Kings Covered Bridge Rehabilitation

Somerset County, Pennsylvania

SIMONE LANDSCAPE ARCHITECTURE COLLINS

HRG Herbert, Rowland & Grubic, Inc. Engineering & Related Services

William Collins, RLA Samer Petro, P.E

Location

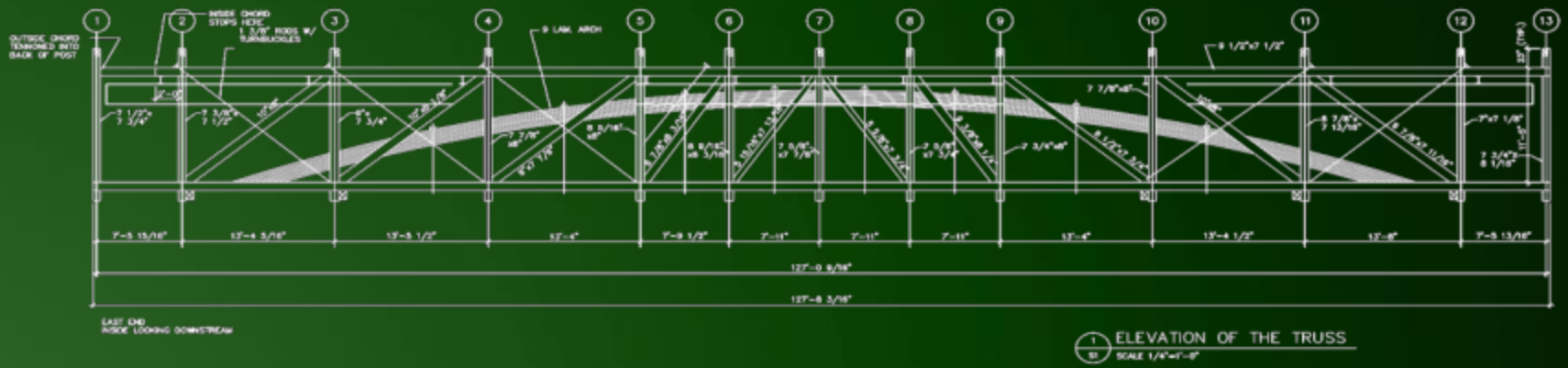
Middlecreek Township, Somerset County, Pennsylvania

History

1803	“Built” date on bridge (incorrect)
mid-1800’s	Probable construction period
1906	“Rebuilt” date on bridge - likely
1930’s	Bypassed with steel highway bridge
1930’s-2002	Used as a King Family farm building
1996	PA funding for stabilization
Fall 2000	Stabilized in place
2002	Acquired by S. Alleghenies Conservancy
2008	Acquired by Middlecreek Township
2009	Completed – bridge and site

