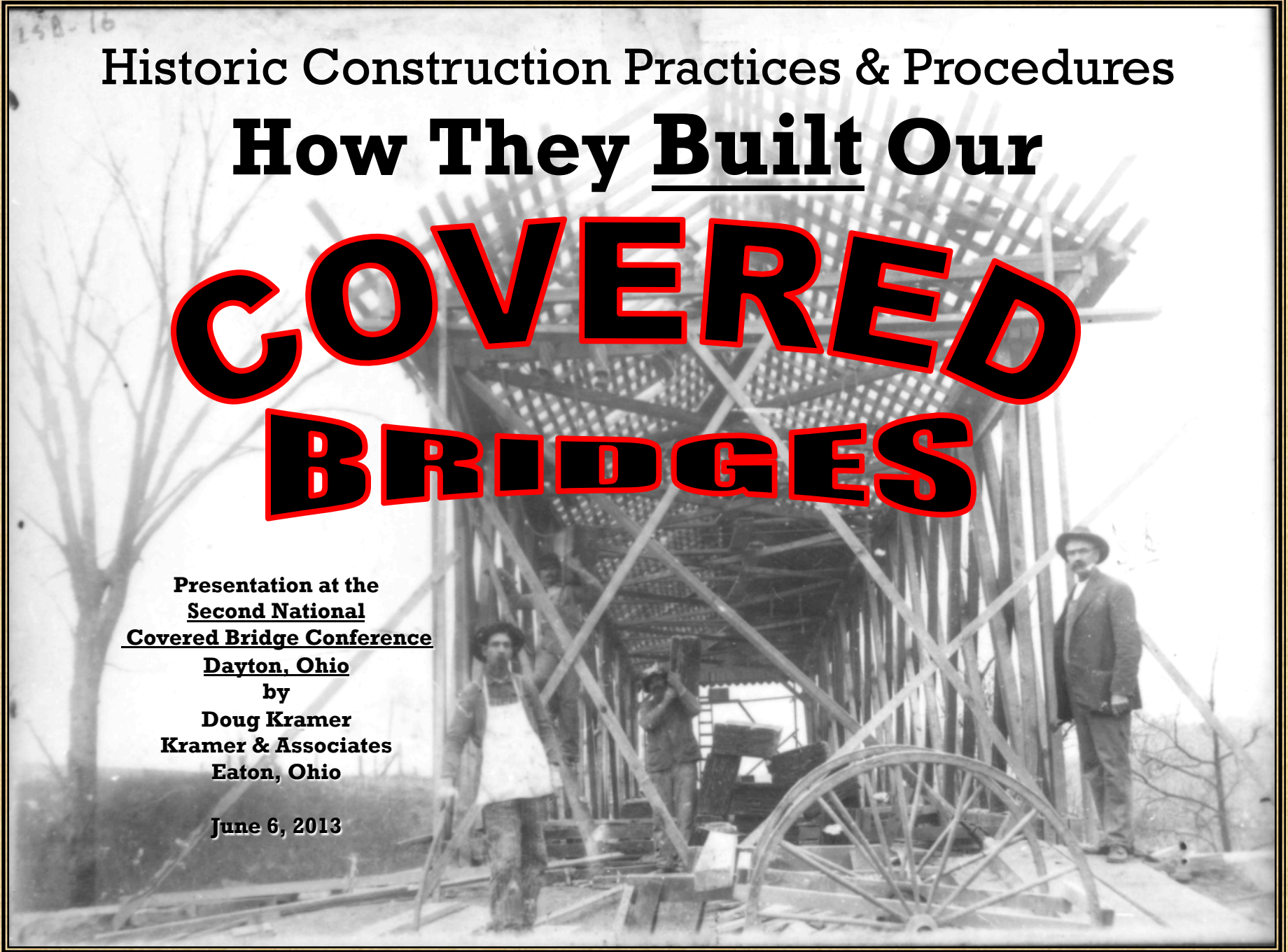
Historic Construction Practices & Procedures

How They Built Our COVERED BRIDGES



Presentation at the
Second National
Covered Bridge Conference
Dayton, Ohio
by
Doug Kramer
Kramer & Associates
Eaton, Ohio

June 6, 2013

Credits and Thanks

Some who have helped with vintage photos, plans, records and ideas….always looking for more….

Melissa Jergensen

David Simmons

Miriam Wood

Jim Crouse

Bill Caswell

Doug Christian

Doug Miller

John O'Fallon

Sheila Duwadi

Eric DeLoney

John Smolen

Robert Durfee

Arnold Graton

Dan and Kathy Collom

Marilyn Payton (Parke Co., IN)

Wendell Spencer

Walt Libby

Naomi Kramer

Anna Kramer

Donna Freeland

Joe Nelson

Dick Roy

Jim Reinoehl

Steve Simmons

Seth Schlotterbeck

Kyle Cross

Jane Lightner

Harold Scudder

Sean McDermott

Chris Leedham

Bill Cockrell

Phil Pierce

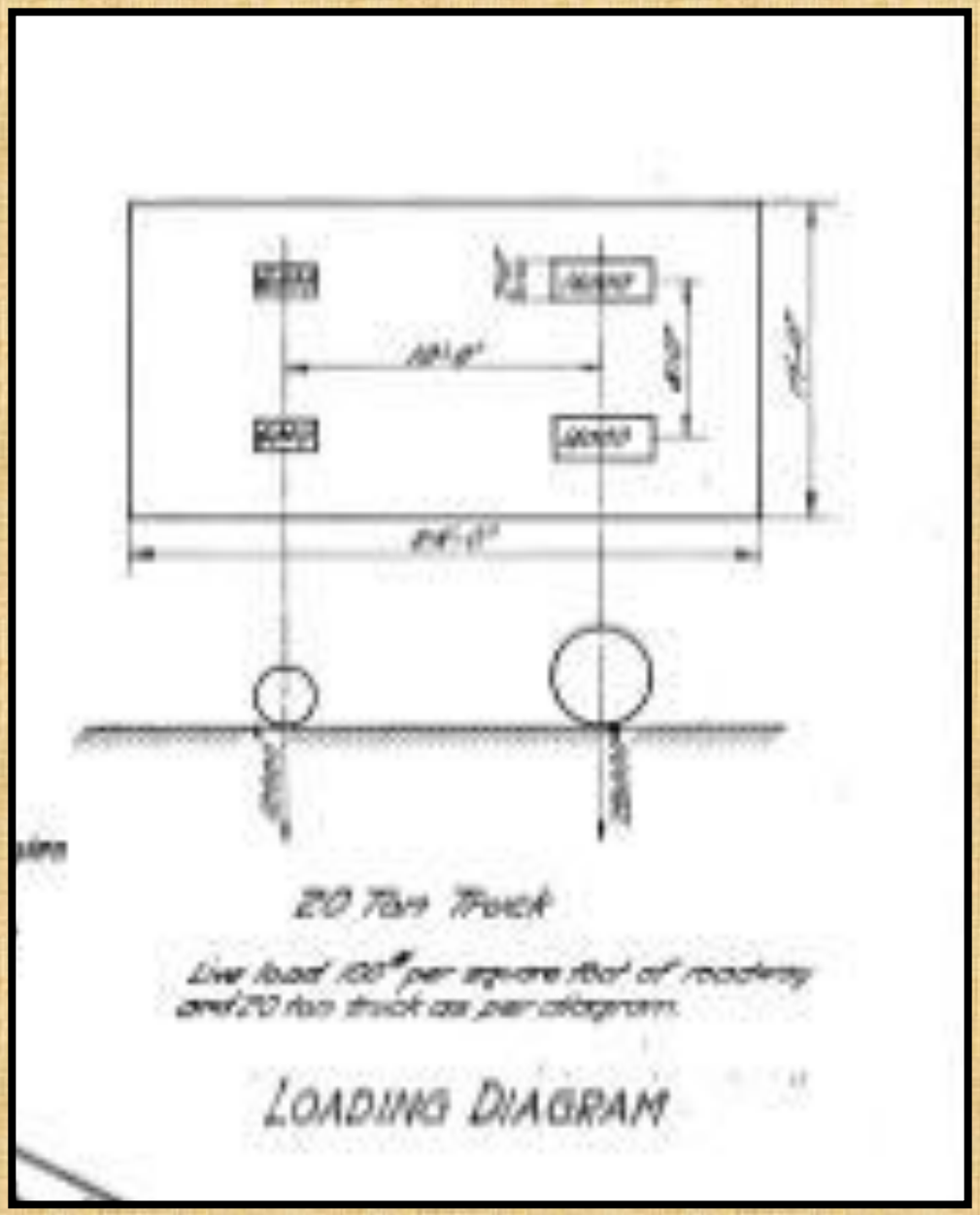
Joe Nelson

Life Without Bridges

“Now what ?”

“Now what ?”

Planning & Designing for Covered Bridges



Engineering Calculations

Live Loads

…maximum 6 Tons…

"…no vehicles drawn by more than 5 horses…" (England, 1629)

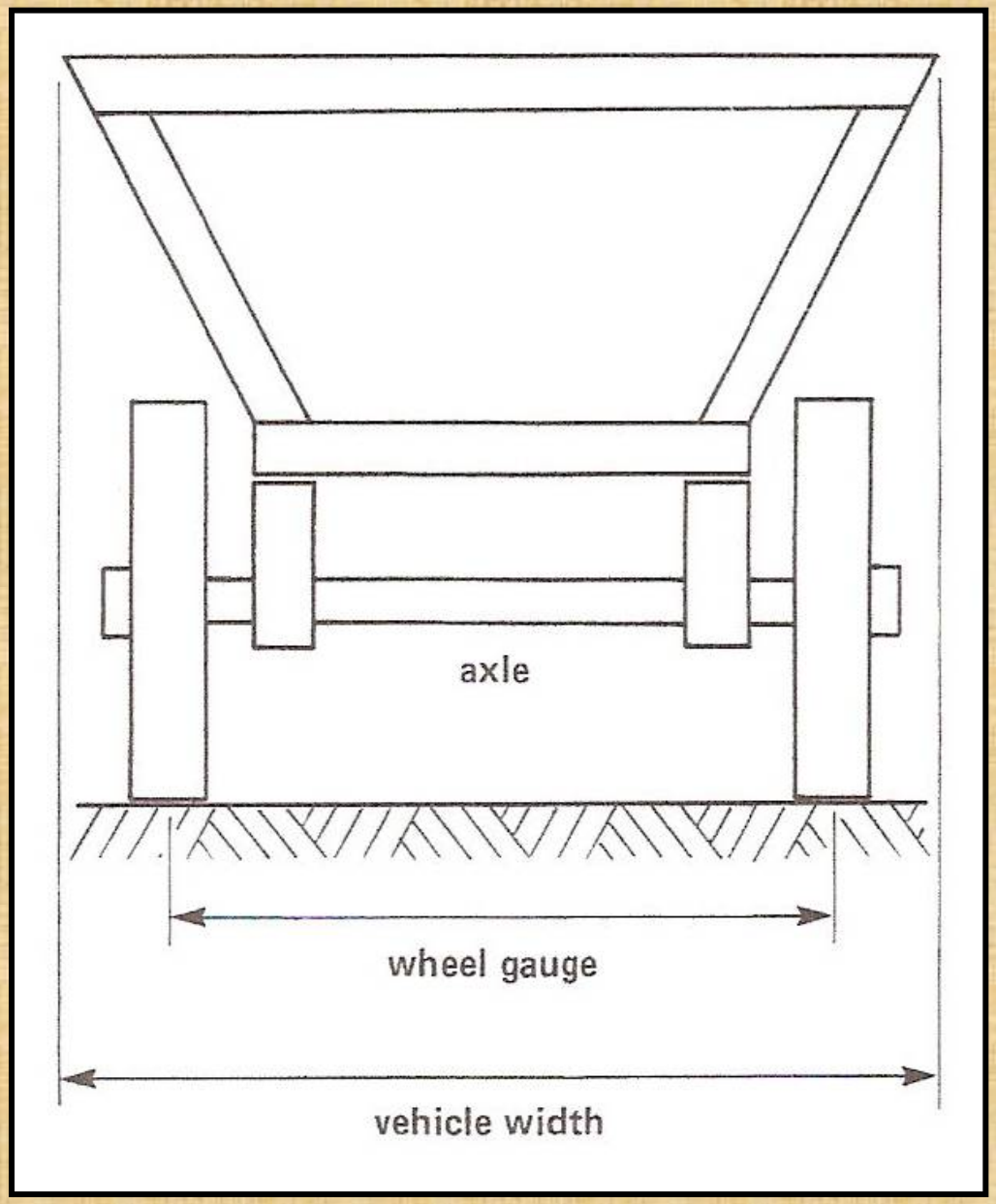
Broad Wheels Act (England, 1753)

18" wide wheels for very heavy loads

Engineering Calculations

Live Loads

Engineering Calculations

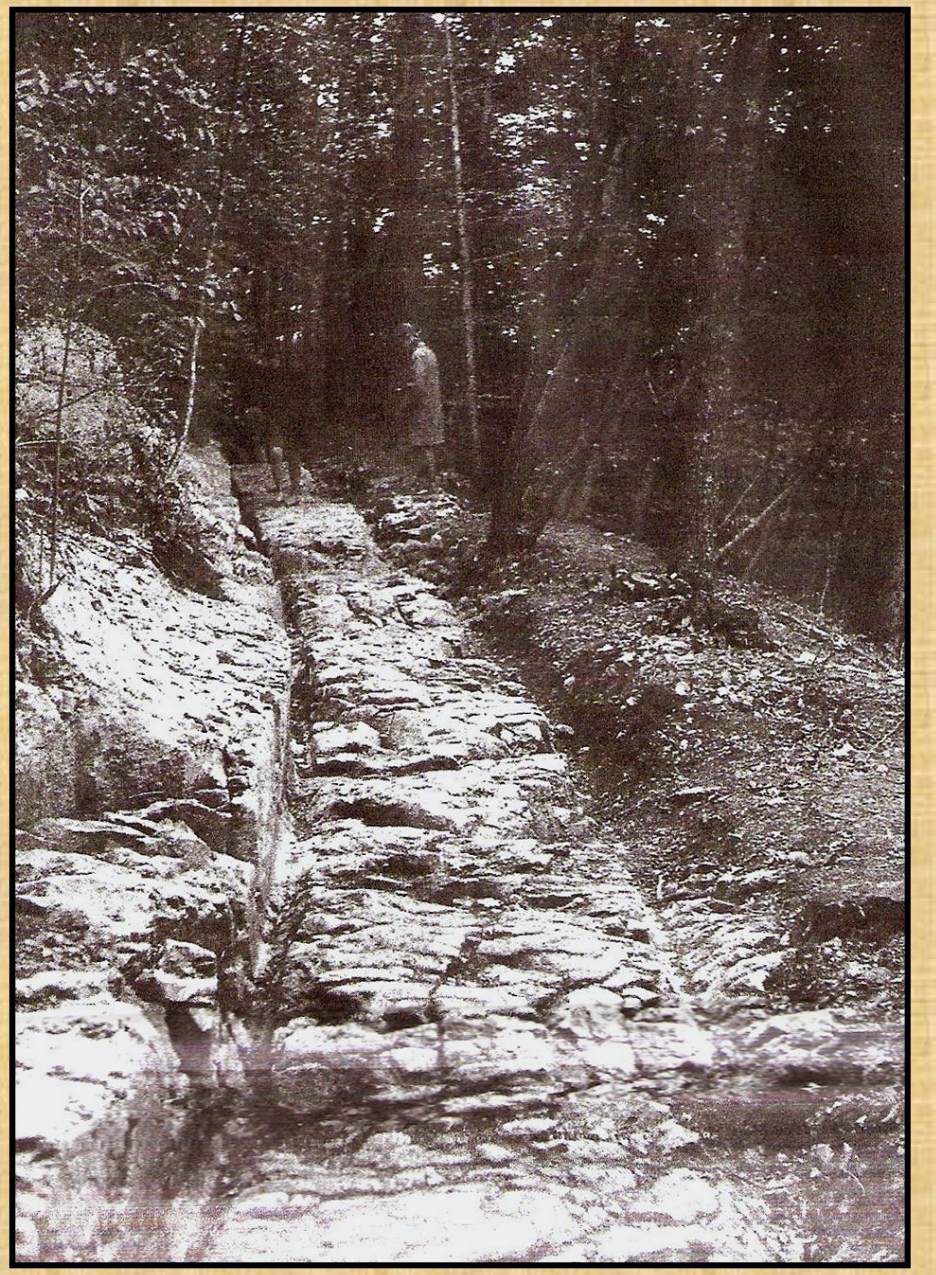


Early Greek Cart

Roadway Width

"…two horse team…"

"… road as wide as the height of the thumbs of a mounted man with his arms extended upward…." (Norse Law, AD 950)



Worn Ruts in Roman Road

Engineering Calculations

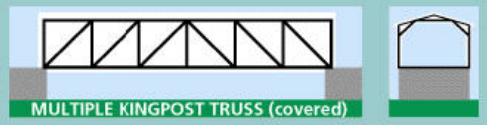
Wheel Guage

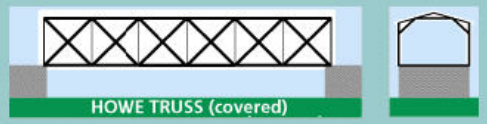
How To Support the Loads: Covered Bridge Truss Types

Covered bridge types (truss)

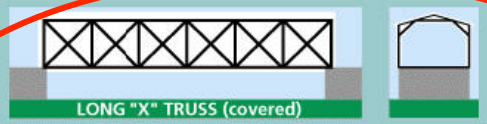
Covered bridges are typically wooden truss structures. The enclosing roof protected the timbers from weathering and extended the life of the bridge.

One of the more common methods used for achieving longer spans was the **multiple kingpost truss**. A simple, wooden, kingpost truss forms the center and panels are added symmetrically. With the use of iron in bridge construction, the **Howe truss** - - in its simplest form - - appears to be a type of multiple kingpost truss.





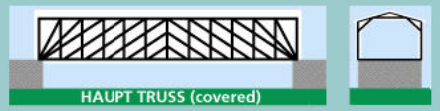
Stephen H. Long (1784-1864) of the U.S. Army Topographical Engineers may be best known for comments he made after one of his missions to explore and map the United States as it expanded westward. In 1819-20, when he viewed the treeless expanse of the Great Plains, he called it the "American Desert" - - and the name stuck. While working for the Baltimore and Ohio Railroad, he developed the X truss in 1830 with further improvements patented in 1835 and 1837. The wooden truss was also known as the **Long truss** and he is cited as the first American to use mathematical calculations in truss design.



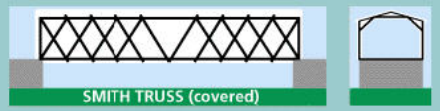
Theodore Burr built a bridge spanning the Hudson River at Waterford, NY in 1804. By adding a arch segments to a multiple kingpost truss, the **Burr arch truss** was able to attain longer spans. His truss design, patented in 1817, is not a true arch as it relies on the interaction of the arch segments with the truss members to carry the load. There were many of this type in the Pittsburgh area and they continue to be one of the most common type of covered bridges. Many later covered bridge truss types used an added arch based on the success of the Burr truss.

The **Town lattice truss** was patented in 1820 by Ithiel Town. The lattice is constructed of planks rather than the heavy timbers required in kingpost and queenpost designs. It was easy to construct, if tedious. Reportedly, Mr. Town licensed his design at one dollar per foot - - or two dollars per foot for those found not under license. The second Ft. Wayne railroad bridge over the Allegheny River was an unusual instance of a Town lattice constructed in iron.

Herman Haupt designed and patented his truss configuration in 1839. He was in engineering management for several railroads including the Pennsylvania Railroad (1848) and drafted as superintendent of military railroads for the Union Army during the Civil War. The **Haupt truss** concentrates much of its compressive forces through the end panels and onto the abutments.

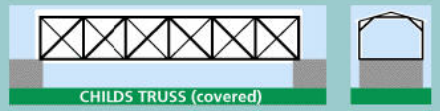


Other bridge designers were busy in the Midwest. An OhioDOT web page cites examples of designs used for some covered bridges in that state. Robert W. Smith of Tipp City, OH, received patents in 1867 and 1869 for his designs. Three variations of the Smith truss are still standing in Ohio covered bridges.



Reuben L. Partridge received a patent for his truss design which is appears to be a modification of the Smith truss. Four of the five **Partridge truss** bridges near his home in Marysville, Union County, OH, are still in use.

Horace Childs' design of 1846 was a multiple king post with the addition of iron rods. The **Childs truss** was used exclusively by Ohio bridge builder Everett Sherman after 1883.



Long Truss Components

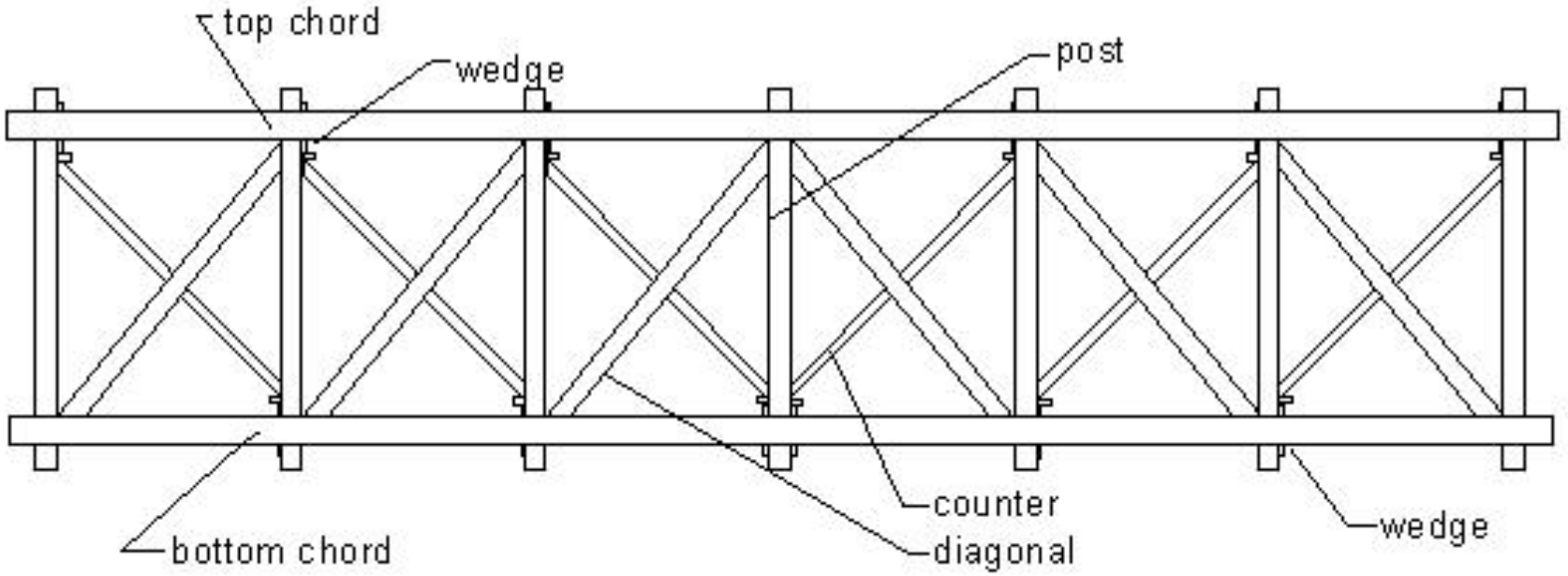


Figure 35. Diagram of Long truss.

