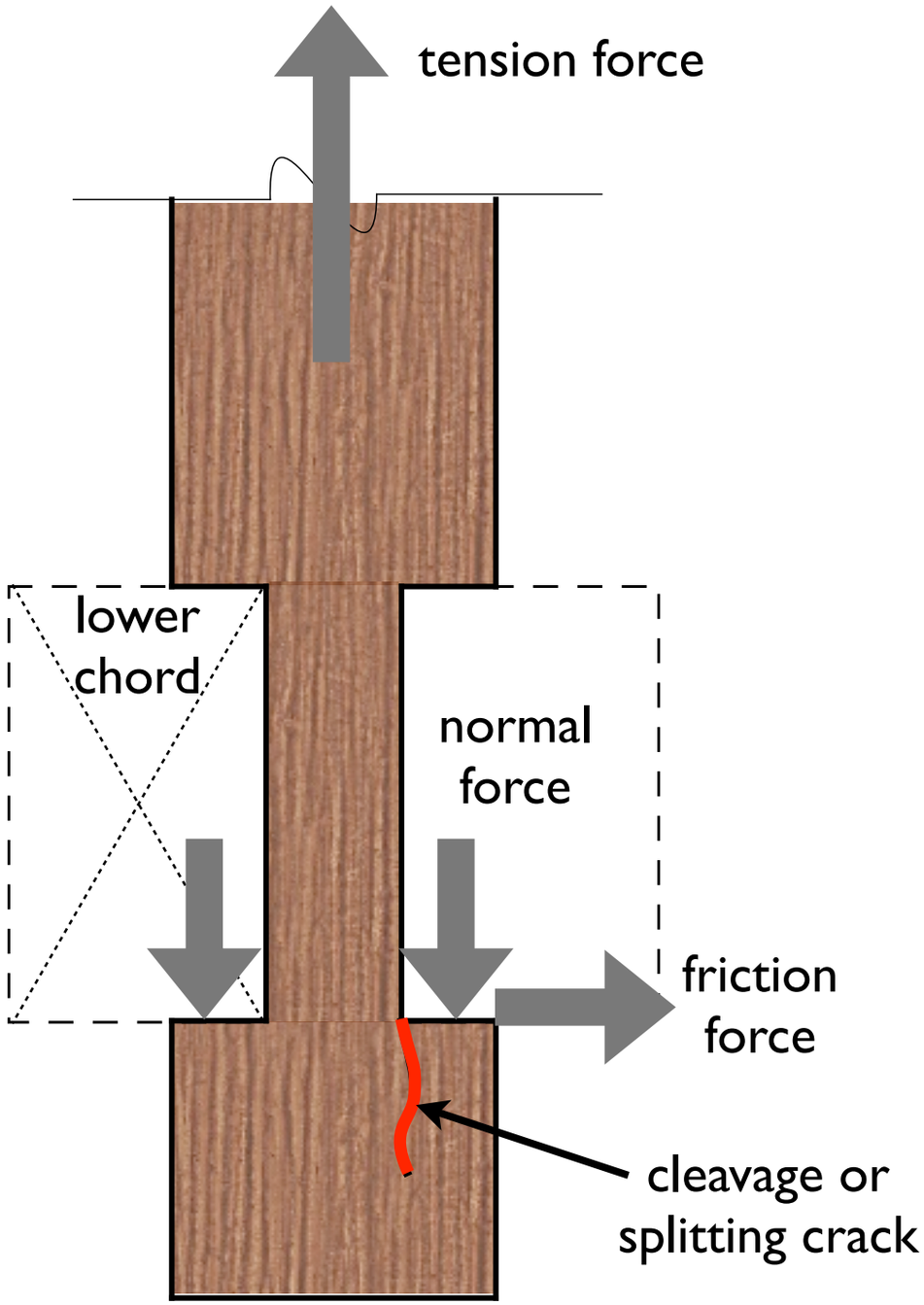
Hune Bridge (1879) Washington Co., OH