Superstructure

Note
bay spacing and repair rods



Multiple Kingpost Truss w/ Retrofitted Tied Arch

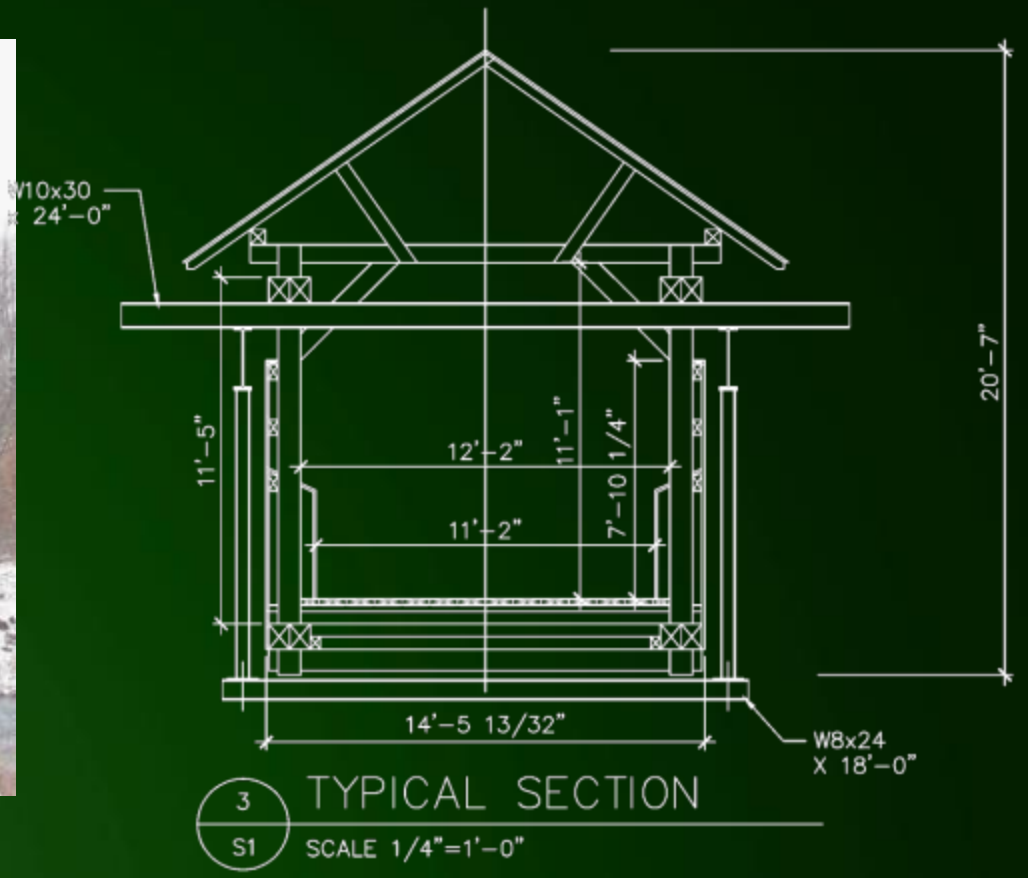
Multiple Kingpost Truss with arch added

- Retrofitted 1906 with nail-laminated arches creating “Arch-Truss”
- Arches “tied” to bottom chord

Bridge data

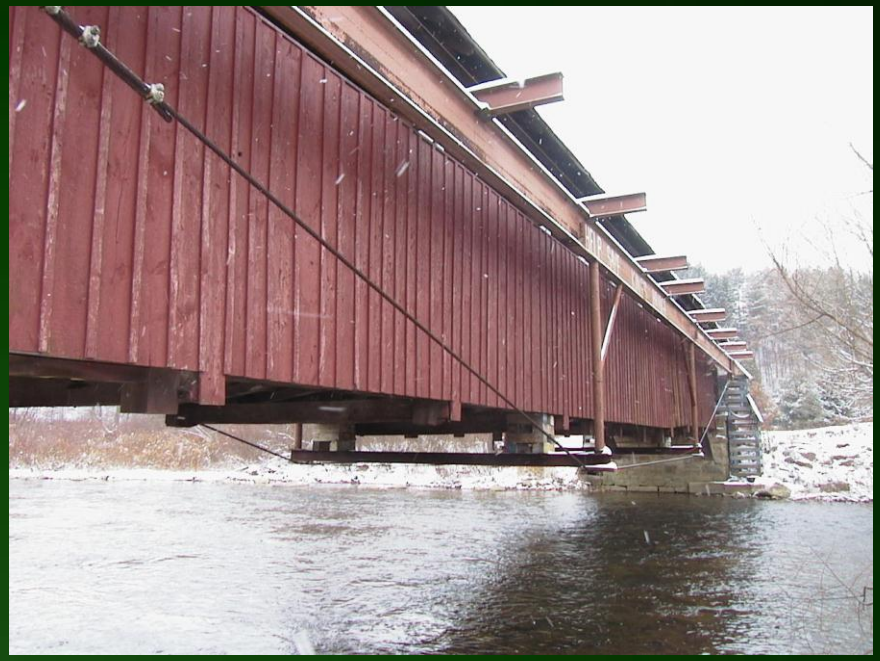
Length:	114 feet clear span
Width:	14’-6” out to out
Superstructure form:	Multiple Kingpost with retrofitted arches (1906)
Primary Species:	White Oak
Timbers members:	hewn, circular, up & down
Substructure:	local limestone
Hardware:	round nails