Truss Type Details

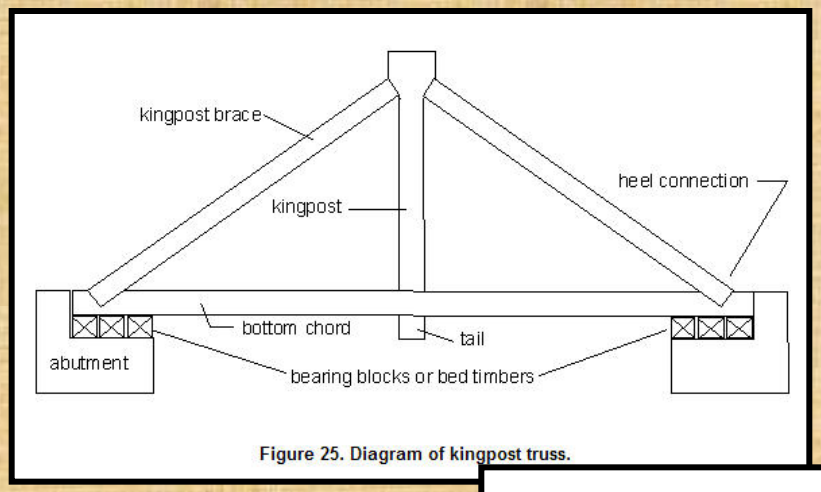


Figure 25. Diagram of kingpost truss.

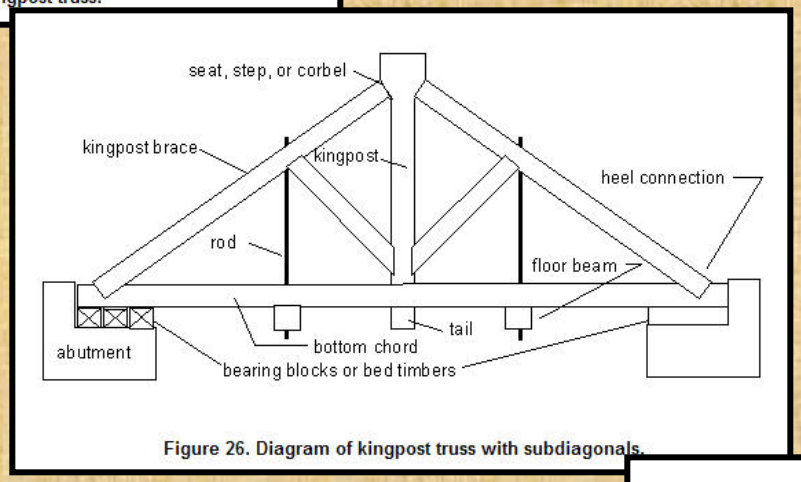
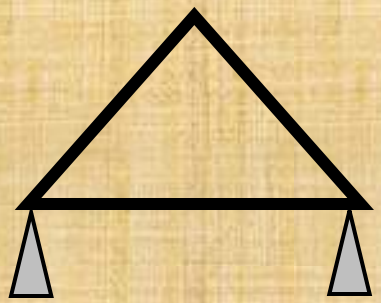
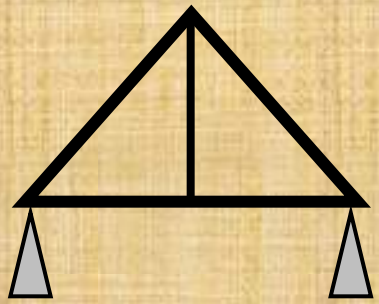


Figure 26. Diagram of kingpost truss with subdiagonals.





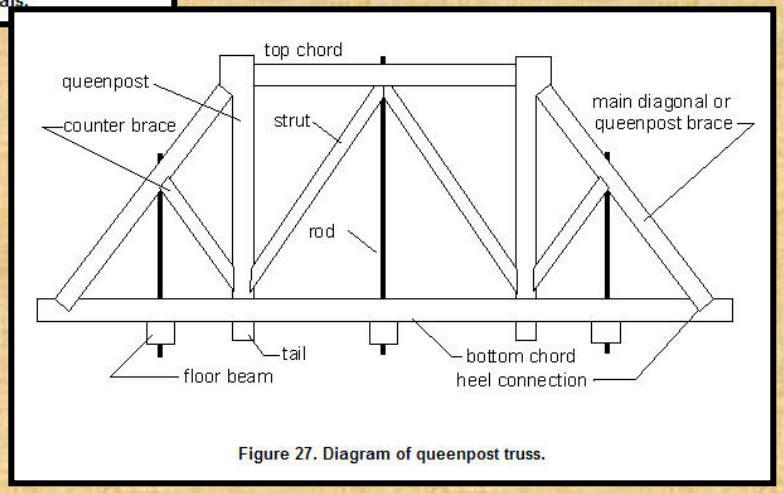


Figure 27. Diagram of queenpost truss.

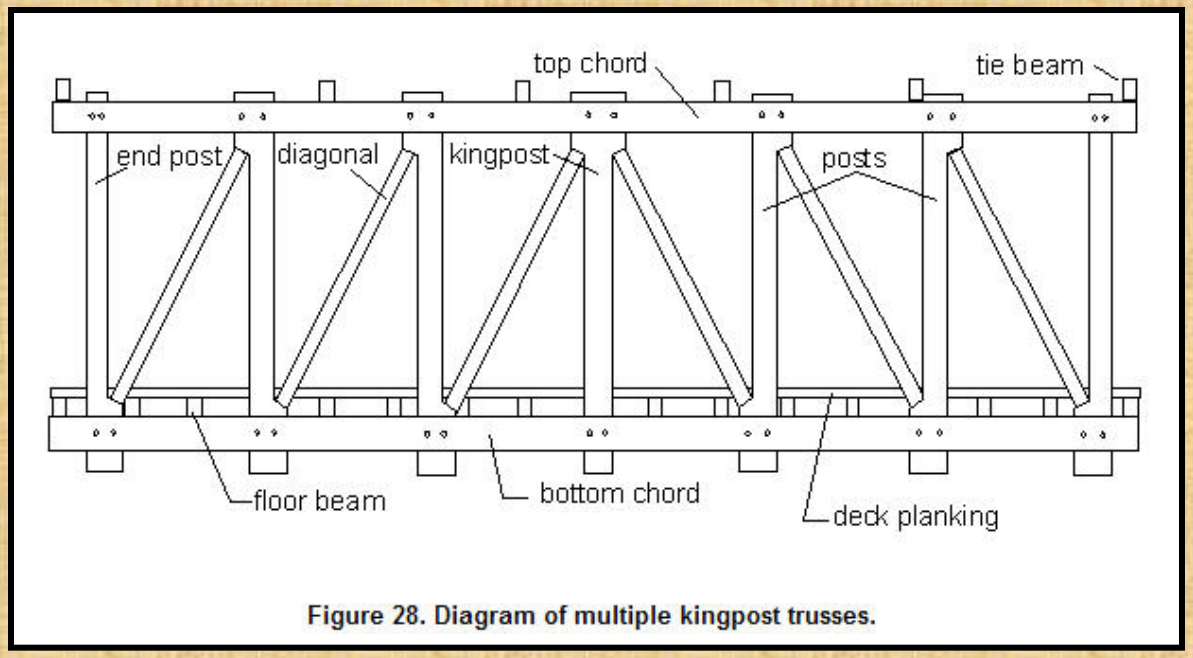


Figure 28. Diagram of multiple kingpost trusses.

More Truss Types

Burr Truss

Preble County

Roberts Double Barreled

(2 Lanes, 3 Trusses)

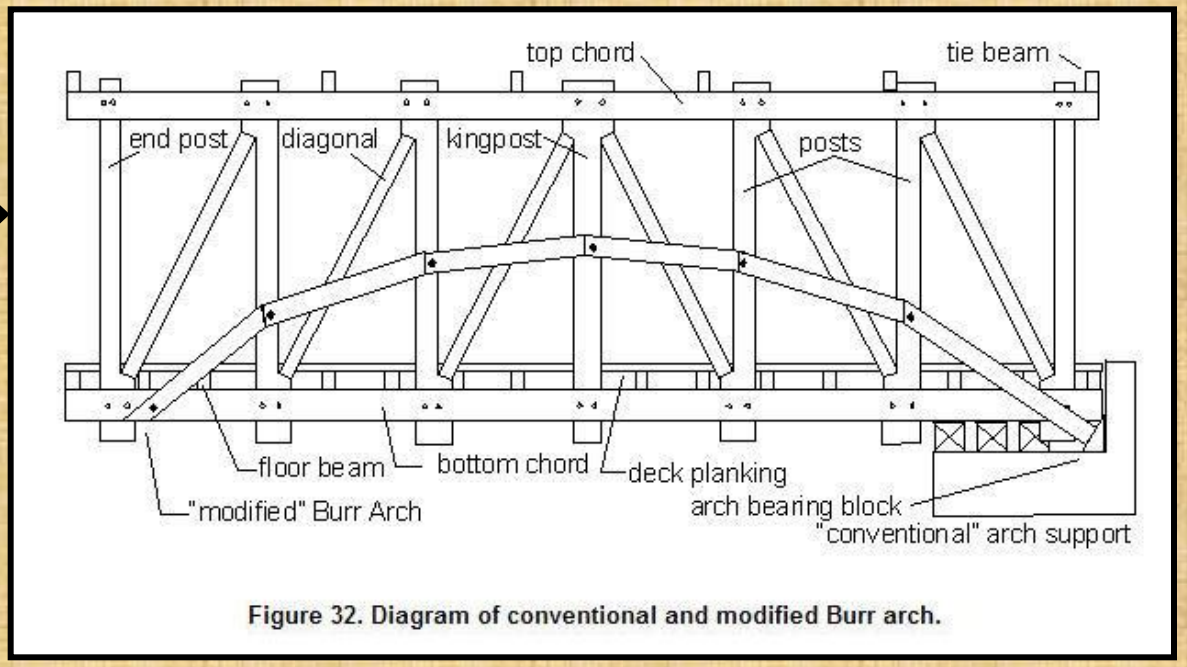


Figure 32. Diagram of conventional and modified Burr arch.

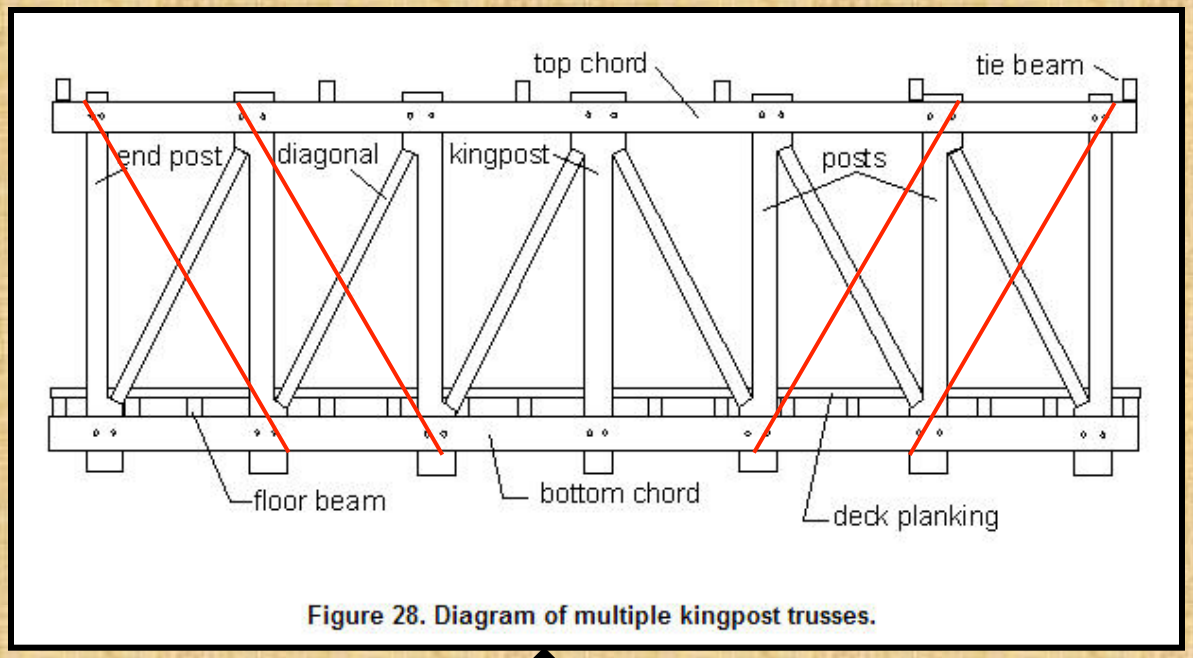


Figure 28. Diagram of multiple kingpost trusses.

The Childs Truss, a modified multiple kingpost truss, as built in Preble County, Ohio 1887 to 1895 by E.S. Sherman

Childs Truss
Preble County
(all except Roberts)

Former Pence Schoolhouse Bridge, Monroe Central Road

The Winchester Covered Bridge
1888-1947

Childs Truss, Built by E. S. Sherman
Preble County's Longest Covered Bridge
Two Spans of 152'-8", Total 305'-4"

Enterprise Road,
East of Gratis,Ohio

Photos during Demolition, 1947

Even More Truss Types

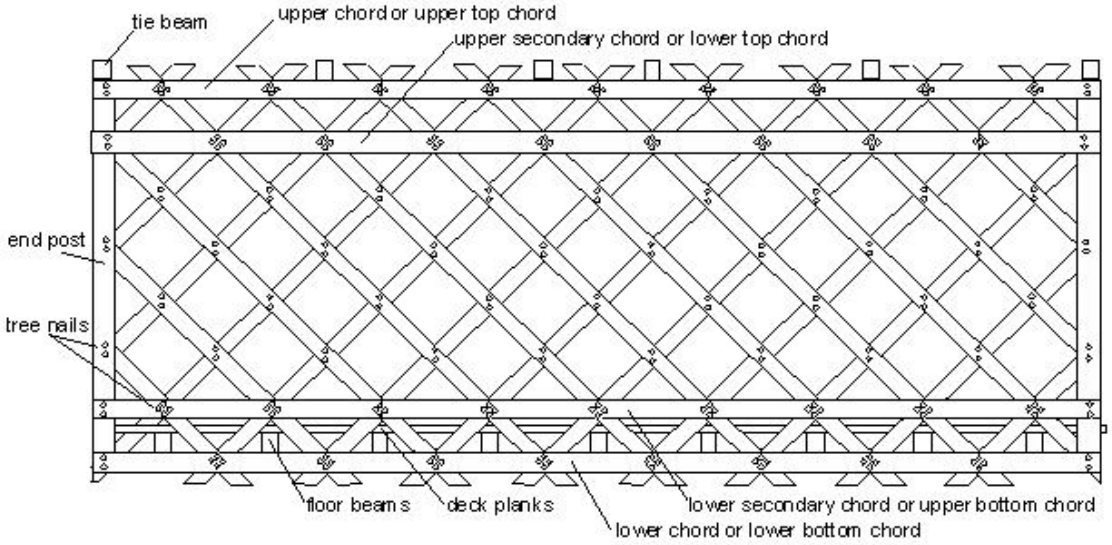


Figure 34. Diagram of Town lattice truss.

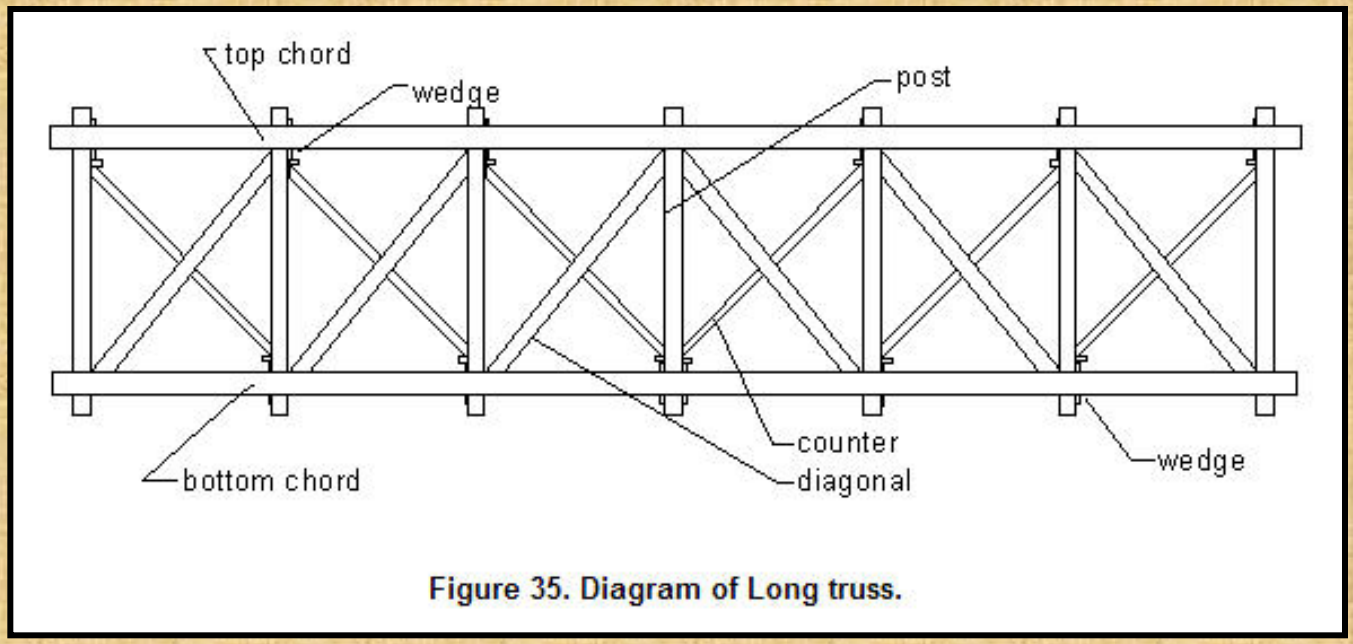


Figure 35. Diagram of Long truss.

Basic Truss Components

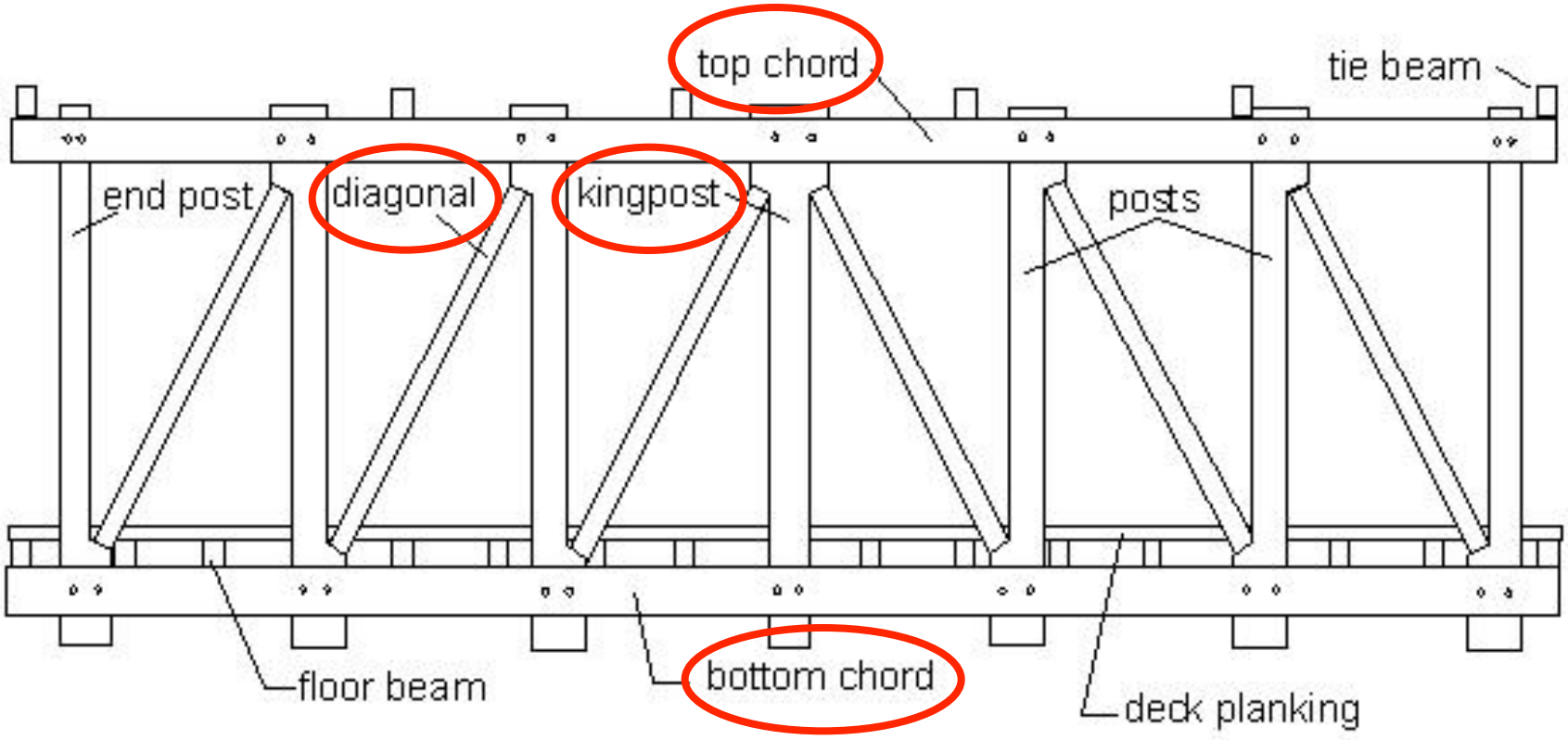
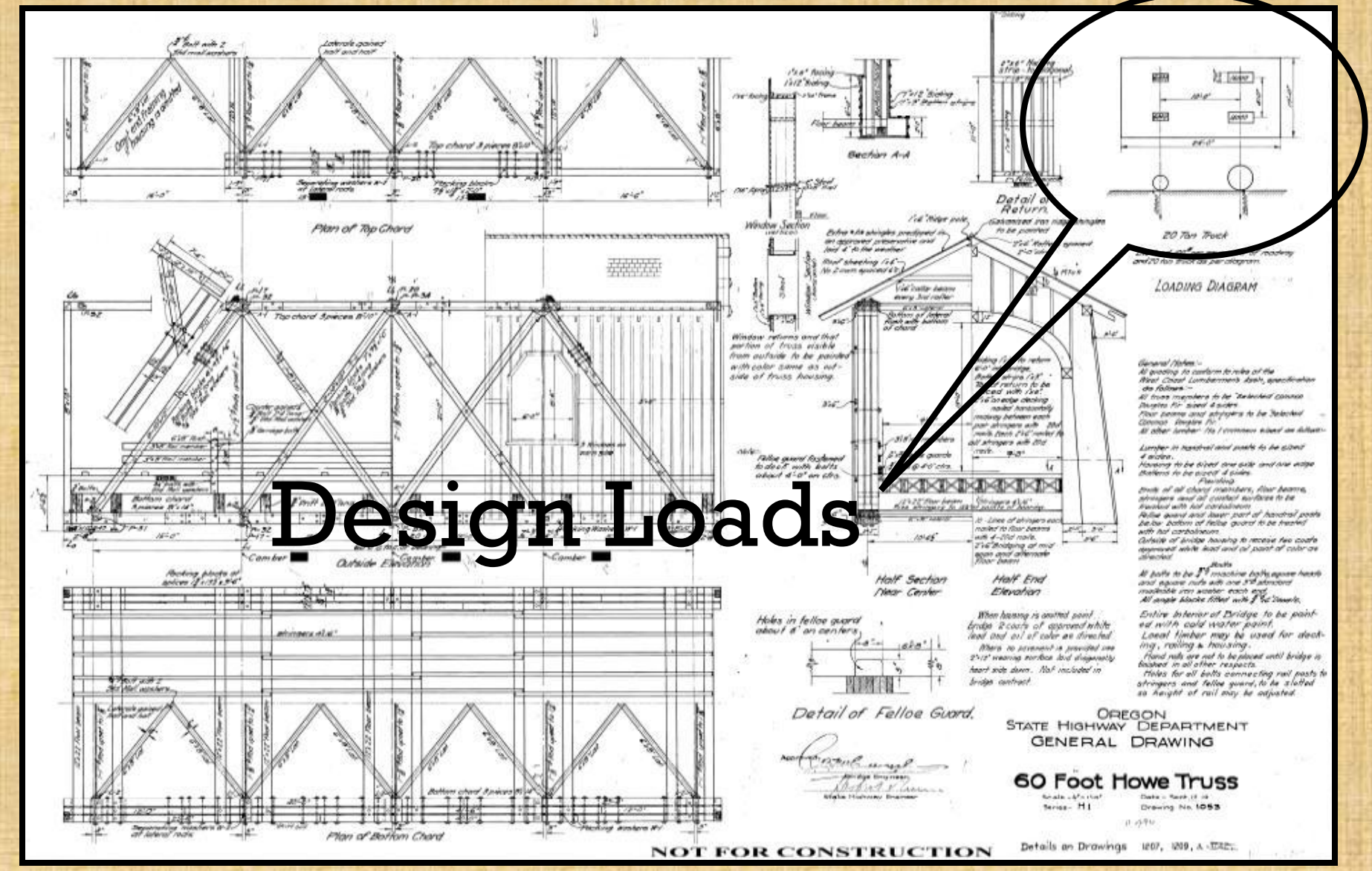
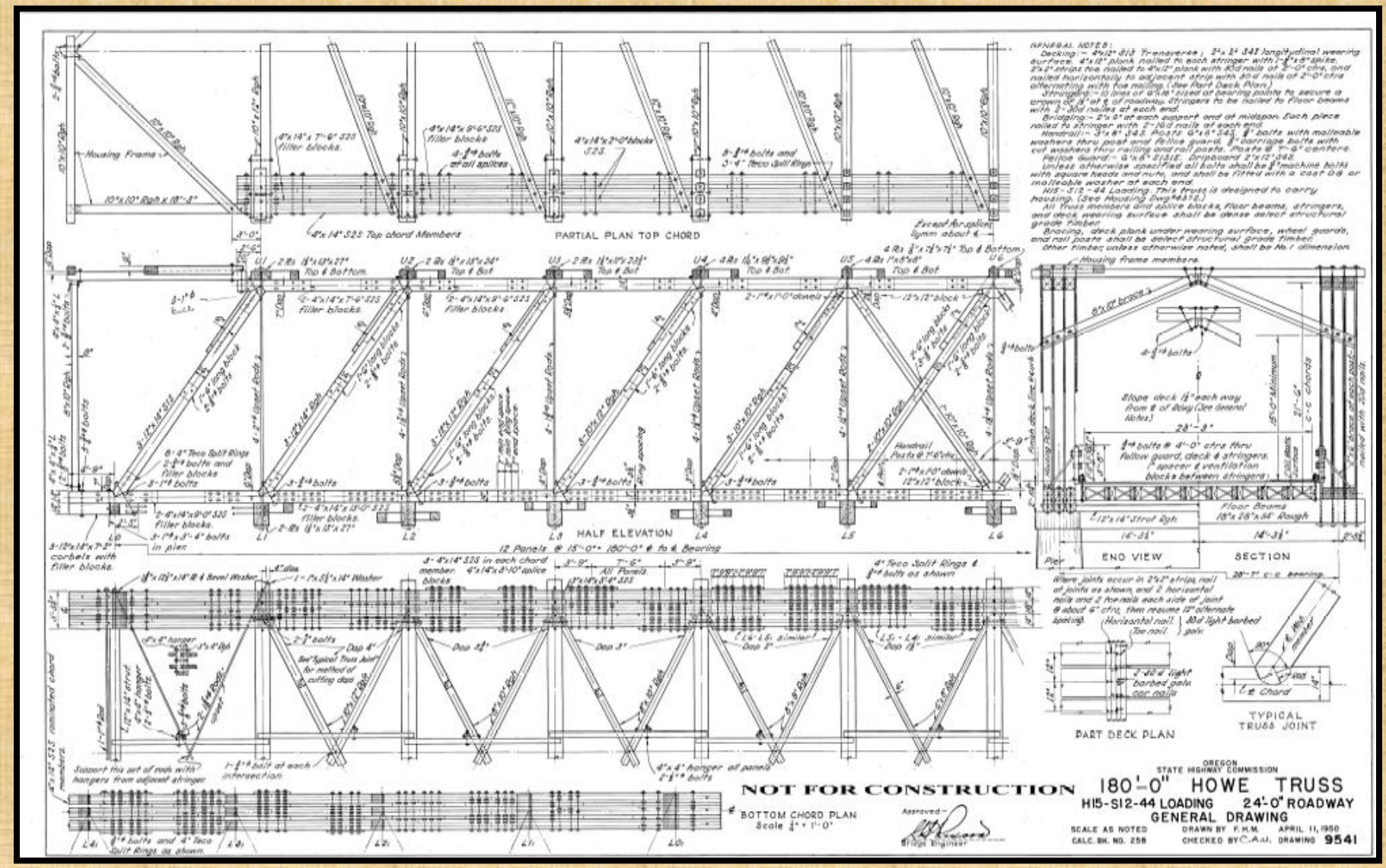