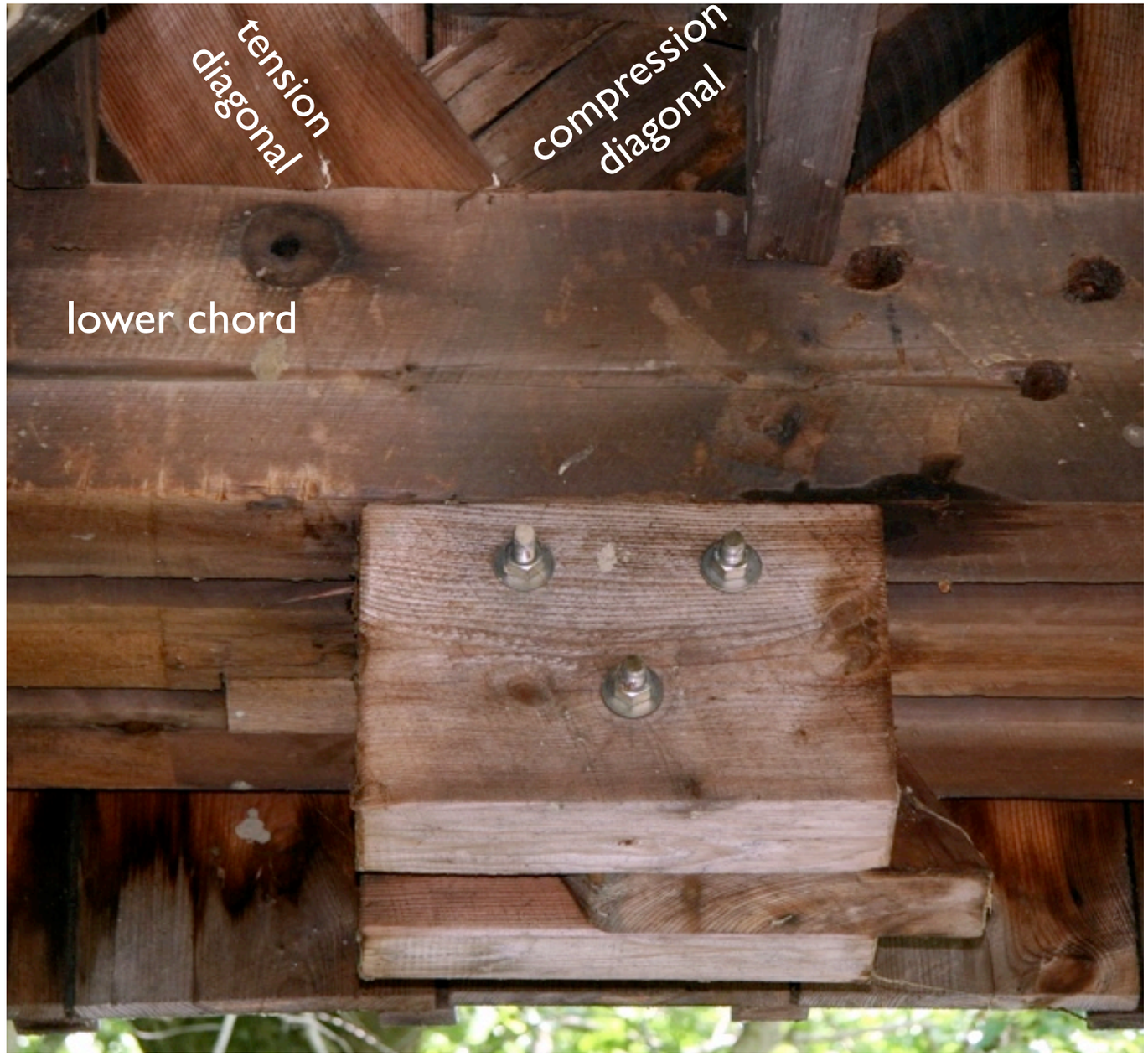
Connection Analysis

Eldean Bridge (1860) Miami Co., OH

(HAER OH-122)