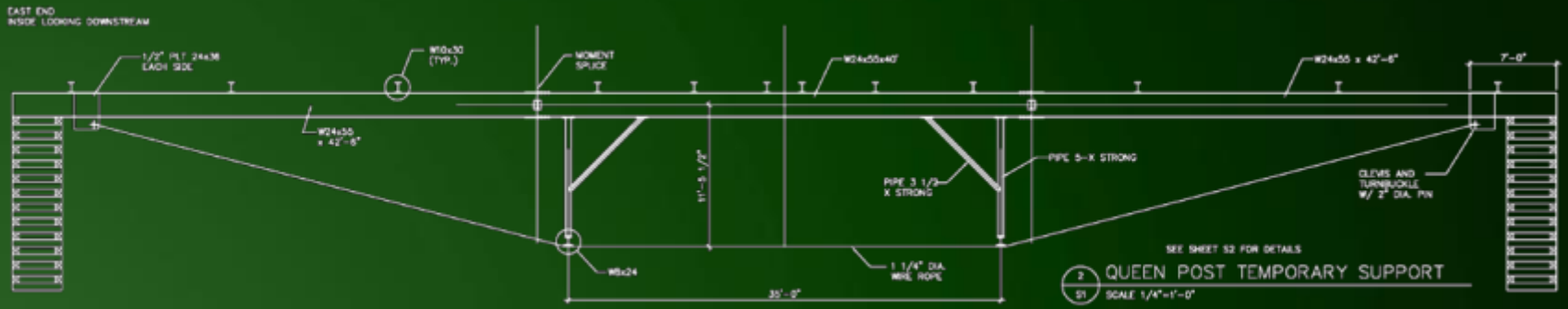
Stabilization



Engineering – DCF Engineering Inc, Cary, NC
Construction – Arnold M. Graton Associates Inc