Figure 28. Diagram of multiple kingpost trusses.

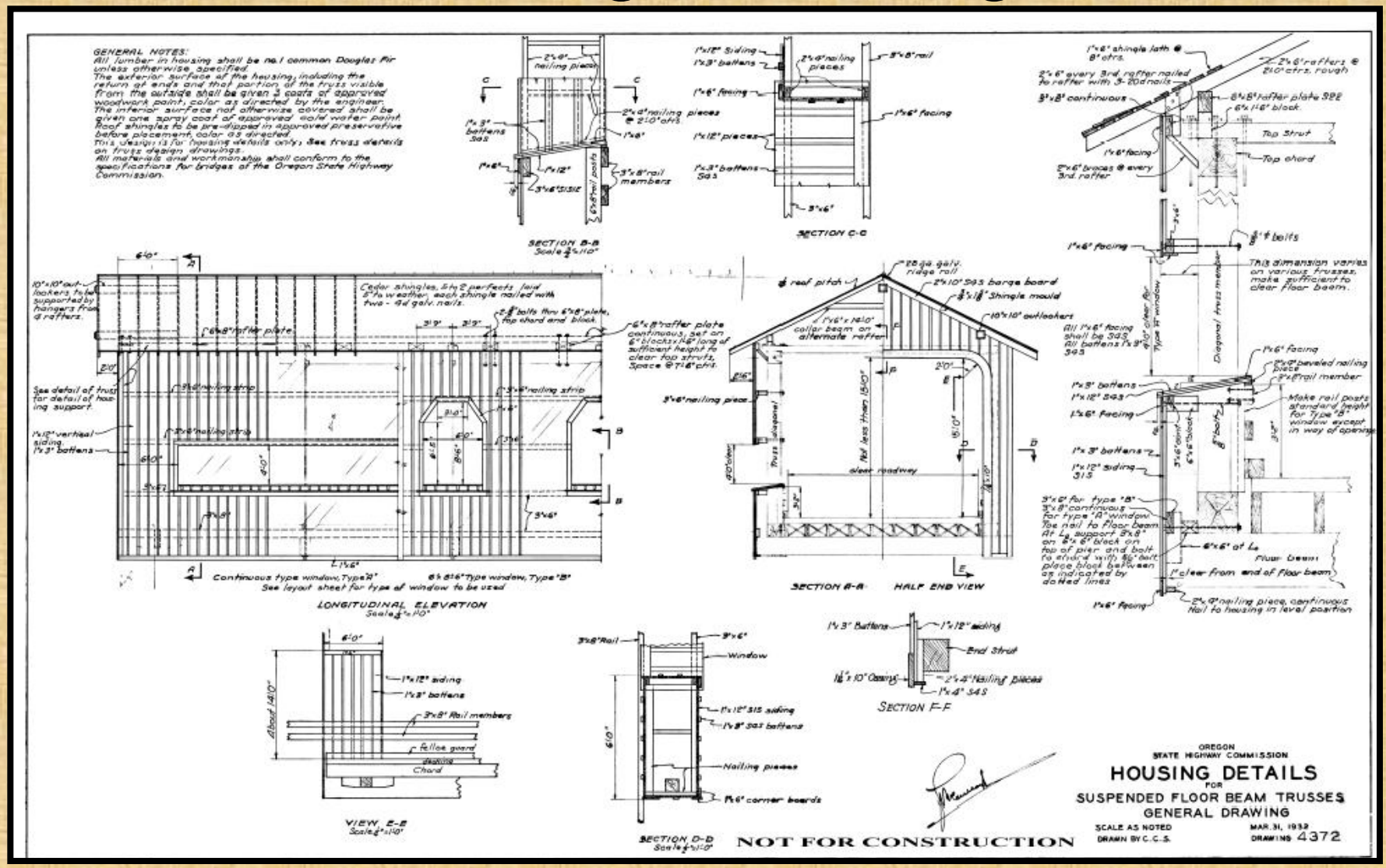
Engineering Plans - Loadings



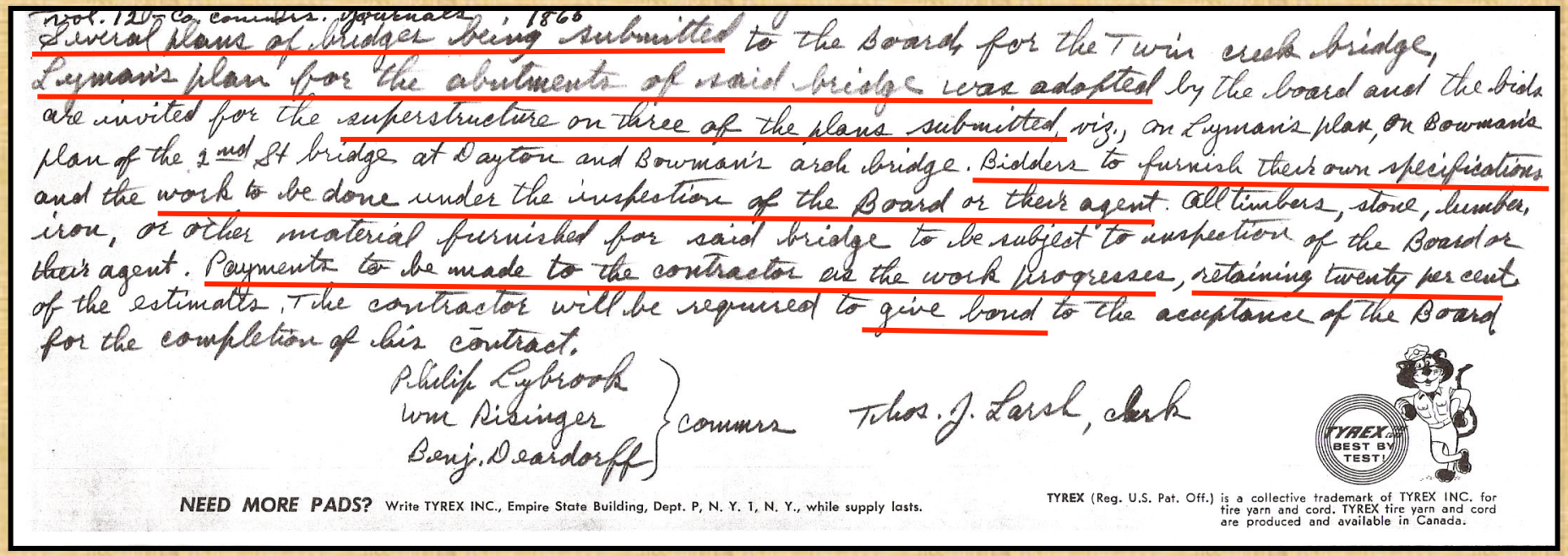
Engineering Plans - Trusses



Engineering Plans – Covering the Bridge



Specifications



Vol. 12 Co. Commrs. Journal 1865

Several plans of bridges being submitted to the Board for the Twin creek bridge, Lyman's plan for the abutments of said bridge was adopted by the Board and the bids are invited for the superstructure on three of the plans submitted, viz., on Lyman's plan, on Bowman's plan of the 2nd St bridge at Dayton and Bowman's arch bridge. Bidders to furnish their own specifications and the work to be done under the inspection of the Board or their agent. All timbers, stone, lumber, iron, or other material furnished for said bridge to be subject to inspection of the Board or their agent. Payments to be made to the contractor as the work progresses, retaining twenty per cent of the estimates. The contractor will be required to give bond to the acceptance of the Board for the completion of his contract.

Philip Lybrook
Wm Risinger
Benj. Deardorff } Commrs

Thos. J. Larsh, Clerk

Preble County, Ohio

1865

Specifications

P.4, Vol 12: Sept. 1st 1865 – Bids opened – contract to H. E. Hebble on plan presented by Wharton Lyman

P.7, Wed, Sept. 6, '65 – Commrs. to meet next day at 9:00 at bridge site to locate & stake off the foundations for the abutments.

Same Page., Thurs, Sept. 7, '65. met at 9:00 & spent day locating & staking but did not finish & set Thurs, Sept. 14th for completing the job.

P.9, Sept. 14, '65. Board met at bridge site (Wm. Risinger & Benj. Deardorff) also H. E. Hebble. (Must have had a written agreement already made up)

"Articles of agreement made and entered into by and between H. E. Hebble and the commrs. of Preble county, O. in relation to the building of a bridge across Twin creek on the township line between Gratis and Lanier township; witnesseth: ..... binds himself to build said bridge on the "Lyman & Greff" plan, at and for the sum of twenty-two dollars per lineal foot for the superstructure and the stone work according to said plan at and for the price of six & 50/00 dollars per perch, and if piling is ordered driven, then said piling to be paid for by said commrs. at such price as is reasonable. ..... binds himself to do said work in accordance with the Lyman & Greff drawing now on file in the Auditor's office of said county and also in accordance with the following specifications, viz; Excavation to be as deep as the bed of the river. Foundation of hewed timber, twelve inches thick, of two layers. Piling to be driven sufficient depth to secure abutments from undermining, and close together. Stone masonry – stone to be of the best within 3 miles laid in courses from 3 to 8 inches thick, to be laid in full mortar to be composed of

Preble County, Ohio

1865

Specifications

fresh lime and clean sharp sand. Superstructure – the bridge shords of pine timber, clamps and packing – block oak, posts, main braces, lateral braces, tie beams, poplar or pine; and floor beams oak timber; weatherboards and battons (?) poplar timber; shingles, pine, 18 inches long, sawed, 5¼in to the weather. Roof, to be lathing to nail shingles to. Flooring to be double thickness; first floor to be laid crosswise of bridge, nailed down with 4in. spikes; – second floor, lengthwise of bridge, spiked down with 4" spikes; – plank to be 2 in. thick. Weatherboards and battons to be dressed on one side, painted with two coats of white lead and oil. The weatherboards are to extend around the end of the chord, inside the bridge, five feet, to protect from the weather. Nails for shingles 4's, nails for weatherboards and batons 10's. Iron bolts, lateral rods 1¼ round, washers 1¼. chord bolts, ¾ round, washers ¾, Tie beam bolts, 5/8 round, washers 5/8. Intersection bolts, 5/8, washers 5/8. all the above bolts are to have forged heads on one end and machine-cut screws and nut on the other, except the lateral rods, which are to have a nut on both ends, with washers 5 in. in dia. and 1 in. thick under each nut, cast iron washers to be under each head and nut of bolts 3 in. in dia. The bridge structure, when raised, must cambre 12 in. and twenty feet wide from out to out according to the plan and specifications. The work to be done in a good and workmanlike manner, and the said Hebble further agrees and binds himself to complete said work by the 25th day of Dec. 1865." Witness our hands and seals this 14th day of September, 1865.

signed H. E. Hebble seal
William Risinger seal
Benjamin Deardorff seal

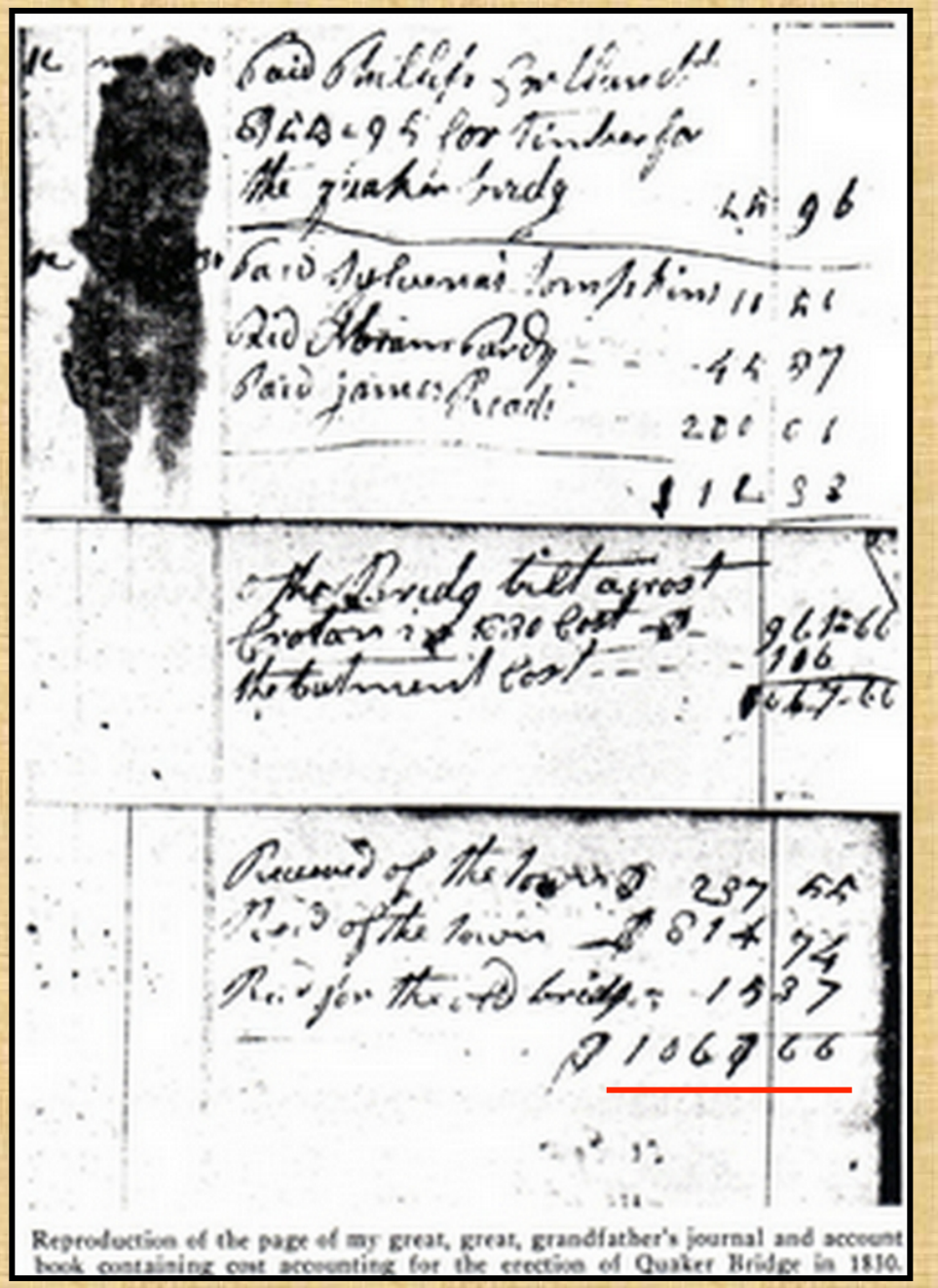
Preble County, Ohio

1865

Covered Bridge Costs

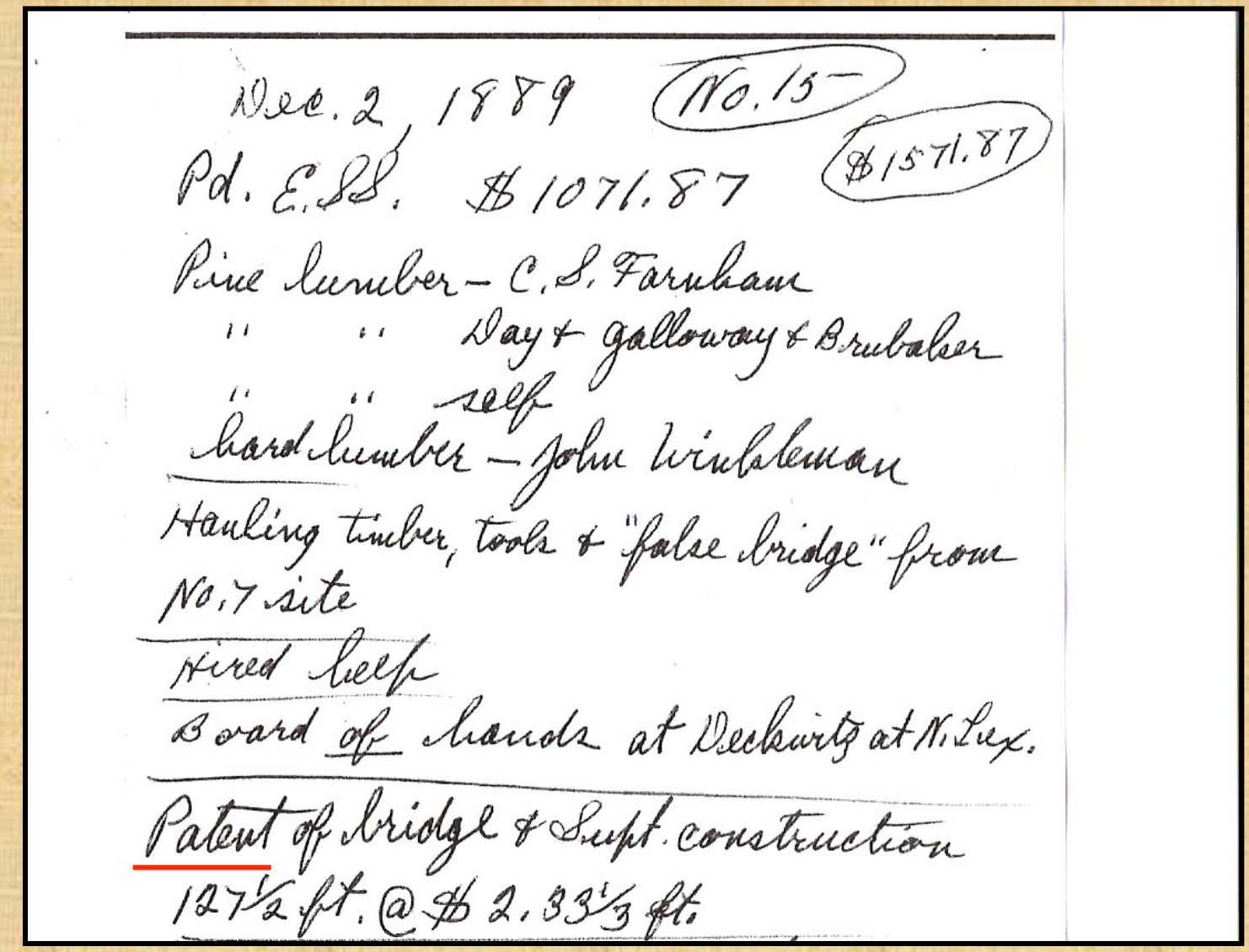
Quaker Covered Bridge, Croton, New York

Built in 1830 for $1067.66



Reproduction of the page of my great, great, grandfather's journal and account book containing cost accounting for the erection of Quaker Bridge in 1810.

Covered Bridge Costs



Dec. 2, 1889 No. 15 — $1571.87

Pd. E.S.S. $1071.87

Pine lumber – C. S. Farnham

" " Day & Galloway & Brubaker

" " self

Hard lumber – John Winkleman

Hauling timber, tools & "false bridge" from No. 7 site

Hired help

Board of Hands at Decksville at N. Lex.

Patent of Bridge & Supt. construction

127½ ft. @ $2.33⅓ ft.

Construction of Covered Bridges

Building a CB in Oregon, 1902

Part 1 of 3

Arthur C. Striker, who worked on a construction crew superintended by his father, Aaron Noble Striker, bridge contractor, has described the erection of a covered bridge at Horse Creek, about fifty-five miles up the McKenzie from Eugene.