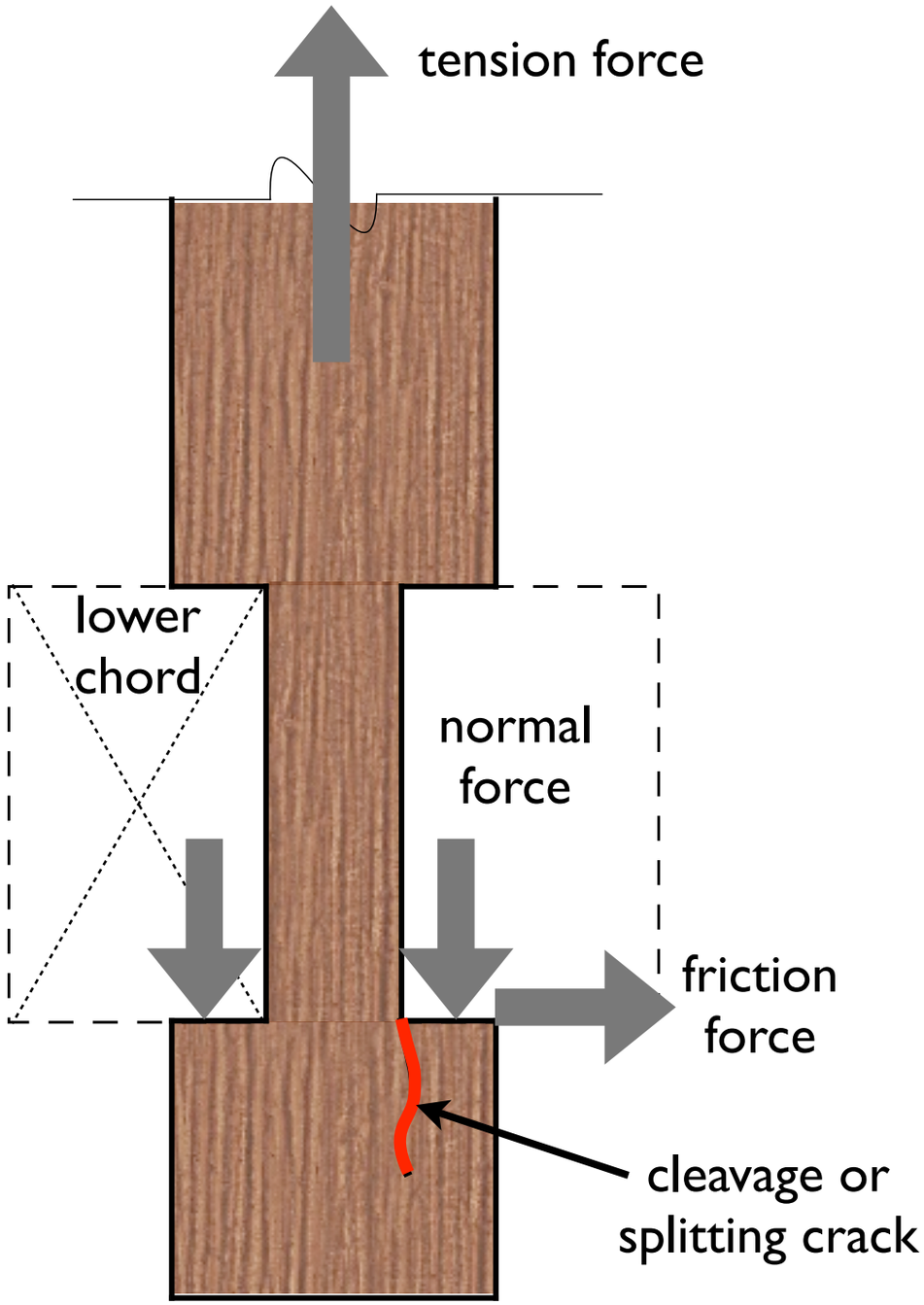
Connection Analysis





Kidd's Mill Bridge

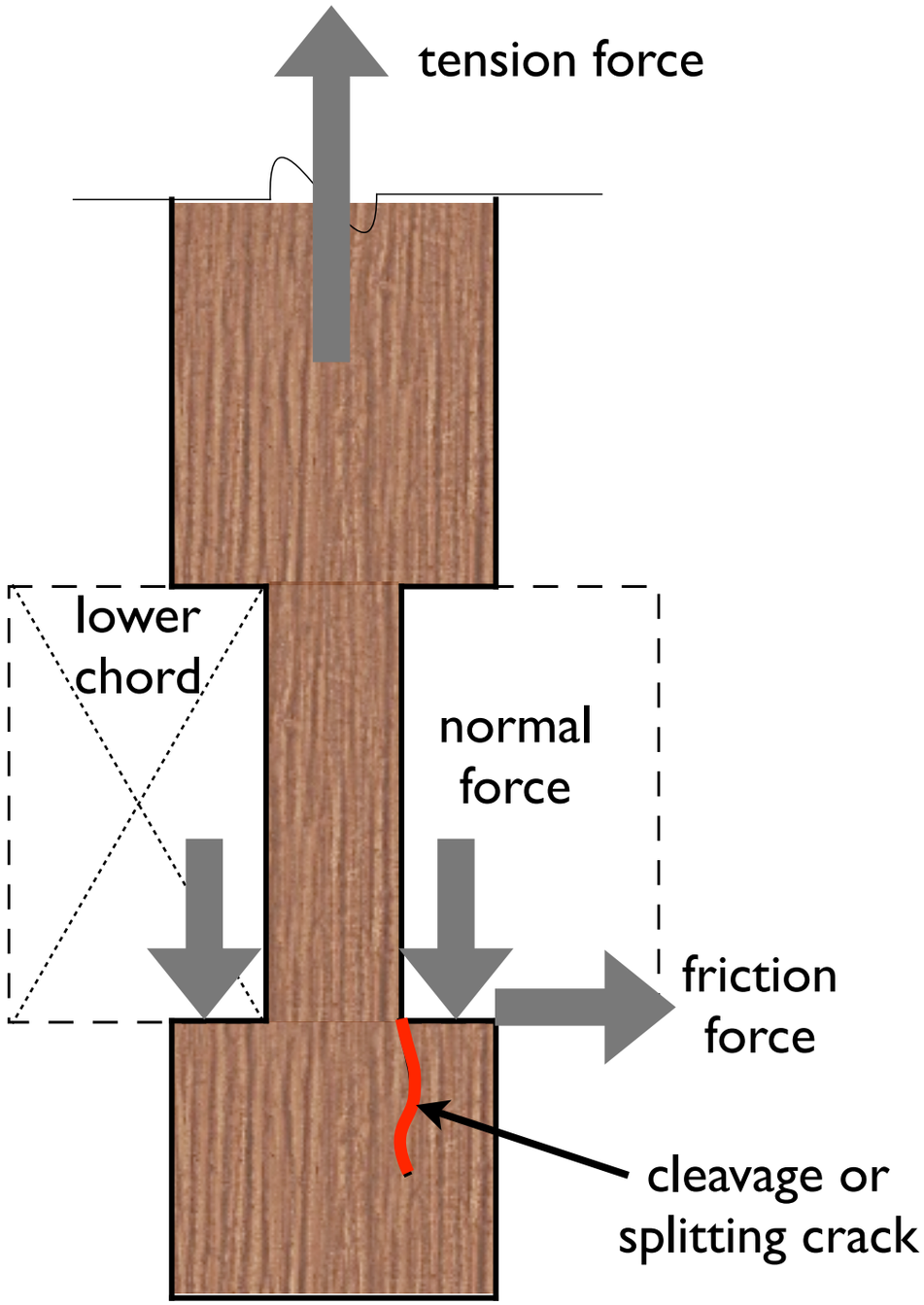
Connection Analysis: Kidd's Mill Bridge



Failure Modes considered:

- Direct tension
- Shear of shoulders
- Bearing on shoulders
- Bearing on chord

Connection Analysis



Fishplate Splice

Hune Bridge (1879) Washington Co., OH

More Info

Historic American Engineering Record (HAER) reports:

Structural Study of Smith Trusses, PA-645

http://www.loc.gov/pictures/collection/hh/item/pa4109/

Kidd's Mill Bridge, PA-622

http://www.loc.gov/pictures/collection/hh/item/pa3990/

Rinard Bridge, OH-130

http://www.loc.gov/pictures/collection/hh/item/oh1983/