Temporary Superstructure





Queenpost-tensioned trusses w/ needle beams

Interior

Used as a barn after bypass

Failures

Both lower chords, several posts and tie beams

Non-destructive Field Testing

Moisture testing

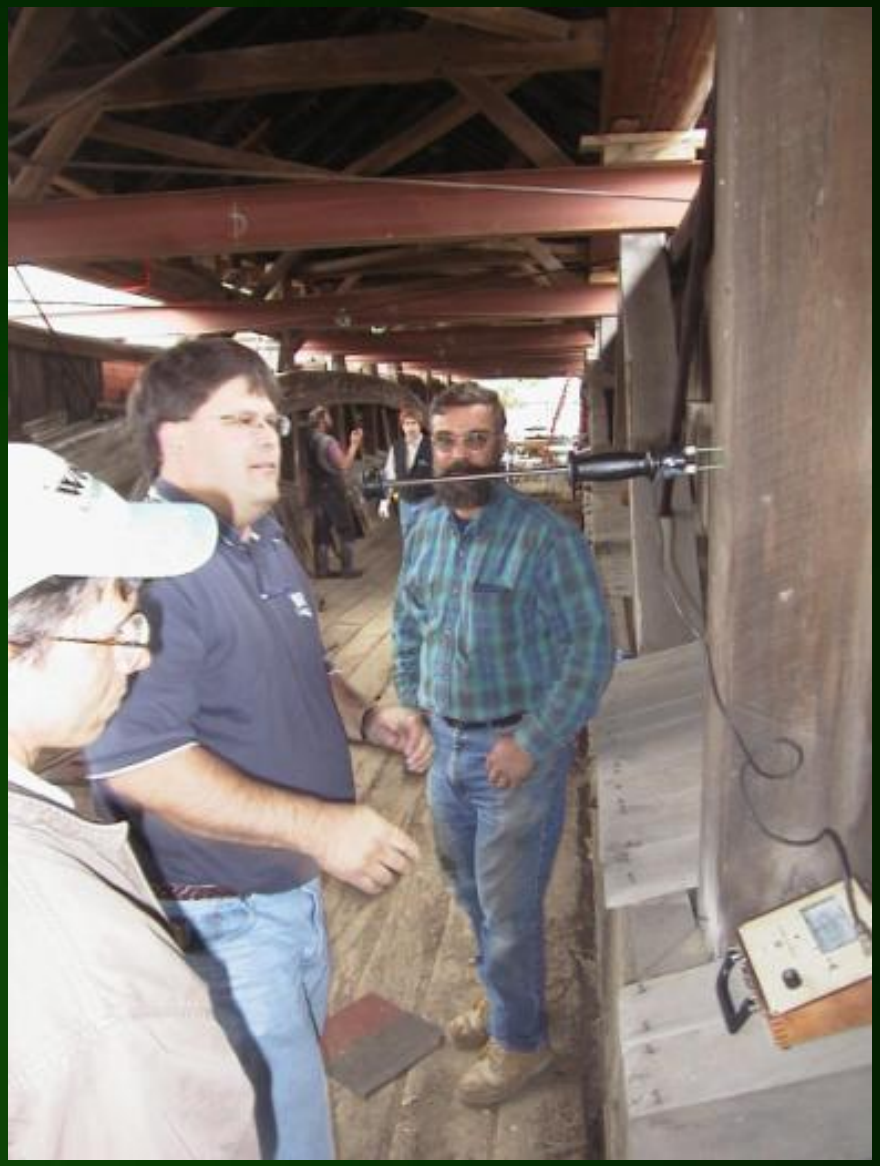
Technical Assistance

USDA Forest Service

Morgantown, WV

Forest Products Laboratory

Madison, WI



Non-destructive Field Testing

Resistance Drilling

Stress Wave Timer

Both chords had relative drilling resistance below 15%

Destructive Testing

4-foot lower chord segment removed for species analysis by Forest Products Laboratory