When the contract was let in 1902, wagons with tools and equipment set out for the bridge site, where a camp was set up. A partial list of tools includes axes, adzes, shovels, picks, hand saws, splitting froes, sledges, splitting mauls, dollies, truss rods, augers, jacks, peavies, hammers, nails, ropes, hand winches, drift pins, rifles, shotguns, and fishing equipment. No lumber was taken, because all such material was available at the site, where even the shingles and clapboards were rived. About six to eight men were required for the job, their pay scale being $2.50 per day, and every man was expected to be able to perform any part of the work necessary.

Building a CB in Oregon, 1902 Part 2 of 3

Bents were put on each side of the river. Heavy cedar logs were placed on level bedrock if possible, and drifted. Several holes were bored through the logs, and steel drift pins were driven in and through to the rock. The main posts were dapped into the mud sills, and dapped into the cap. Instead of sway braces, we placed diagonal posts inside of end posts and main bents. The posts were leveled, and sawed off before being capped.

After the bent was put in, the lower falsework went up, and work on the truss was started. After we placed the lower chord, we set the upper chord on the falsework directly above the lower chord, about fourteen feet. Then we placed diagonals between the two chords. At each panel we put in cross-ties on the upper chords, then dropped in rods, and tightened. A hand winch was used for raising diagonals and upper chords.

The next step was to swing the truss, which meant to tighten the truss rods, first at one end, then at the other, working toward the center. Then the useable lumber was salvaged from the falsework, and the remainder broken up to float downriver.

Building a CB in Oregon, 1902

Part 3 of 3

Striker's description of hand-hewing beams is easily understood. "First have a chalk line to hew to. Chop plumb notches, then slab off to the line. Score into the line, and hew to the face of the stick. When two faces are hewed, tip over, level, and draw line same as before."

Life in this bridge builder's camp was hearty. "There was plenty of fresh fish for the table, and game was plentiful. Fresh eggs and milk were often supplied by farmers. The food was plain, but it was wholesome and plentiful. A man from the crew would cook. He would prepare meals and all the men would help him wash the dishes. The cook would then join the crew and work on the bridge. The men fished some after supper, but usually went to bed early, having worked about a ten-hour day. No drinking was permitted in my father's crew, nor any profanity."[47]

Taken from "Oregon Covered Bridges" by Lee H. Nelson

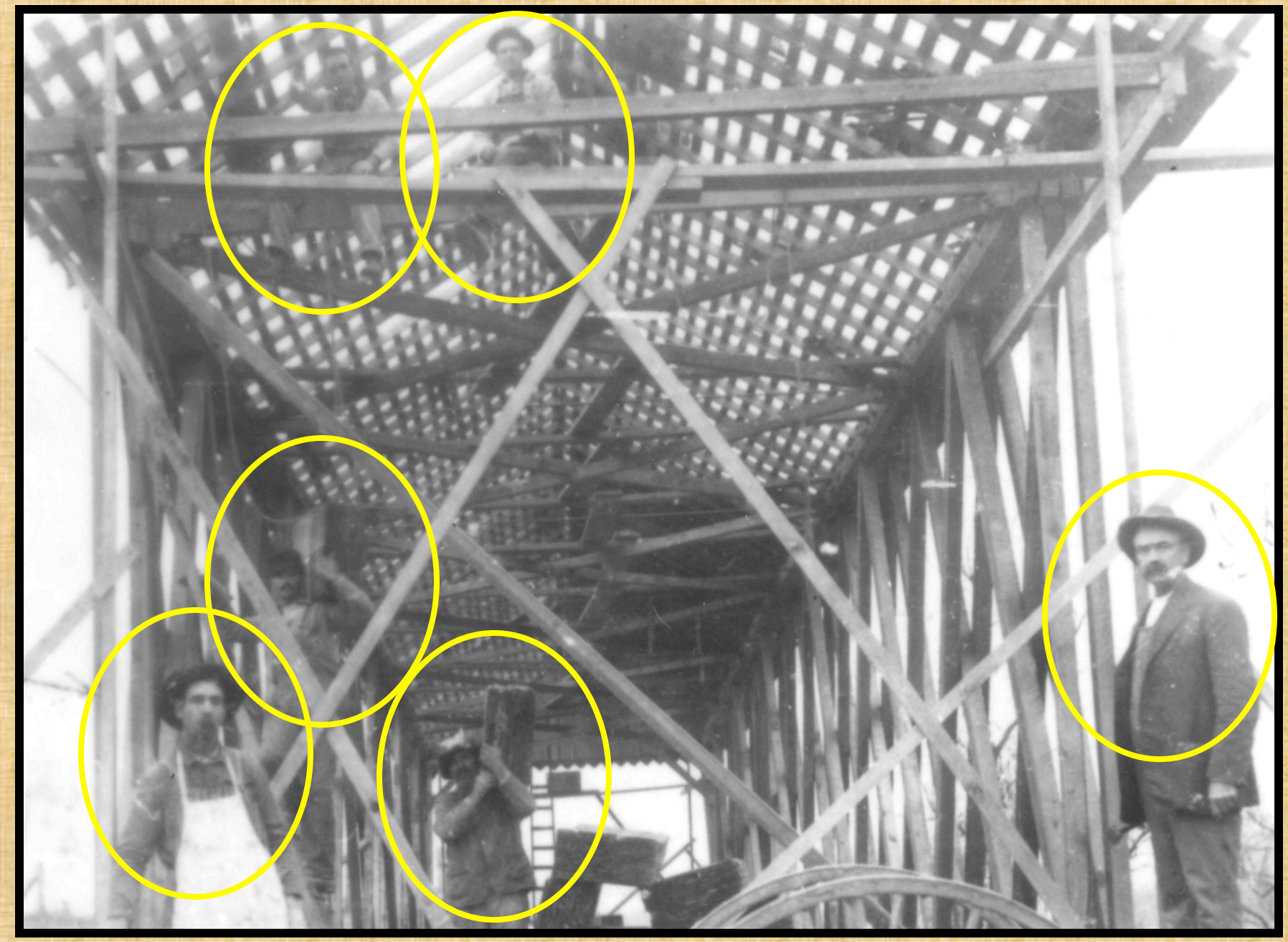
The Bridge Crew

Kentucky

Straight Shoot Bridge

1907

Kentucky pictures contributed by Melissa Jurgensen



Proud Crew Shows the Ladies their Project

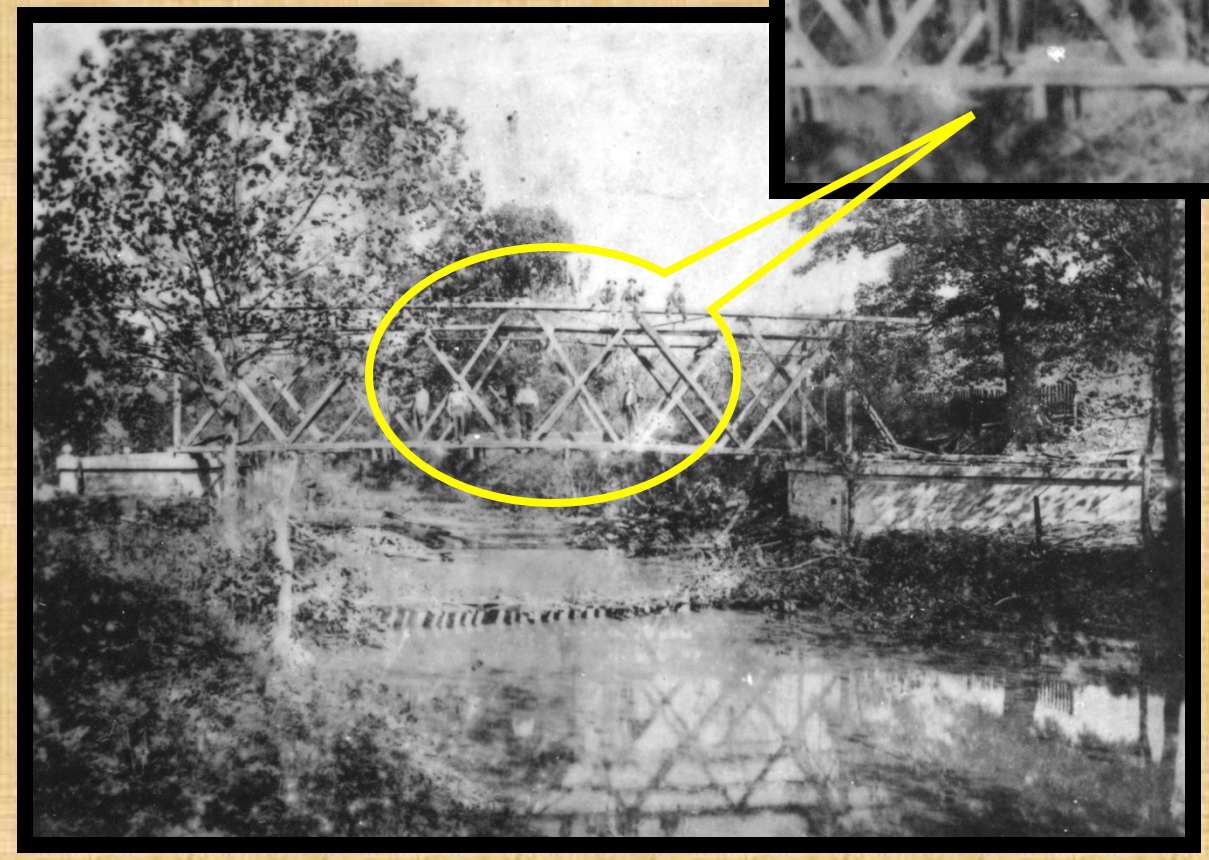
Lowell Bridge, Oregon, 1907

Ohio Bridge Crew (location unknown)

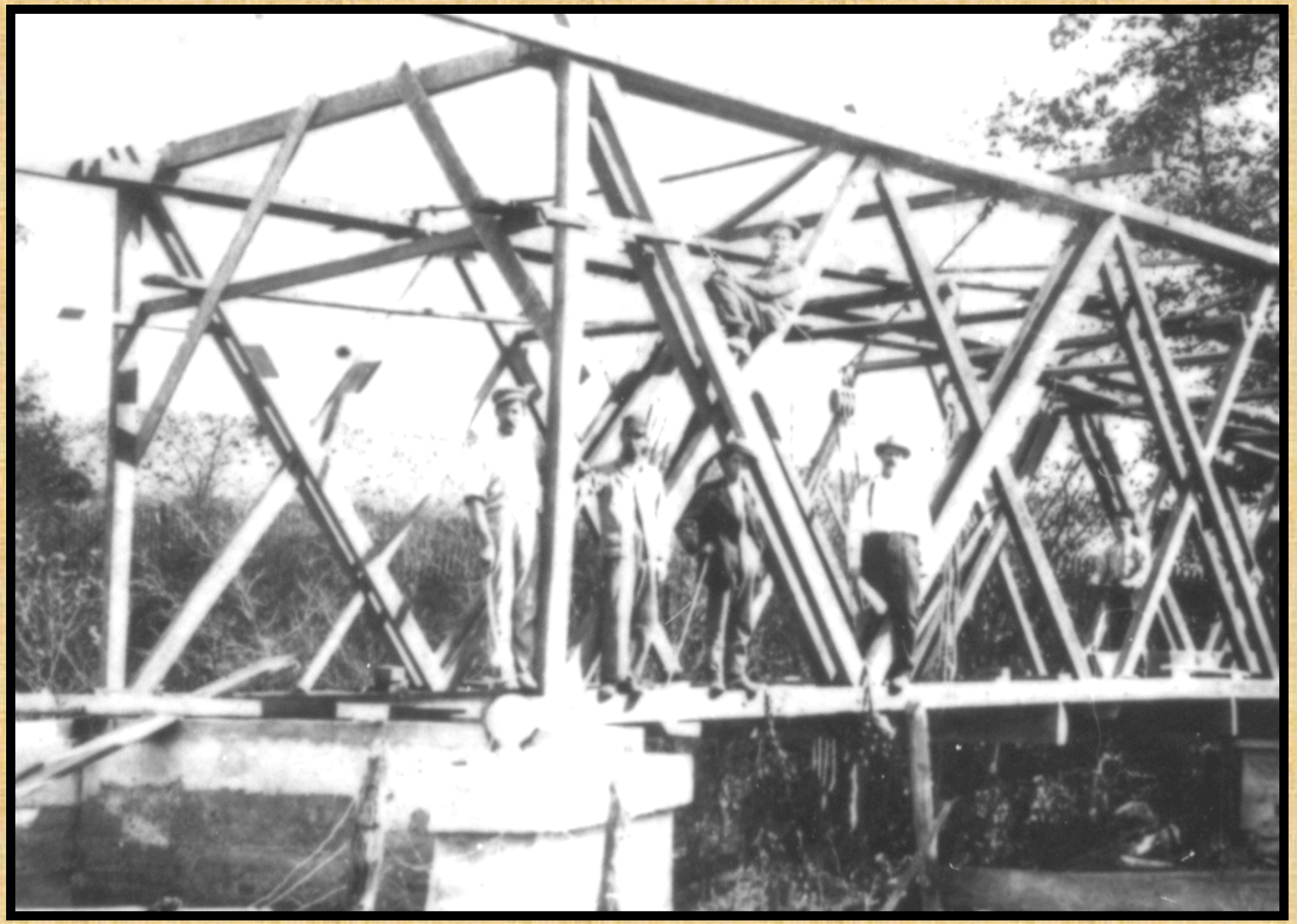
Photo from David Simmons, Ohio Historical Society

And if you have a bunch of CCC guys, you can have a really big crew

Dalesburg, Kentucky Builders 1908

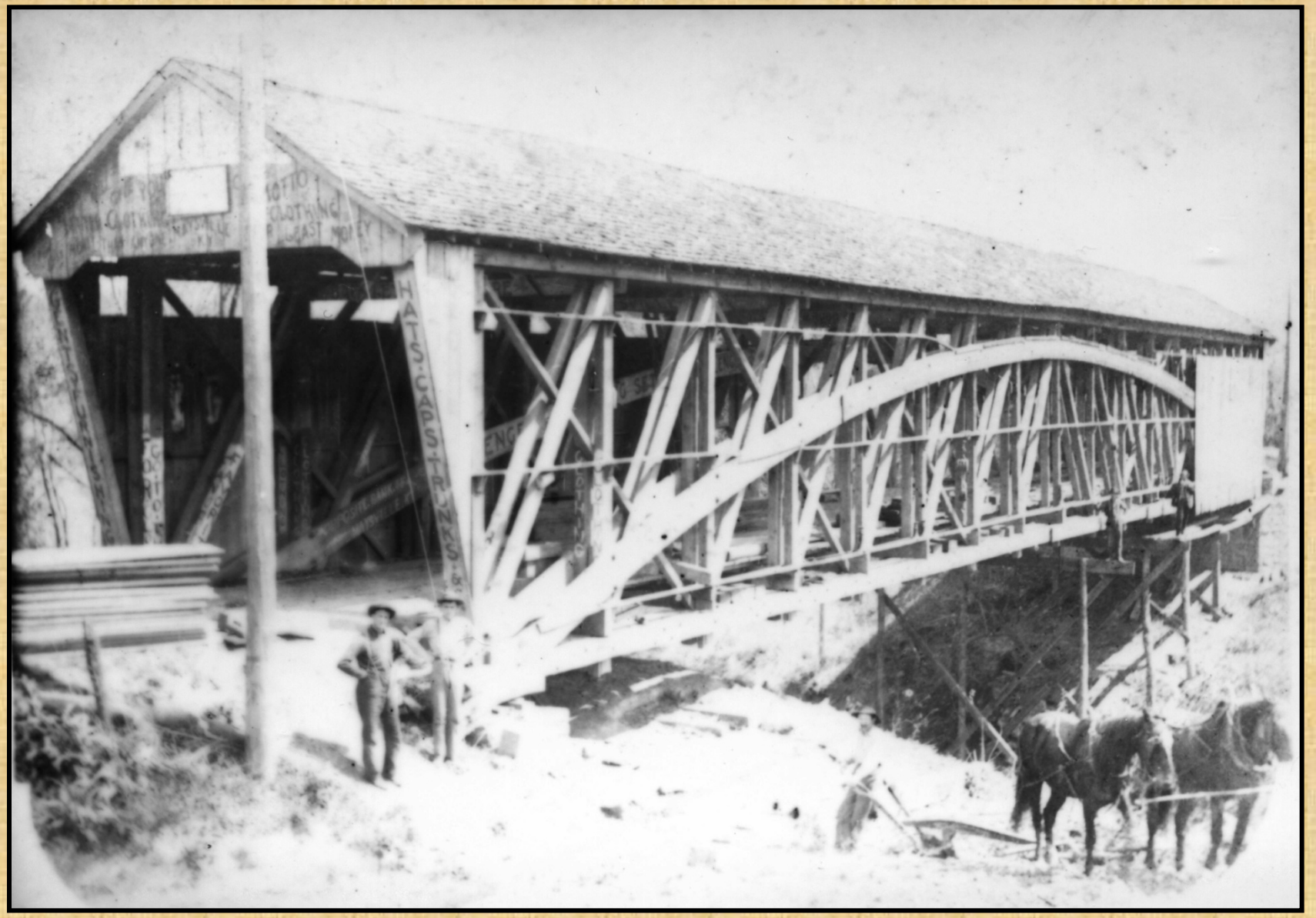


Dalesburg, Kentucky 1908

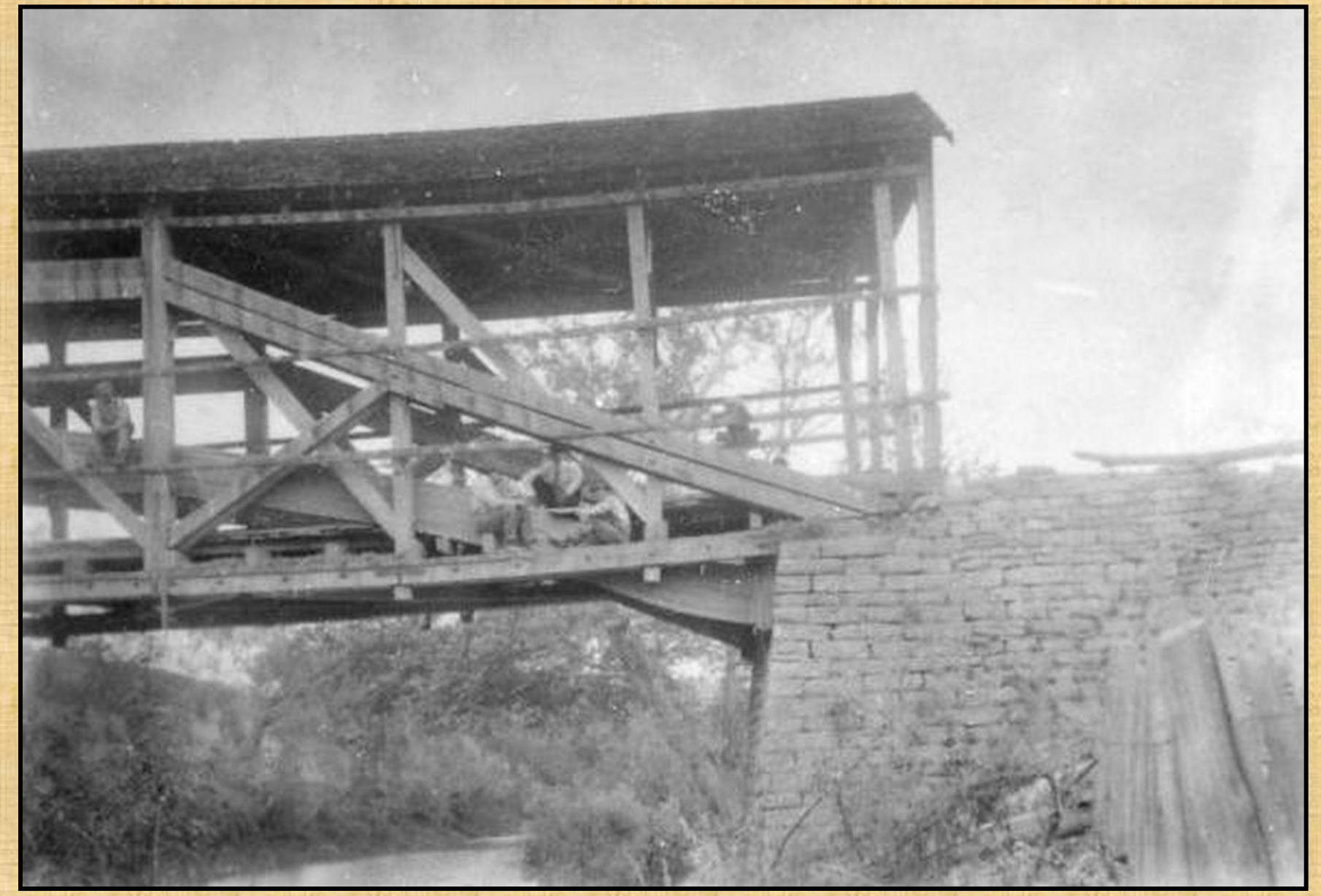


Morgan, Kentucky 1905

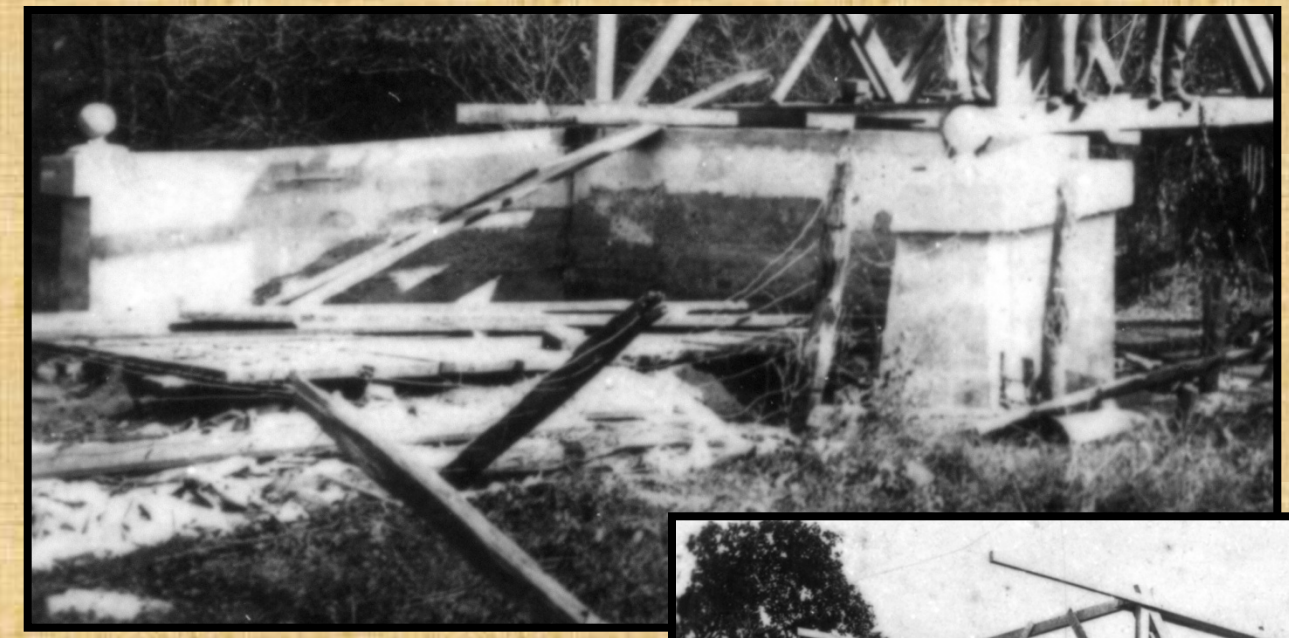
Mayslick, Kentucky 1905



Arch Stressed, Kentucky



Building a Covered Bridge

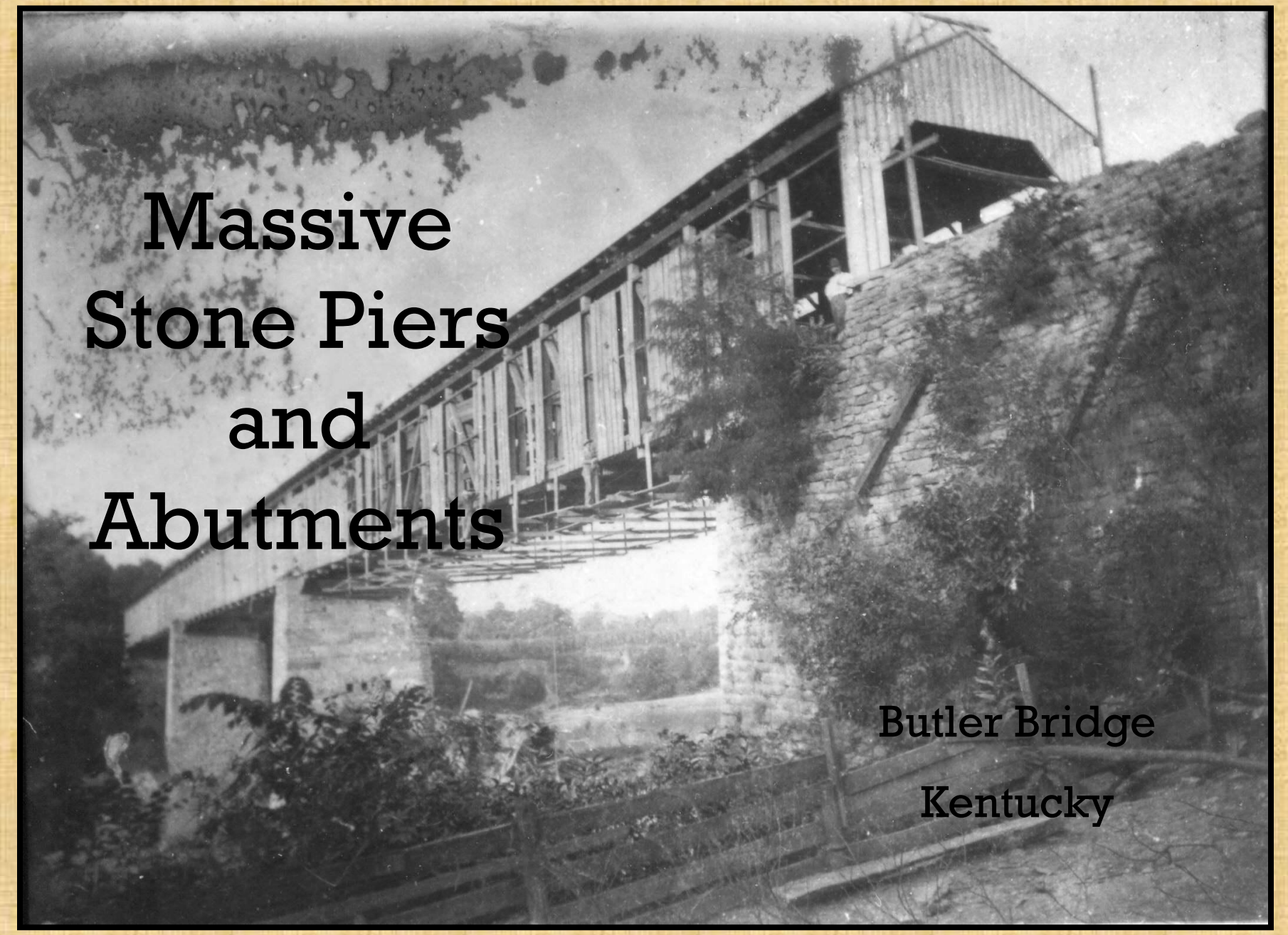


First, Abutments (and Piers)

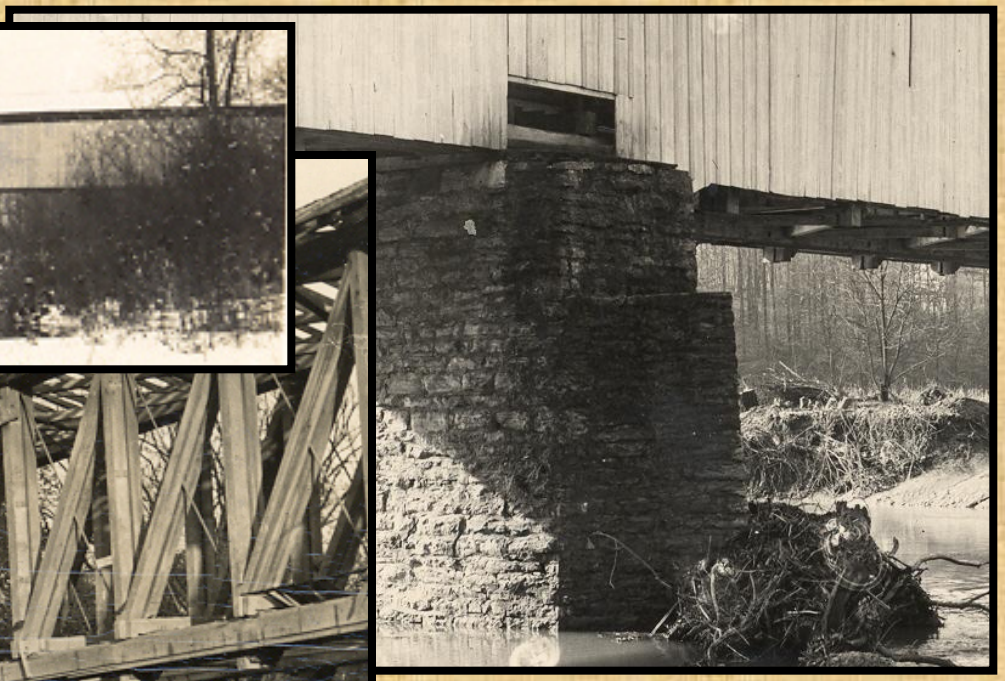
Abutments are usually made from locally quarried stone, or concrete poured in hand-made wood forms

Dalesburg, Kentucky

1908


Massive
Stone Piers
and
Abutments
Butler Bridge
Kentucky

Limestone Abutments and Pier

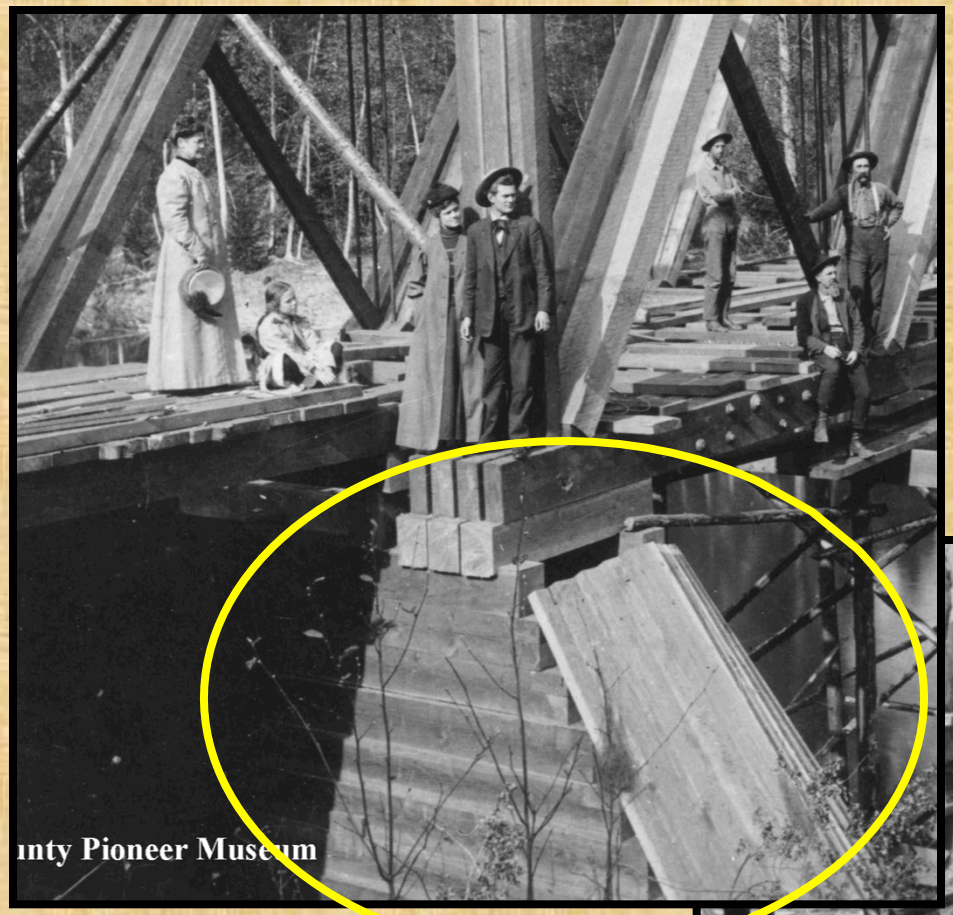


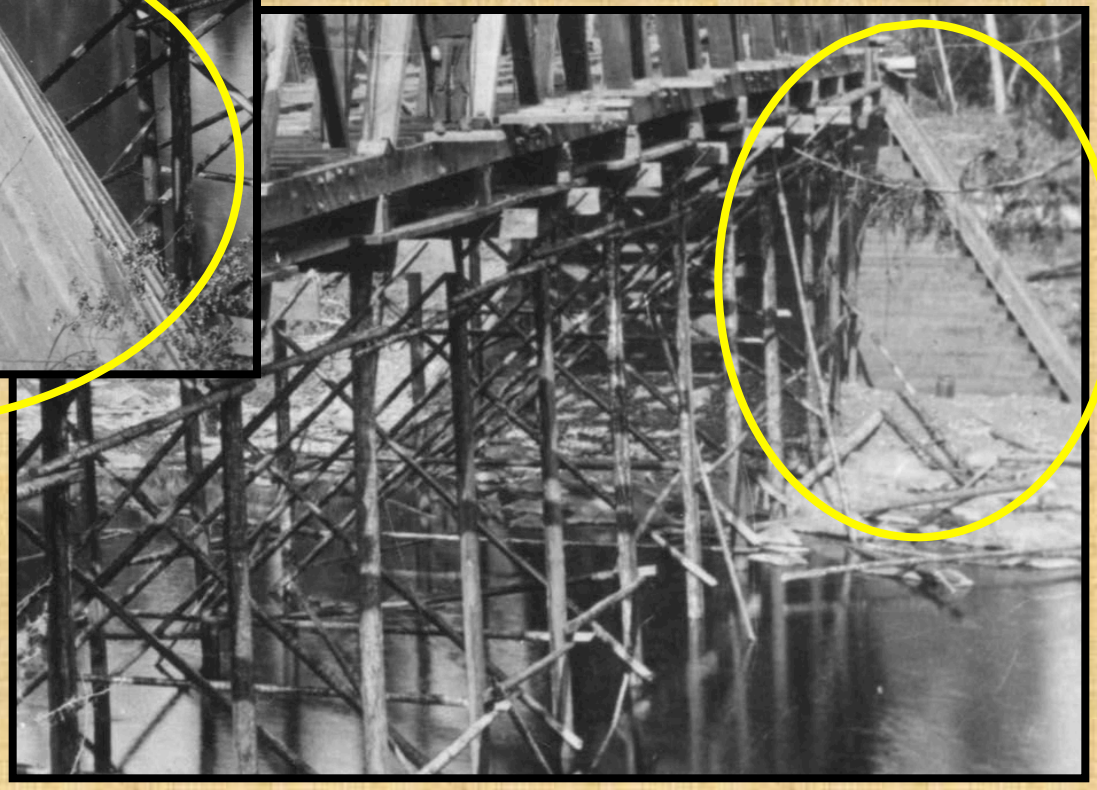
The Last Winchester Covered Bridge

Preble County Ohio

Demolished 1947

Timber Abutments used in the West





Building the Temporary Falsework

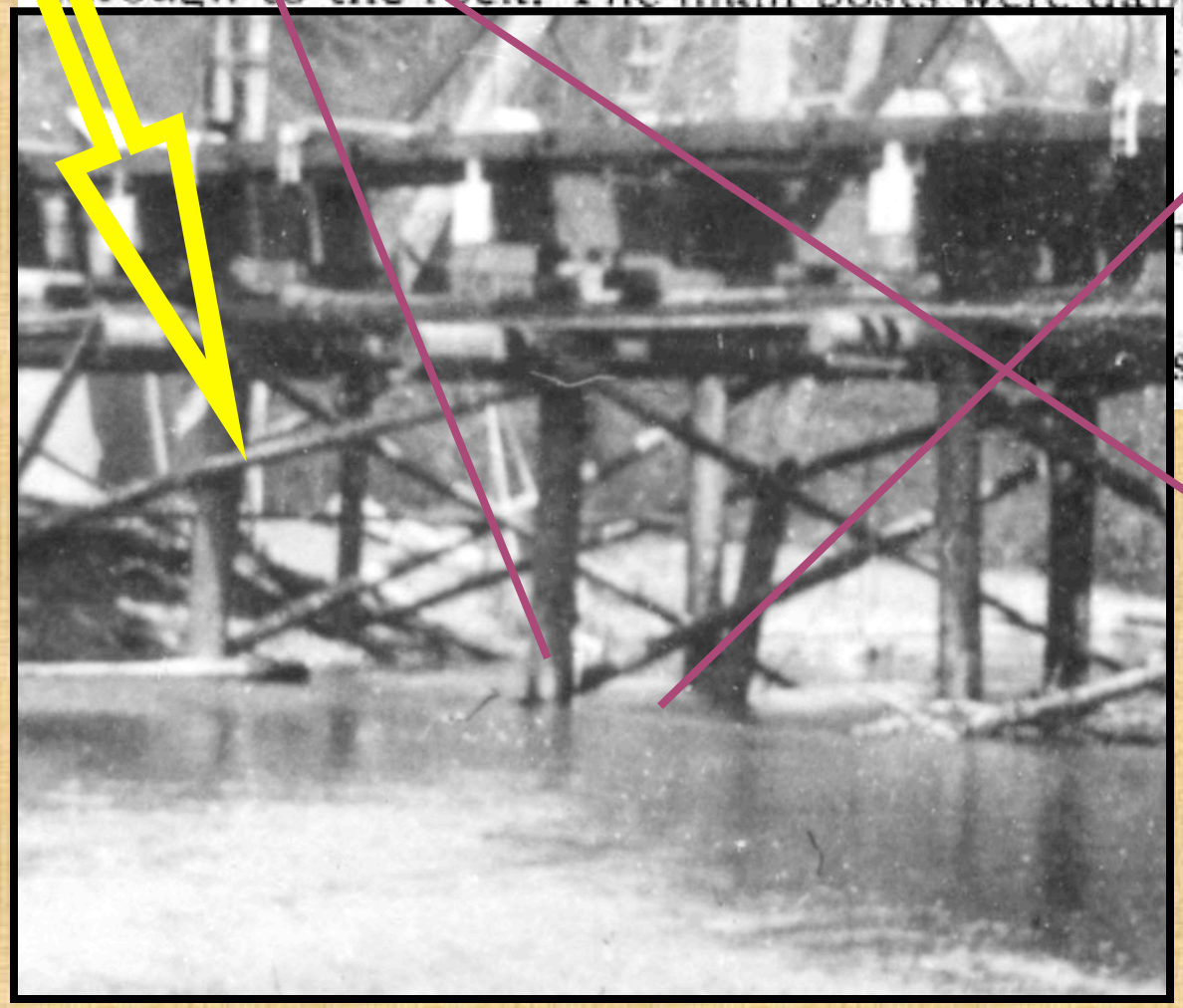
Bents were put on each side of the river. Heavy cedar logs were placed on level bedrock if possible, and drifted. Several holes were

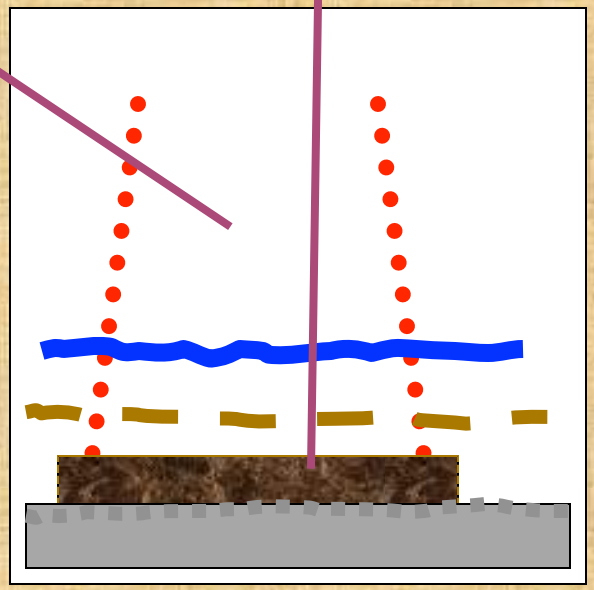
rough to the rock. The main posts were dapped into the mud sills,

es, we placed diagonal

he posts were leveled,

sework went up, and

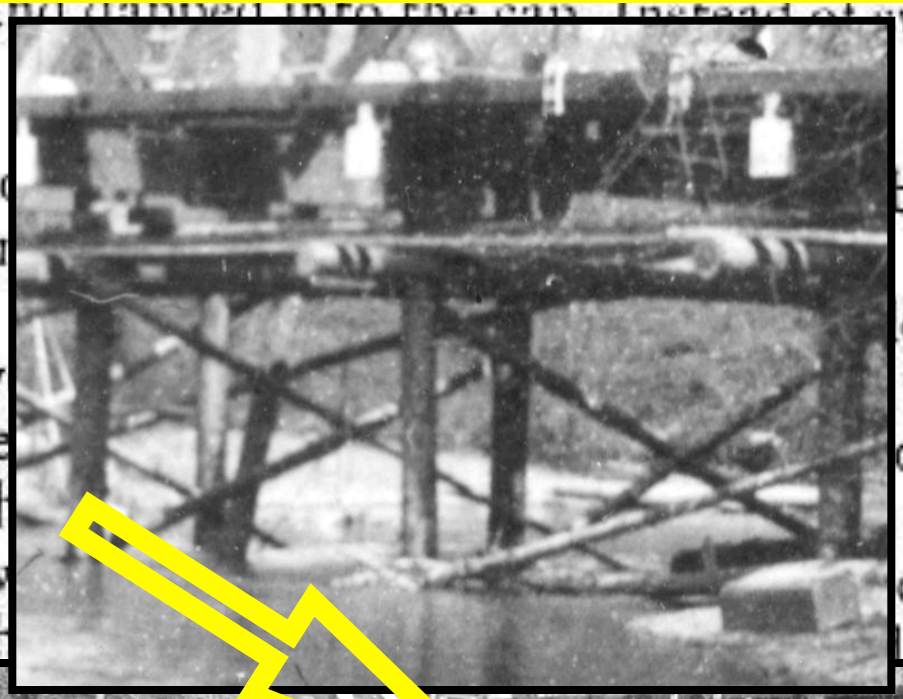


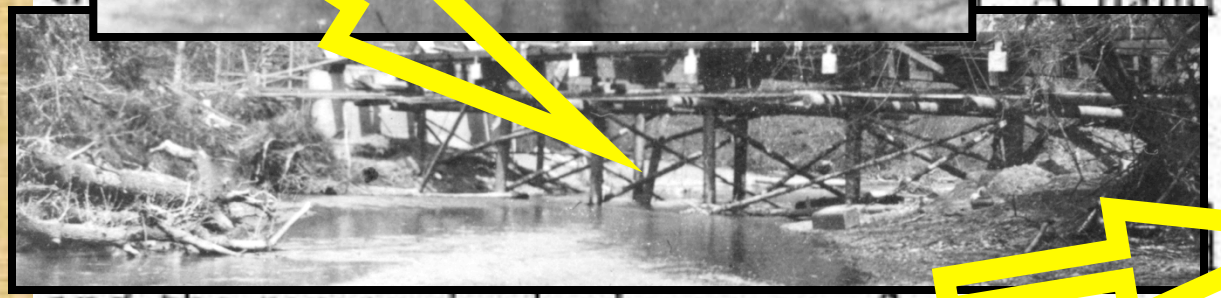


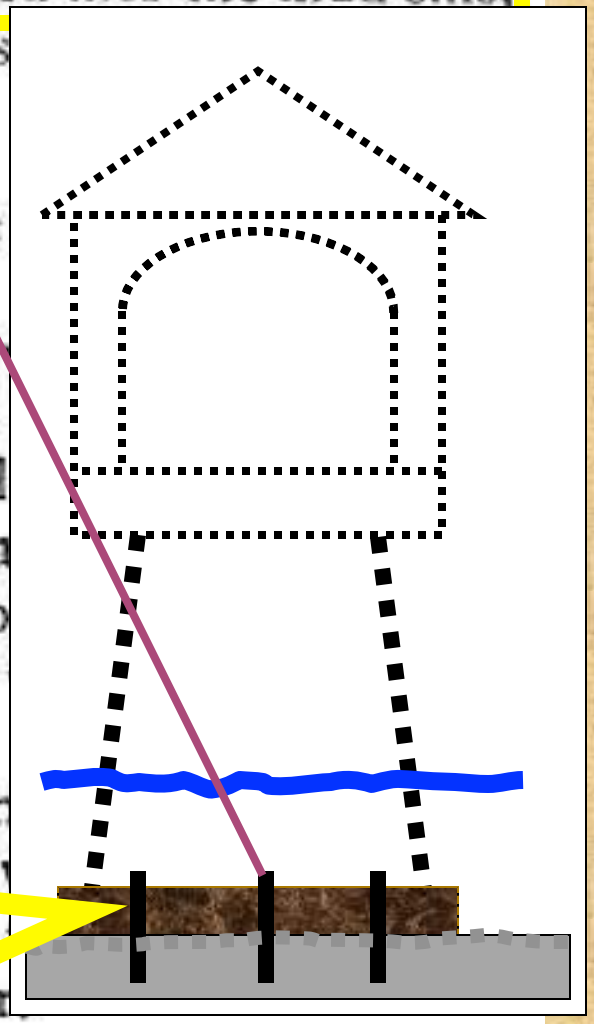
Building a CB in Oregon, 1902

Part 2 of 3

Bents were put on each side of the river. Heavy cedar logs were placed on level bedrock if possible, and drifted. Several holes were bored through the logs, and steel drift pins were driven in and through to the rock. The main posts were dapped into the mud sills,

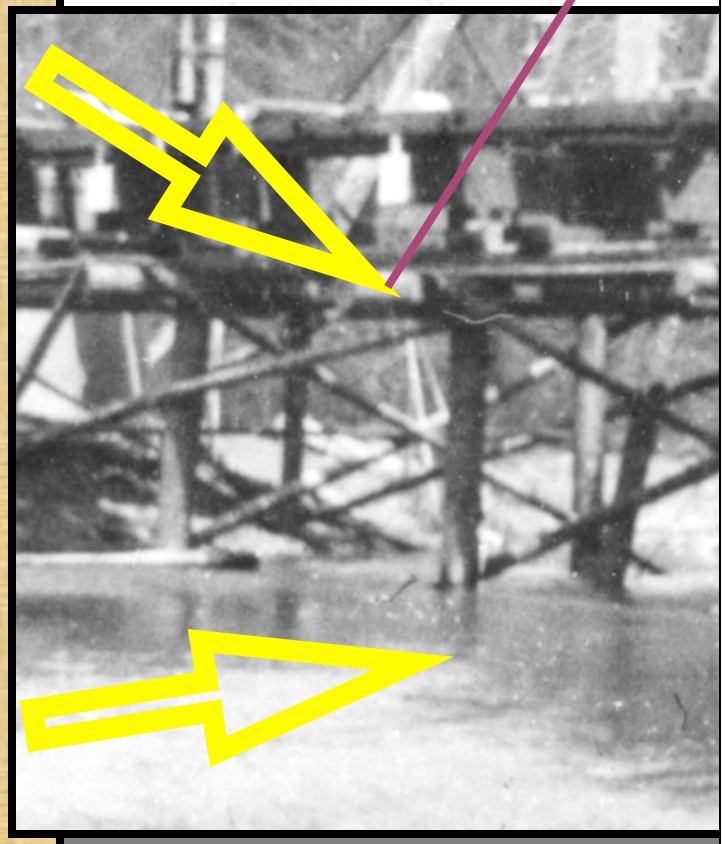


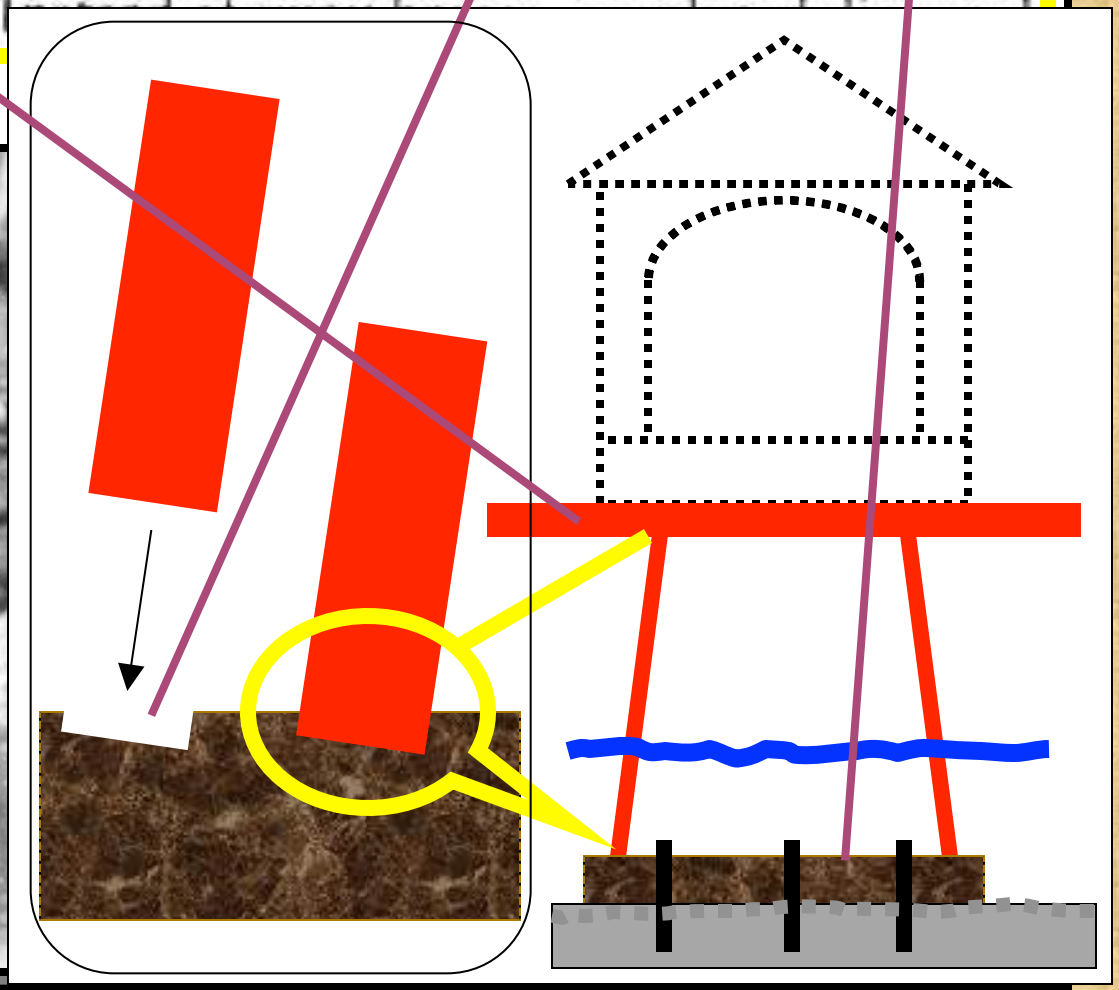




Building a Covered Bridge

Bents were put on each side of the river. Heavy cedar logs were placed on level bedrock if possible, and drifted. Several holes were bored through the logs, and steel drift pins were driven in and through to the rock. The main posts were dapped into the mud sills, and dapped into the cap.



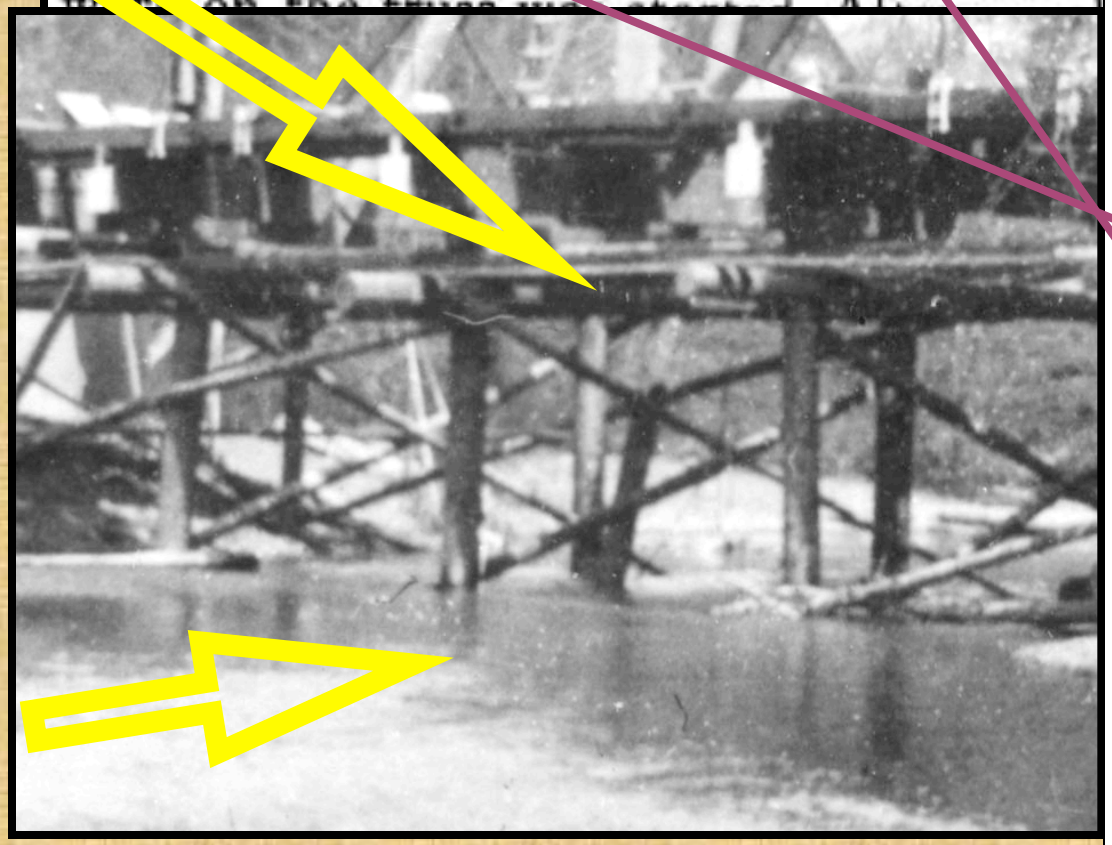


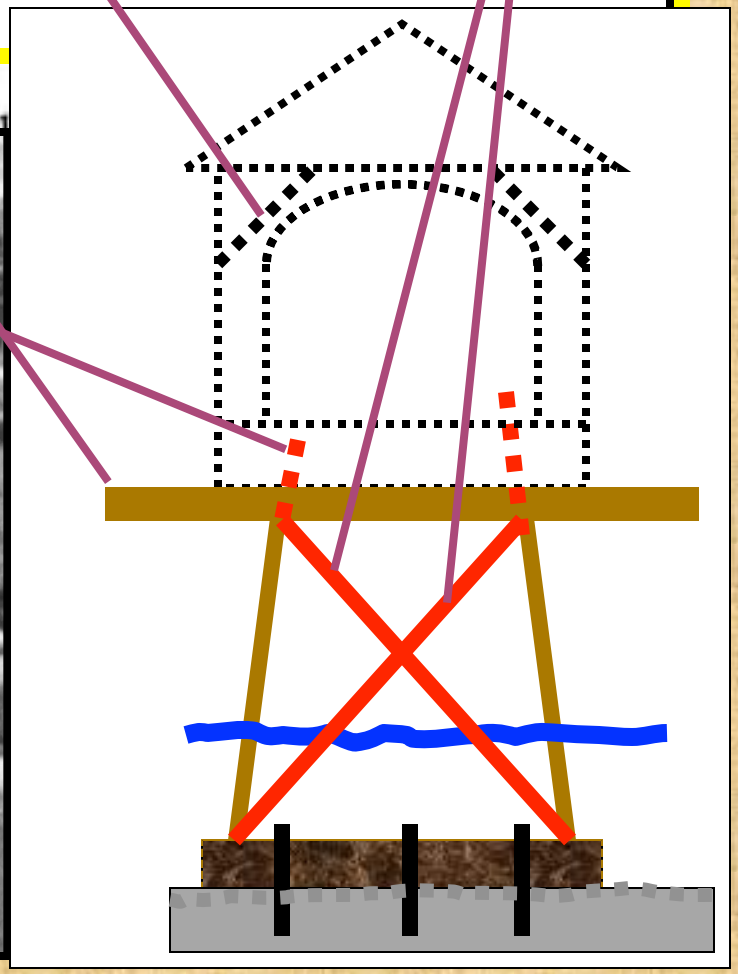
Building a Covered Bridge

through to the rock. The main posts were dapped into the mud sills, and dapped into the cap. Instead of sway braces, we placed diagonal

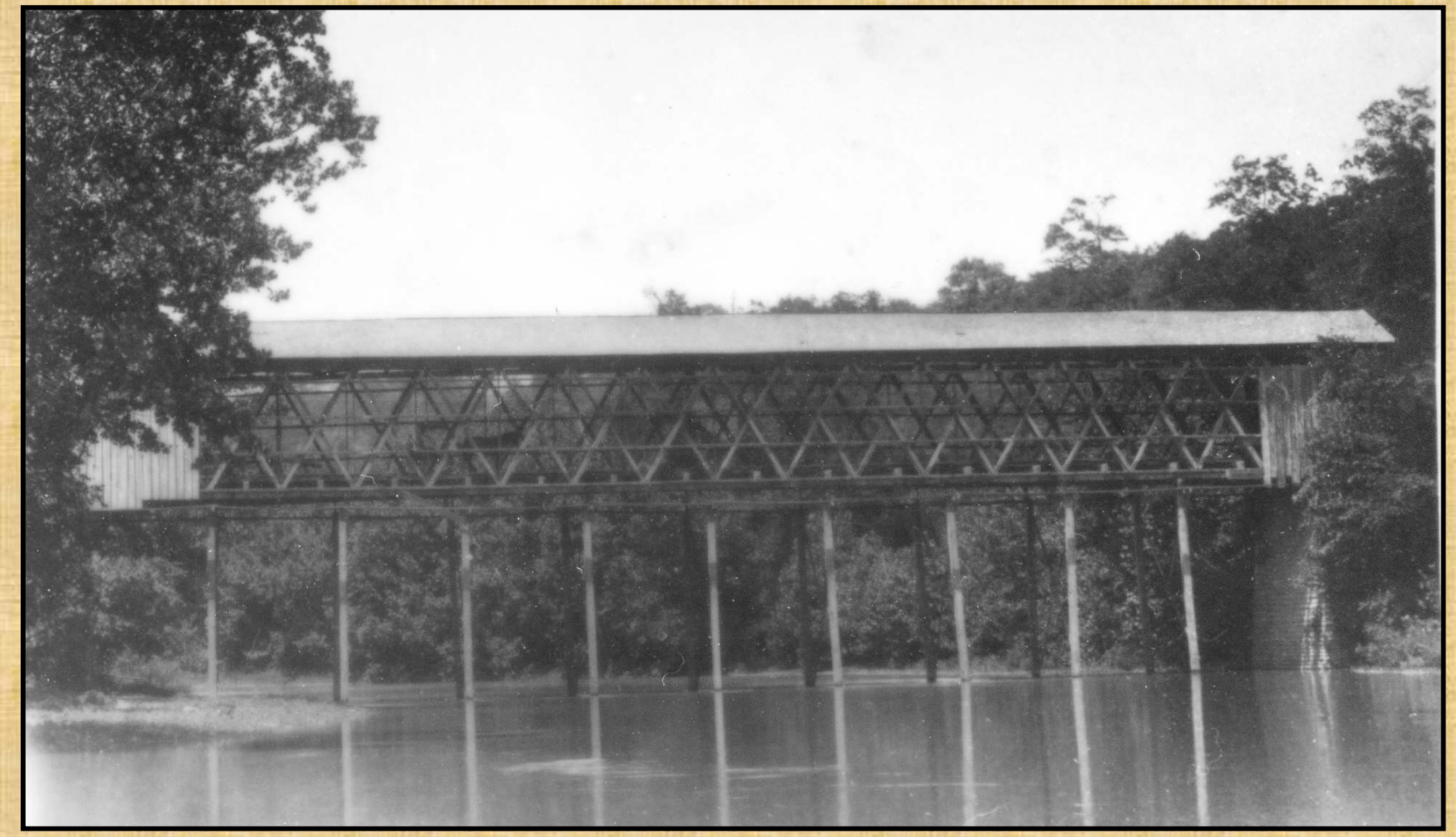
posts inside of end posts and main bents. The posts were leveled, and sawed off before being capped.

After the bent was put in, the lower





Falsework across a major river



Pike Street Bridge, Kentucky

Cables from the Ends

Oregon

Preparing the Lumber

- **While some of us have been getting this temporary falsework built in the creek, the rest of our men have been selecting trees, cutting and hauling logs, and going ahead with hand hewing some of the larger pieces out there where they fell, in the woods. Everything is brought for final cutting to our "bridge yard", in this case at one end of the bridge.**

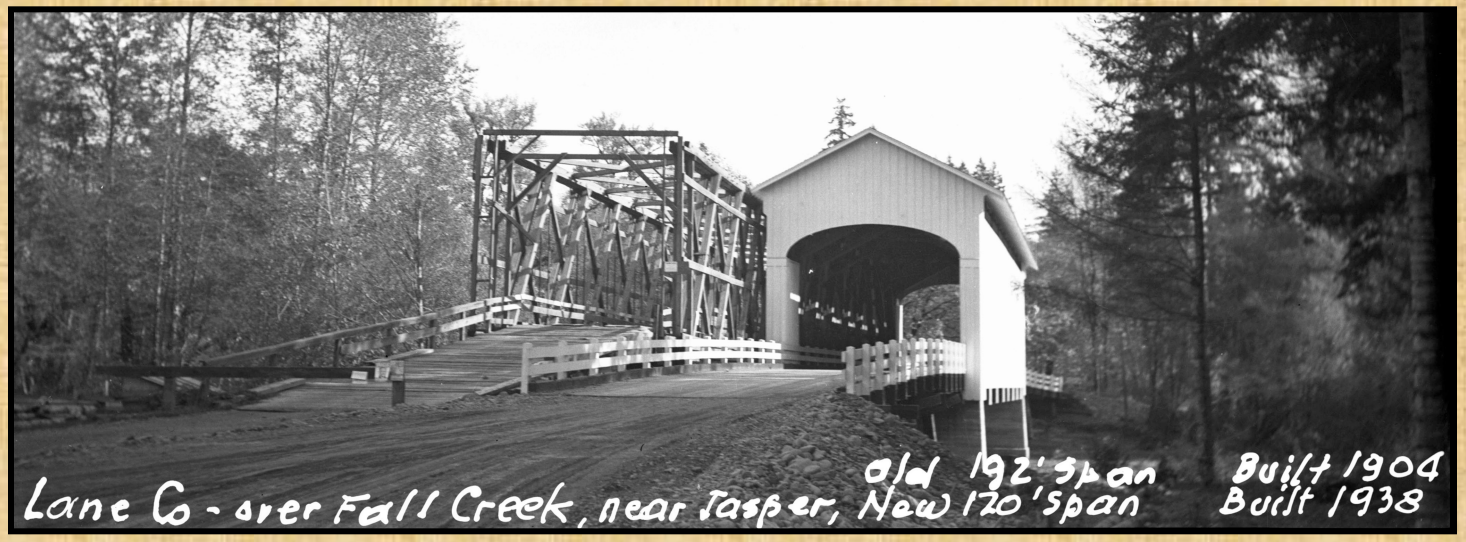
These "first person" accounts are written herein by Doug Kramer, taking "journalistic license" to more completely explain the construction process, and are based on personal construction experience and research of available covered bridge historical publications.

The "Yard"

A Bridge Site "Yard" from the 1940's

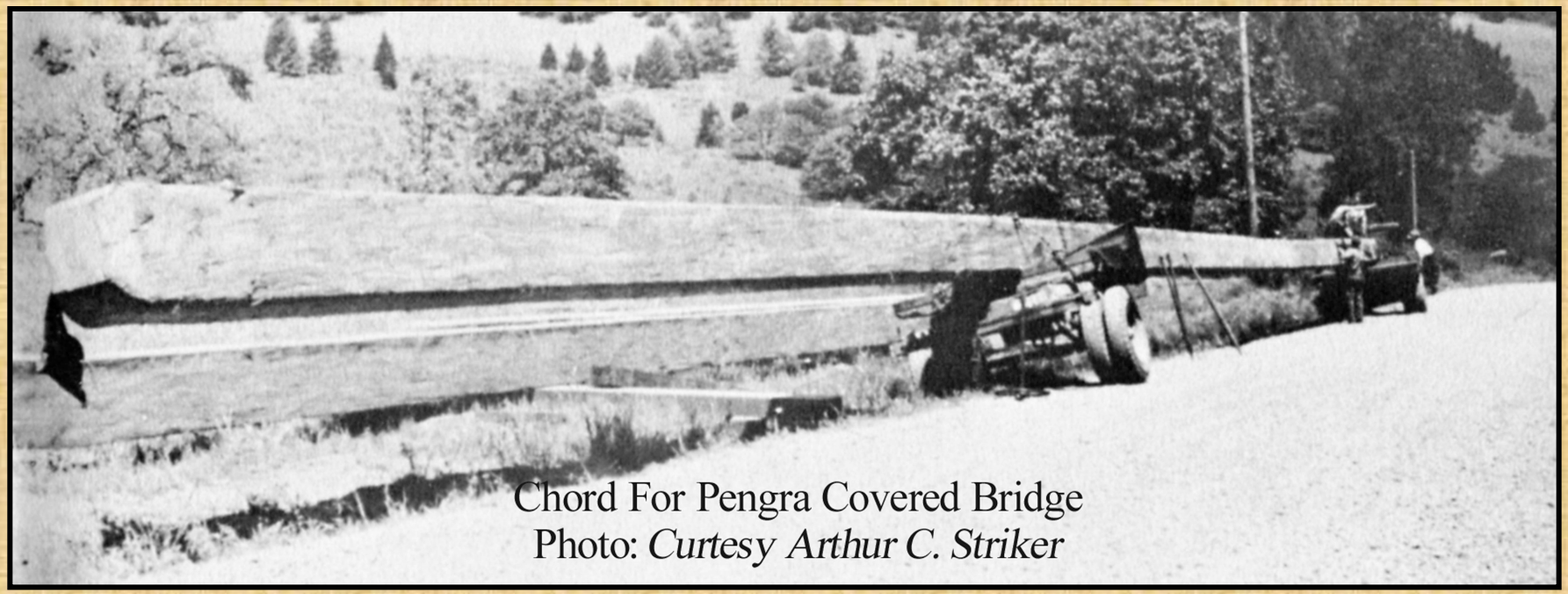
Another "Yard" Scene

Assembling and Numbering the Chord Pieces for a Trial Fit



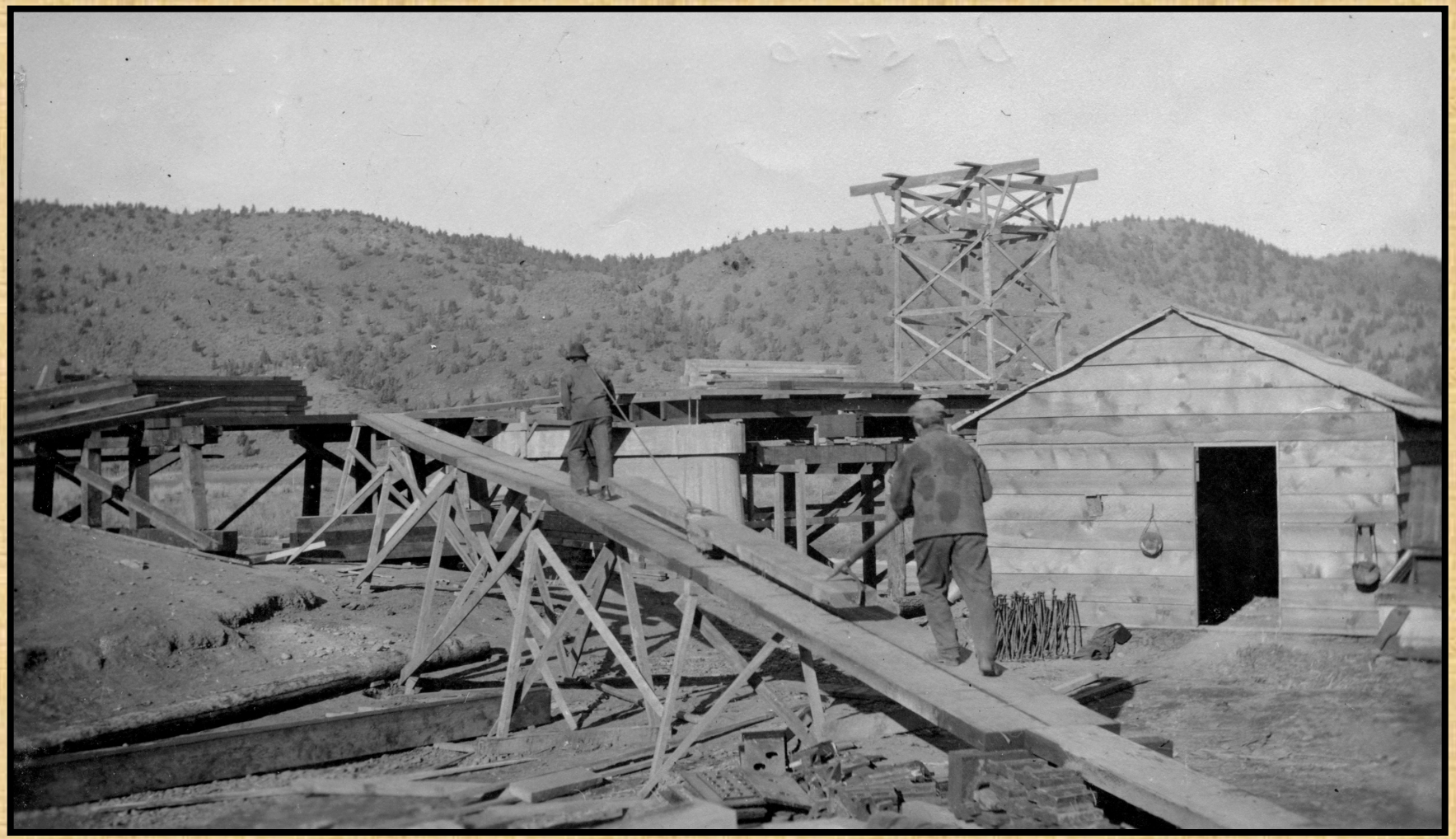
Oregon, long timbers !

1938



Chord For Pengra Covered Bridge
Photo: *Curtesy Arthur C. Striker*

Dragging Timbers Out to the Bridge



So, we are now to the first parts of the bridge or falsework that are too heavy for a few of us to lift up by hand and set in place. Even some heavy timbers, like the parts of lower chords, were at least to be located down low and horizontal, so up to this point in the project we could drag them across and use pry bars and rollers to slide them into their final position.

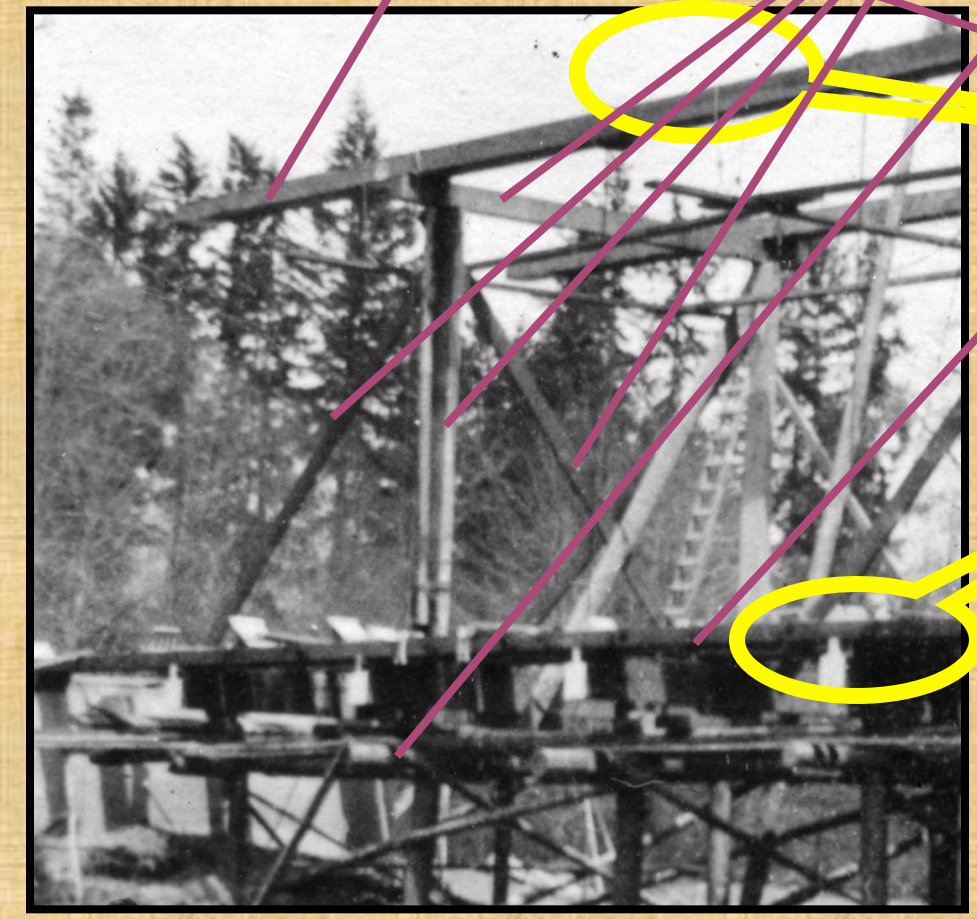
We will need some mechanical lifting assistance for this next phase.

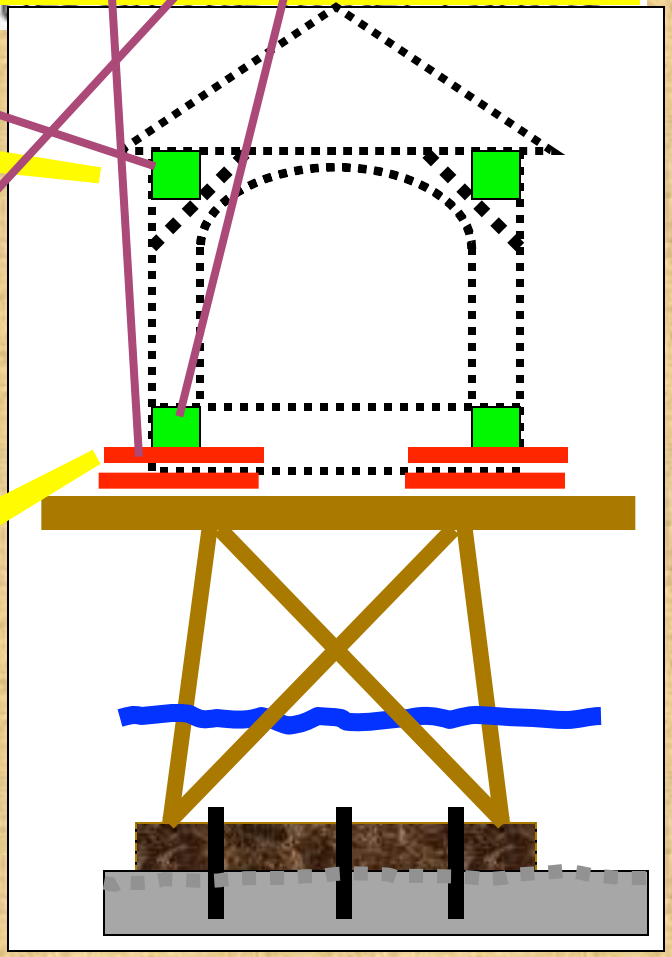
Gin Pole

(Cable-Supported) with Block and Tackle Oregon 1920's

Building a Covered Bridge

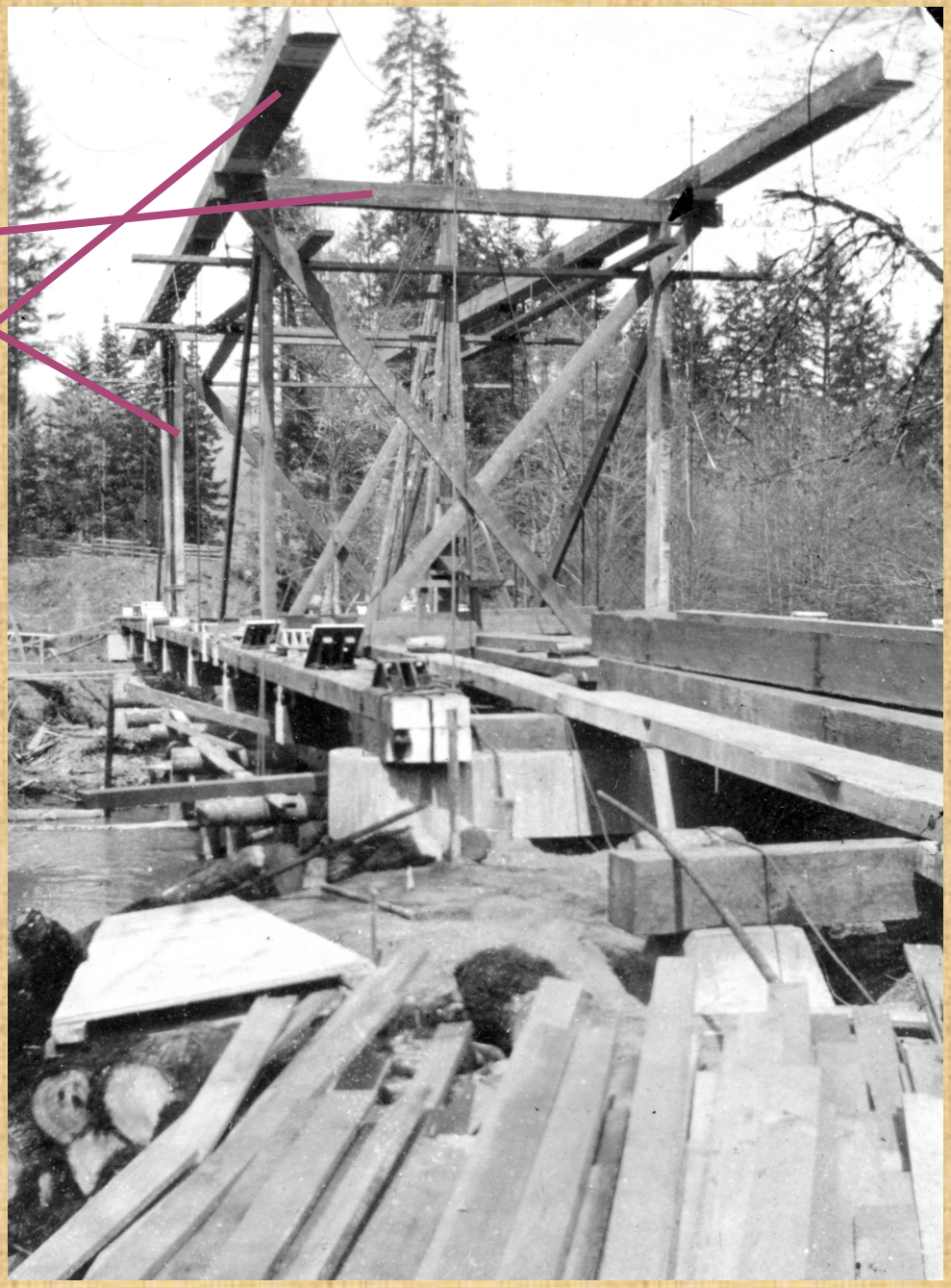
After the bent was put in, the lower falsework went up, and work on the truss was started. After we placed the lower chord, we set the upper chord on the falsework directly above the lower chord, about fourteen feet. Then we placed diagonals between the



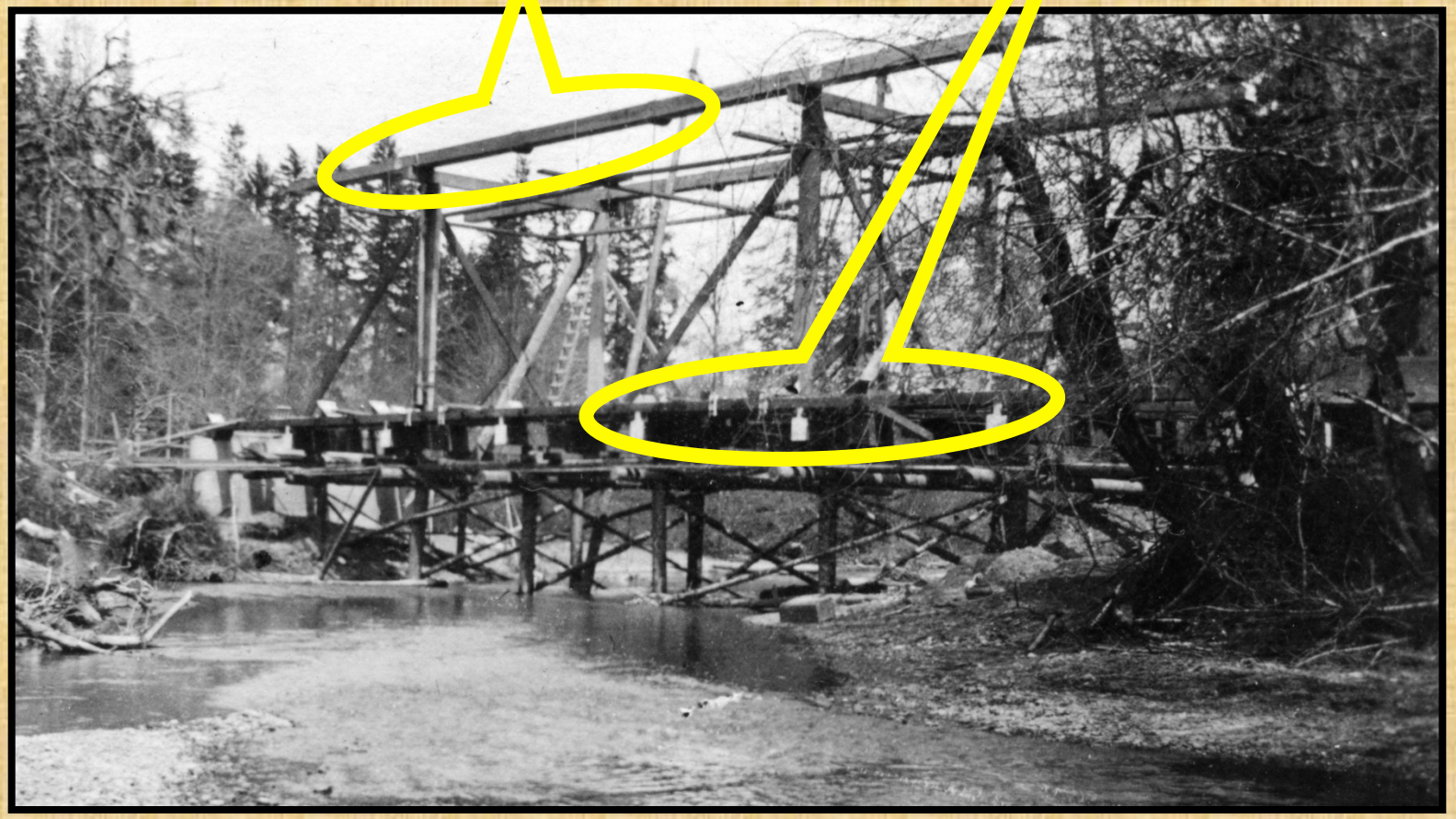


So we're here now. We laid some planks across from bent to bent, and carried out each floor beam (cross beam) and set it crosswise on the lower falsework, in it's final position. We laid some temporary walk boards across those, then carried out chord pieces and put together the lower chords in place on top of the floor beams.

Now we have built our upper falsework, bracing it in both directions to prepare to support the upper chords. We have assembled the upper chords and hoisted them up and over onto the tops of the cross pieces of the upper falsework.



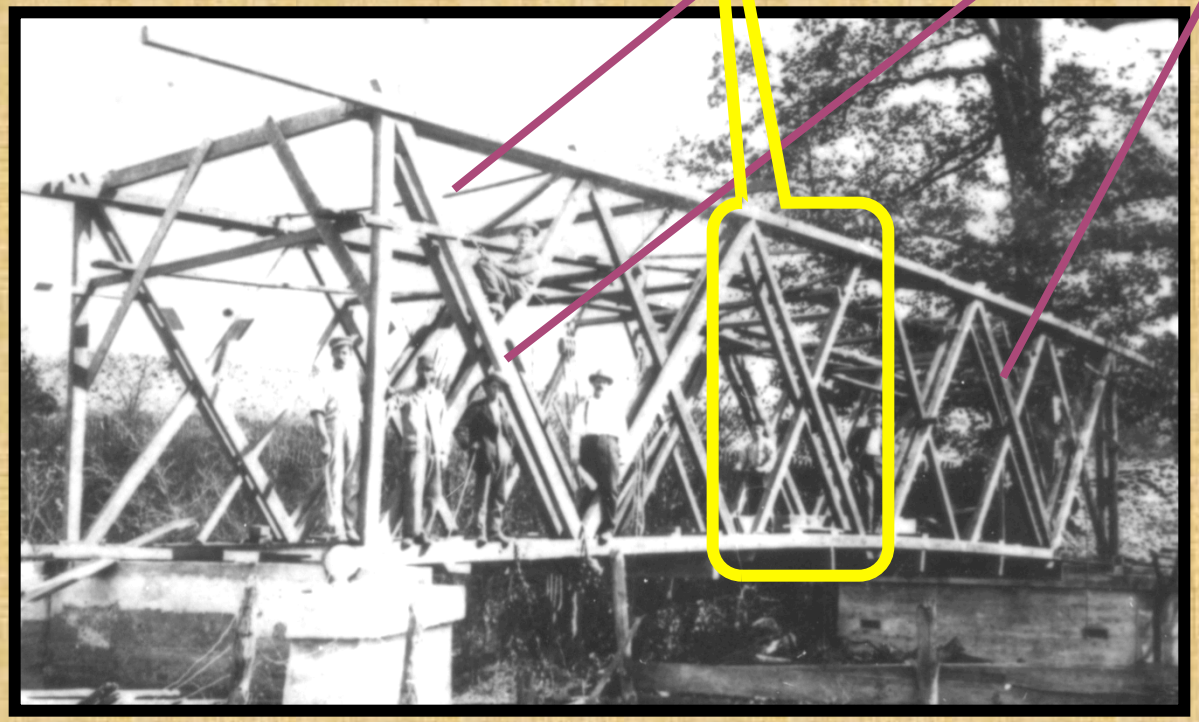
So far, we have our Lower Chords set on our Temporary Falsework and the Upper Chords propped up in place.



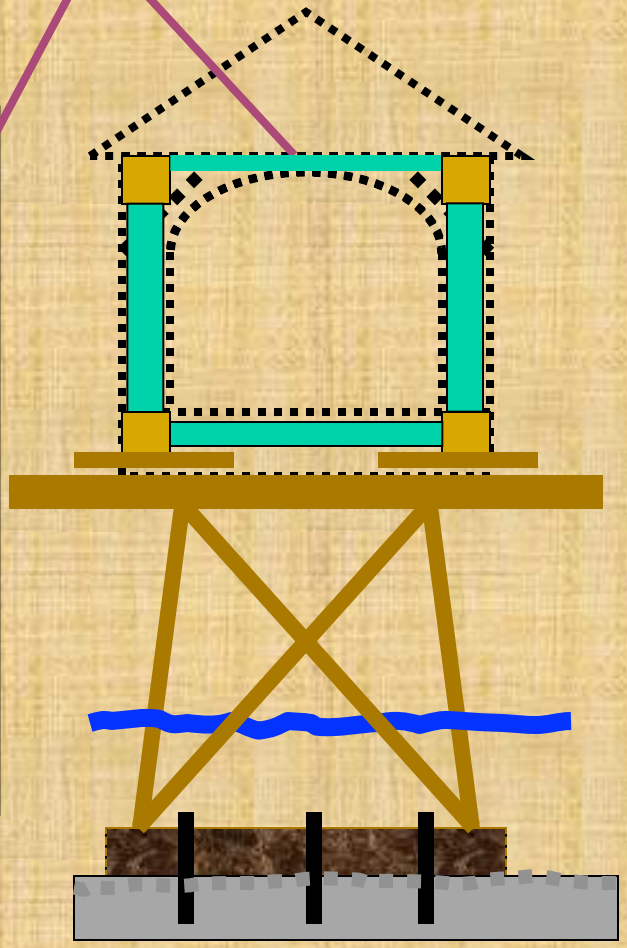
We sure need the big rains to hold off for another two months or so.

Building a Covered Bridge

chord, about fourteen feet. Then we placed diagonals between the two chords. At each panel we put in cross-ties on the upper chords, then dropped in rods, and tightened. A hand winch was used for raising diagonals and upper chords.



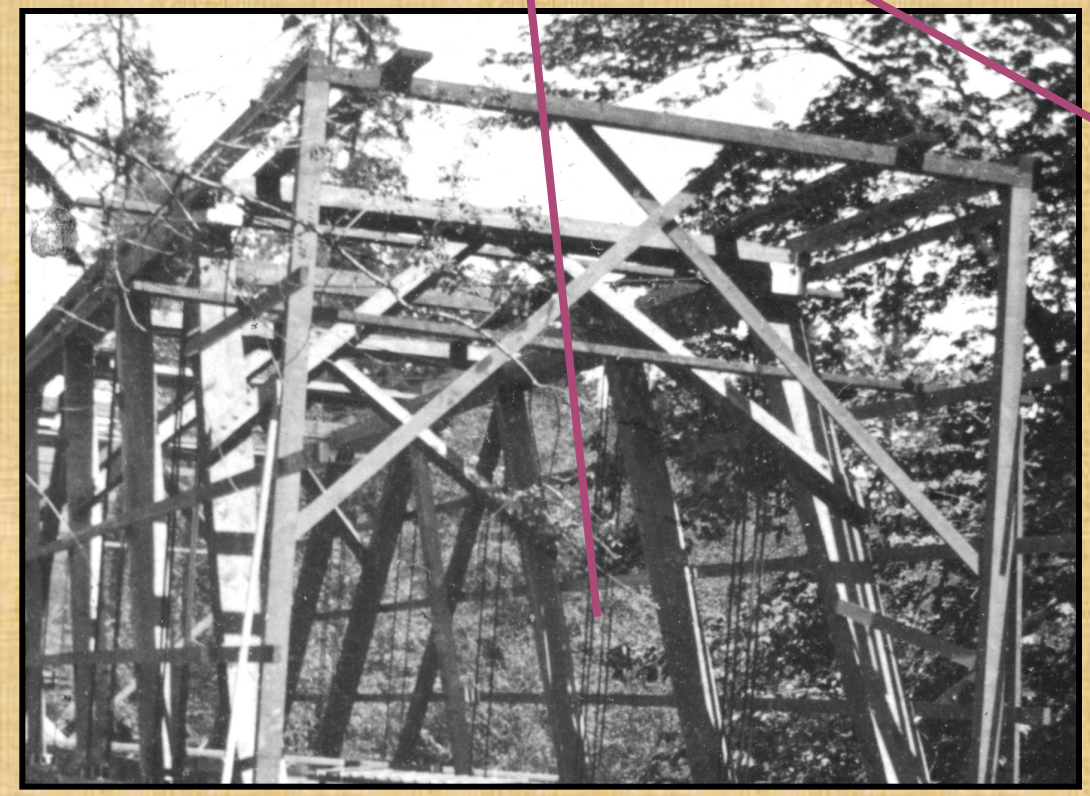
Dalesburg, Kentucky 1908

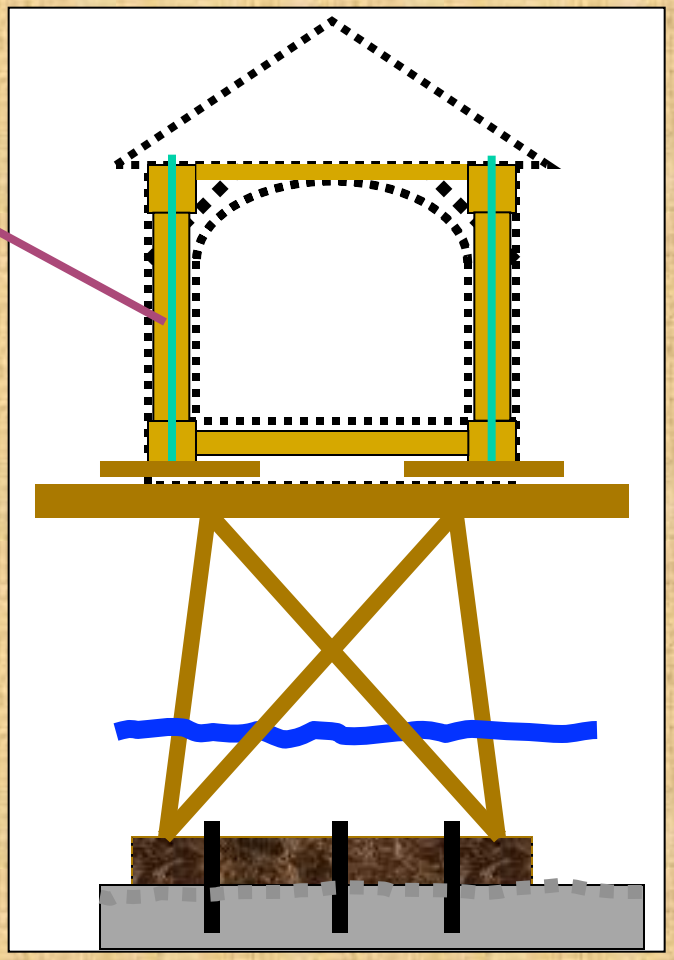


Fitting the Diagonals

Building a Covered Bridge

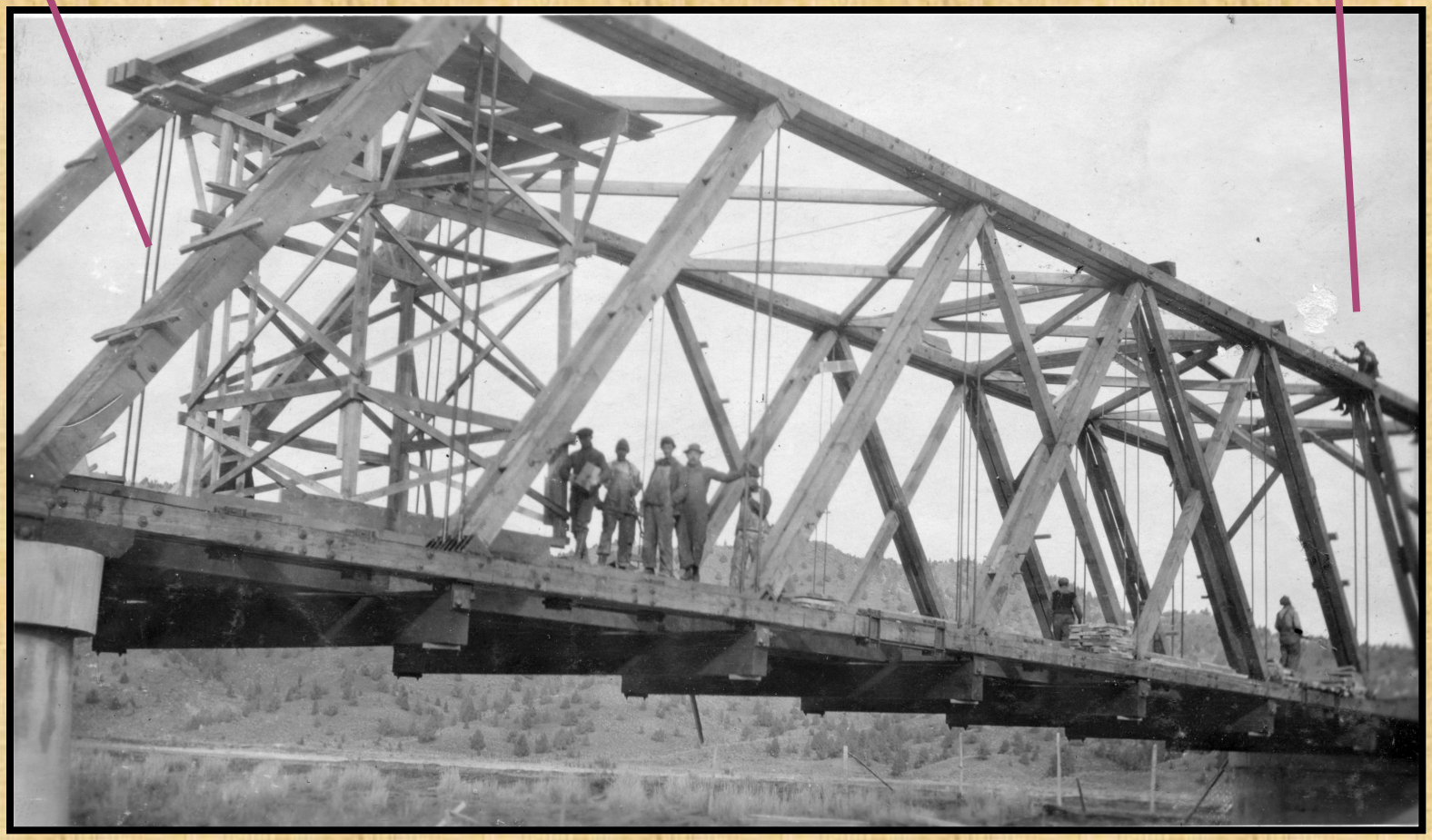
chord, about fourteen feet. Then we placed diagonals between the two chords. At each panel we put in cross-ties on the upper chords, then dropped in rods, and tightened. A hand winch was used for raising diagonals and upper chords.



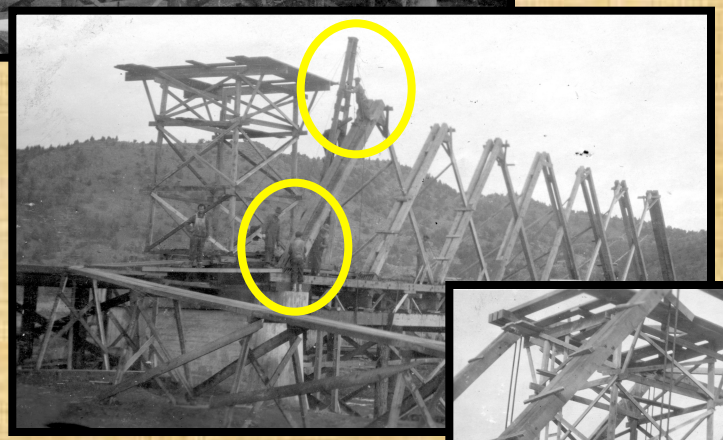


Building a Covered Bridge

The next step was to swing the truss, which meant to tighten the truss rods, first at one end, then at the other, working toward the center. Then the useable lumber was salvaged from the falsework, and the remainder broken up to float downriver.



Another Way To Build The Truss

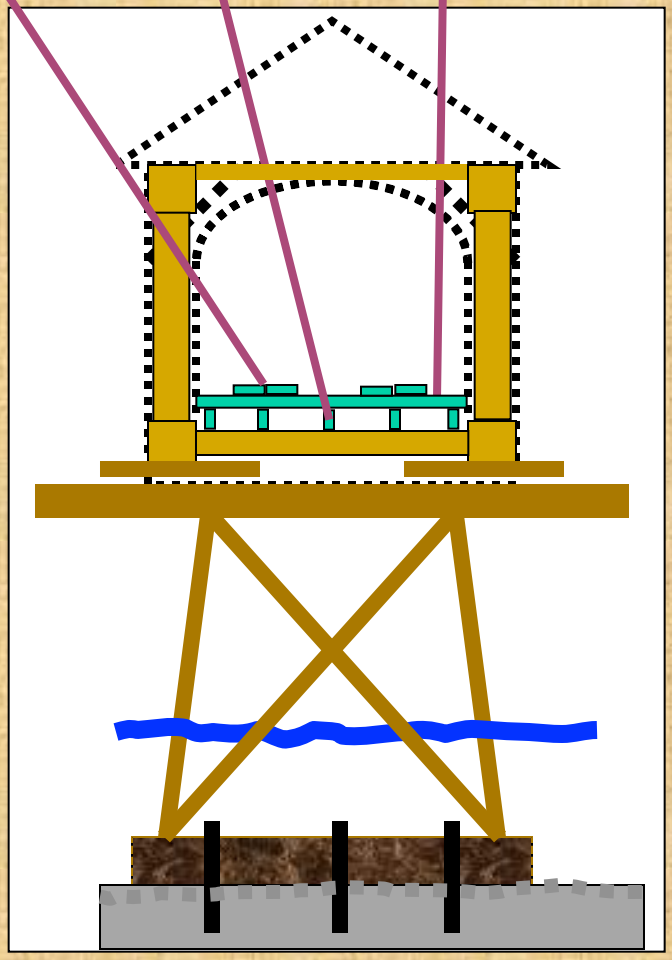


The Floor

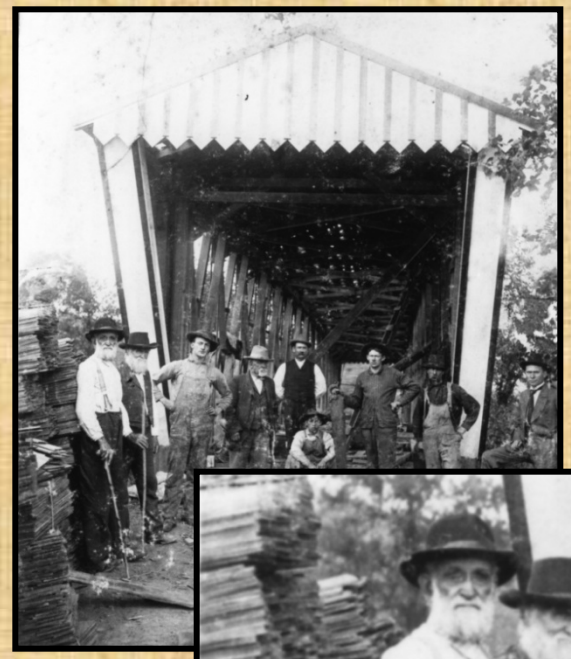
Floor system cross-braces, stringers and planks were put in, so we could finally have a place to walk on. We added running boards on the floor to help keep wagons in their place.

Looking Glass Creek, Oregon

Winchester Bridge, Enterprise Road, East of Gratis, Preble County



Floor System

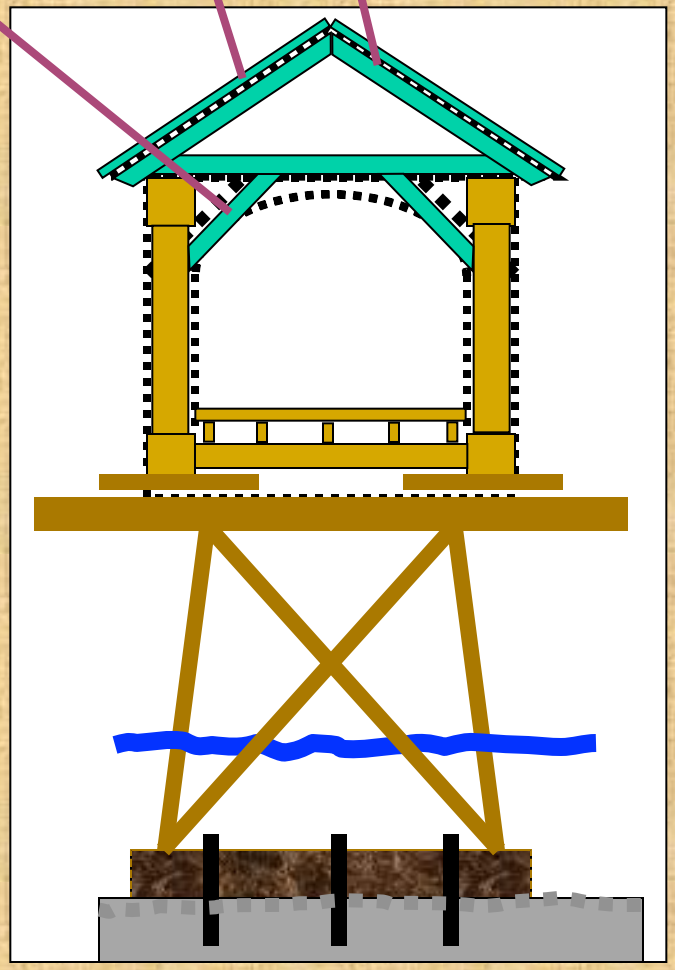


Making Shingles for the Roof

Working on the Switzer Bridge, Frankfort, Kentucky, early 1900's

The Roof

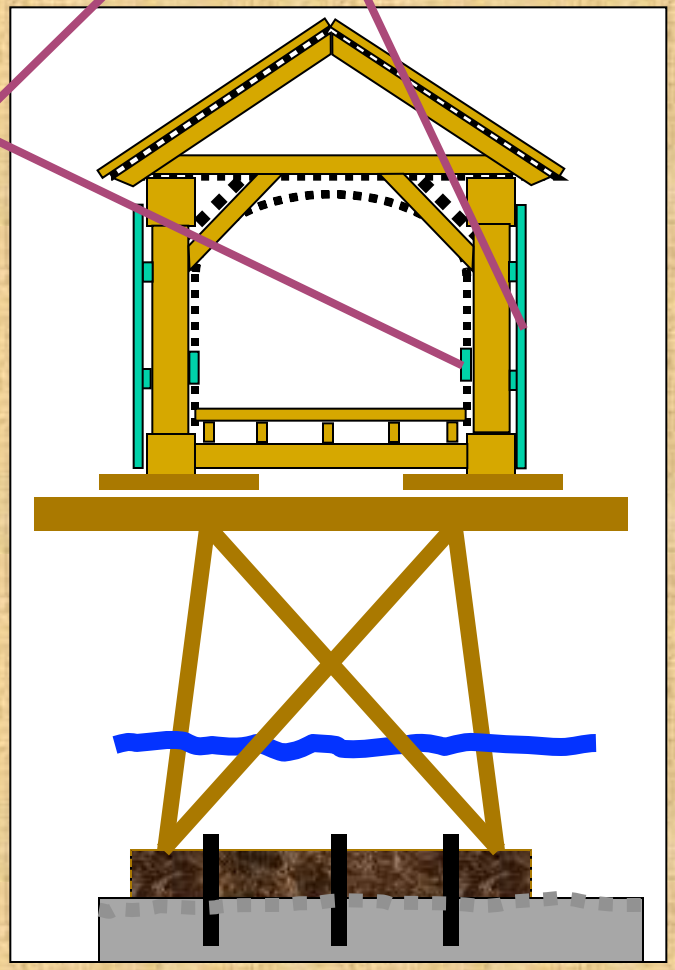
Then the knee braces and the roof system were added. Rafters were set, much like on a building, then wood strapping and cedar wood shingles were nailed on.



Roof Framing

Siding and Rails

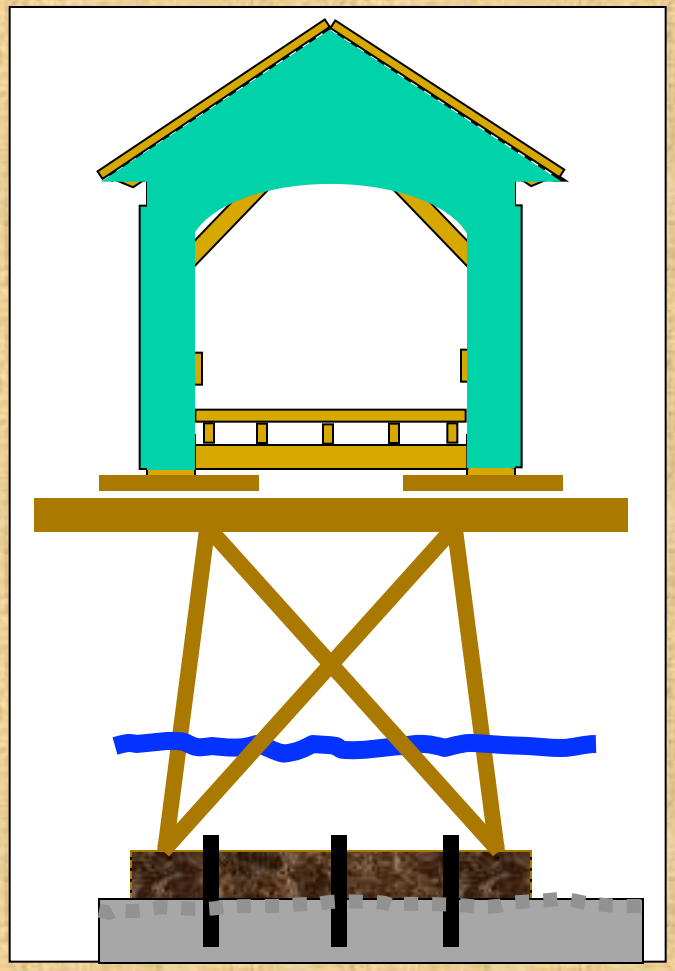
Nailers were placed along the sides, and siding attached. Hub rails were sometimes put on the inside to keep wagon axles from catching on the trusses.



Siding Framing

Finishing the Pretty Parts, the Portals

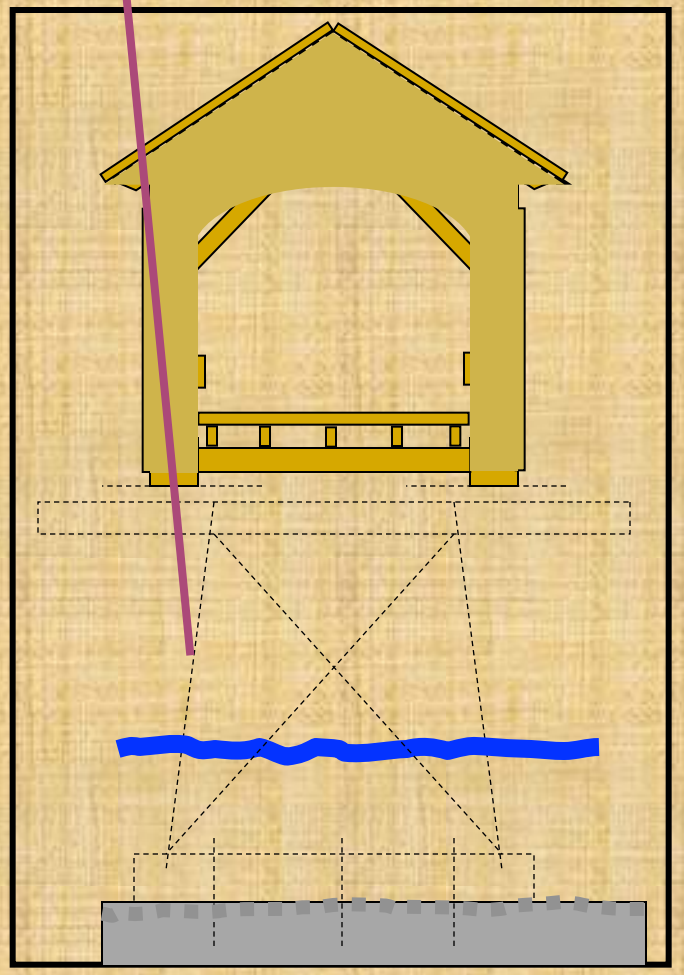
The rest of the siding, around the end portals, was nailed on. Usually the siding was then whitewashed or painted red, but some bridges were just left unpainted.



Removing the Falsework

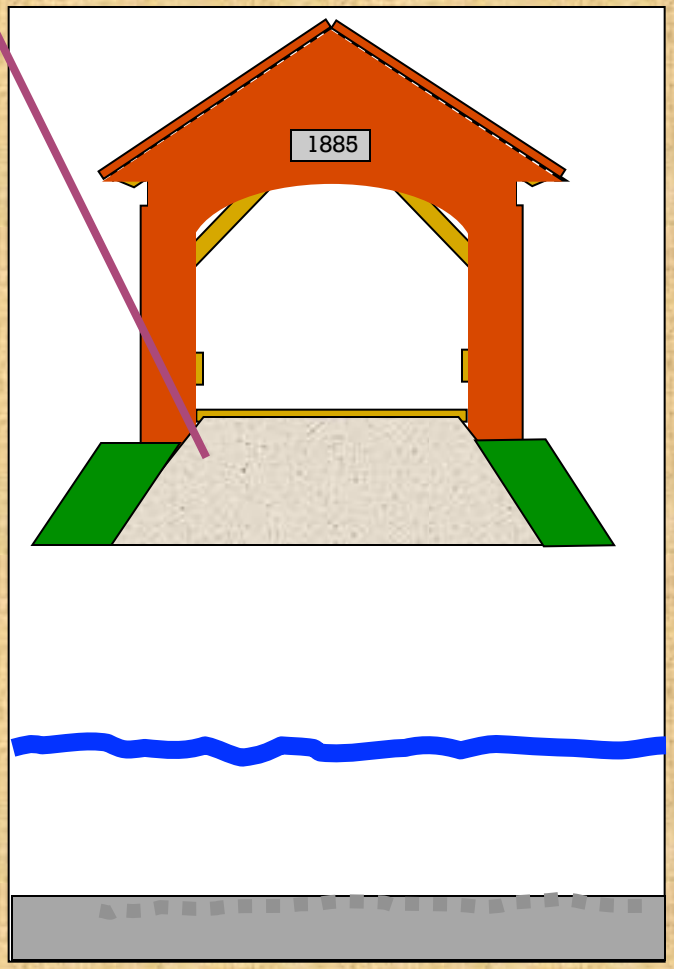
center. Then the useable lumber was salvaged from the falsework, and the remainder broken up to float downriver.

For the first time since we built the falsework to start the project, the creek is all clear, and our new covered bridge is standing on its own, spanning from one side of the creek to the other. Our crew has taken about four months to build the bridge, after the stone work.



Preparing the Road, Opening the Bridge

We have graded and finished the road approach, and we are done, the bridge is open!

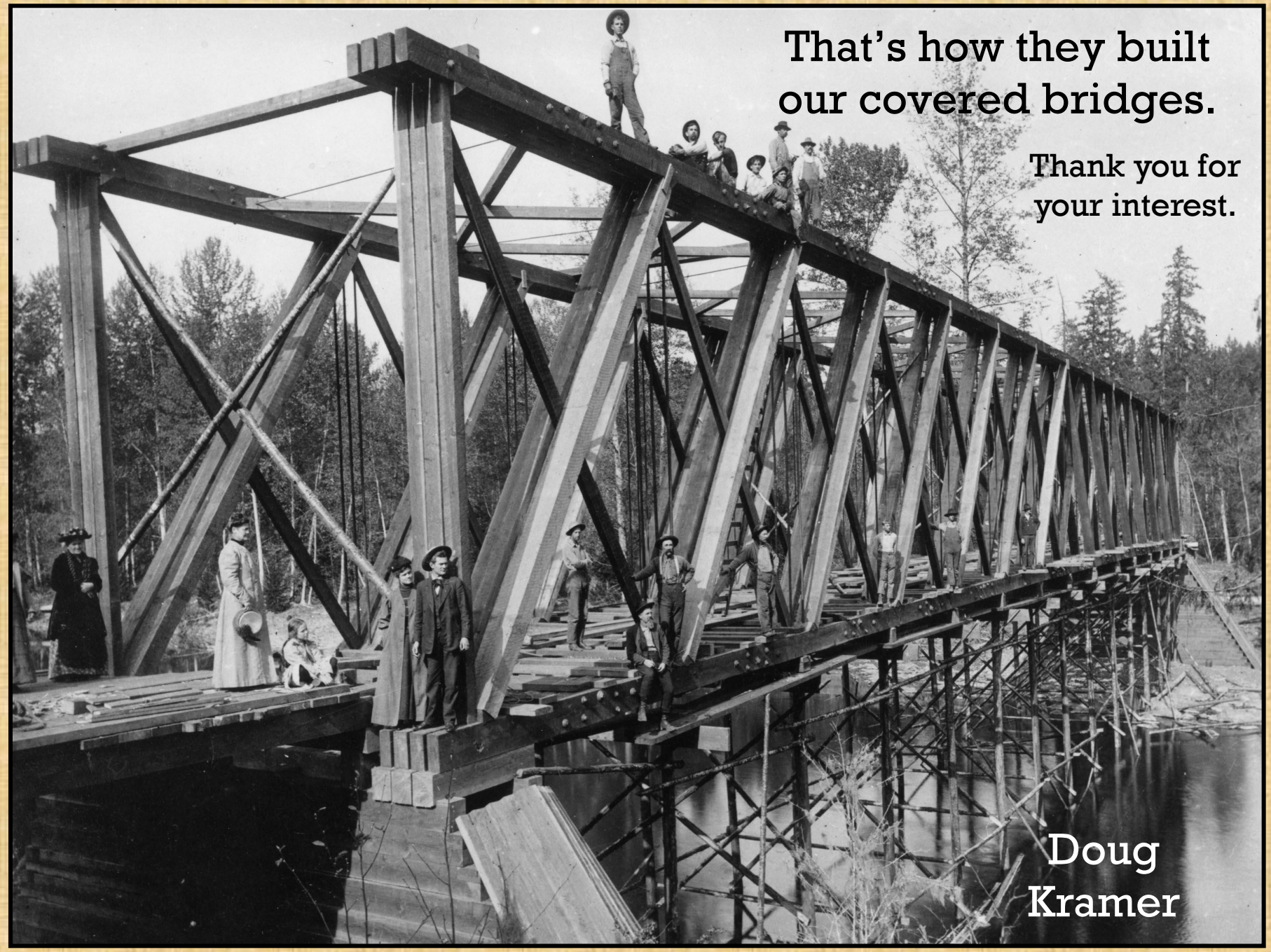


Eldean Covered Bridge

Wedges in the Long Truss

Eldean Covered Bridge

Miami County, Ohio


That's how they built
our covered bridges.
Thank you for
your interest.
Doug
Kramer