Mapping

Lower chord segments

Lower tie beam / tail of truss post

Failure from compression force of truss brace

Lower Chord

Failure in both trusses

Substructure

Horizontal thrust from broken chords, struts ceased to work

Bed timbers

Note deformation

Retrofitted Struts

Typical failure at seats

Arches

Nail-laminated retrofits

Arches

Deformation and previous interventions

Thrust Block at Portal Post

Bearing

Chord seat at abutment

Roof assembly

Mortised, pinned, and wedged horizontal X-bracing

Post - upper tie beam, rafter sill

Cantilevered tie beams failed where leaks occurred

Truss Bracing

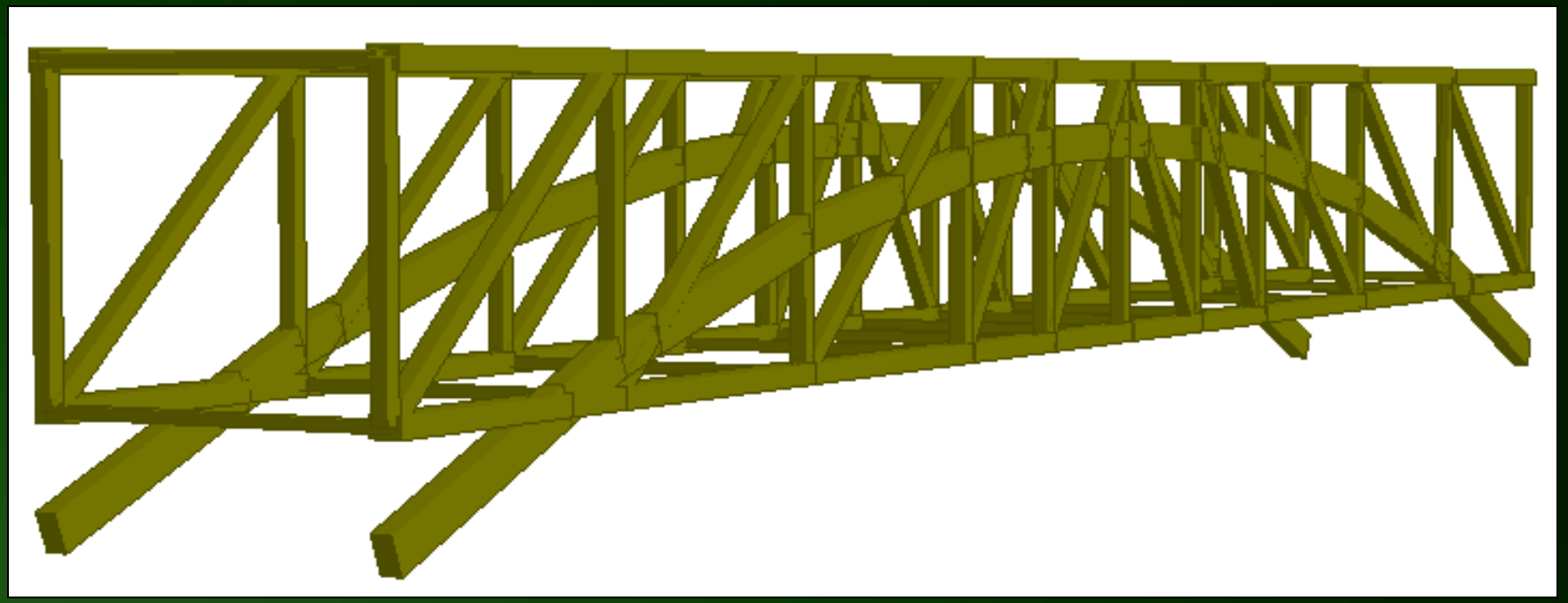
water damage
at truss post

Preservation Philosophy

Resource eligible for National Historic Register

- *Rehabilitate for pedestrian use*
- *Retain historic fabric as much as possible*
- *Replace with in-kind materials*
- *Meet the Secretary's Standards*

Structural Analysis



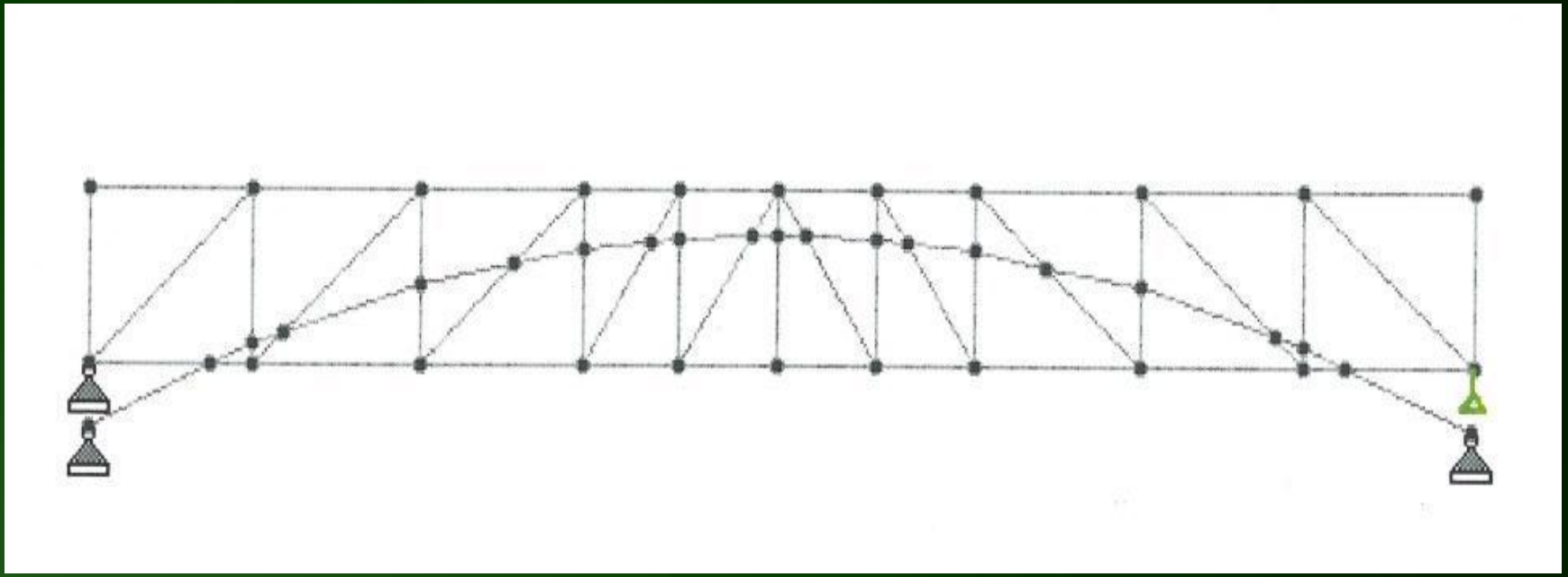
3-D rendering (STAAD Model) – *Samer Petro, P.E.*

- 3-D Model STAAD
- Provides member forces, moments, and deflections

Goal of Analyses:

1. Compare stresses to allowable stresses based on (NDS)
2. Understand arch-truss system

Modeling

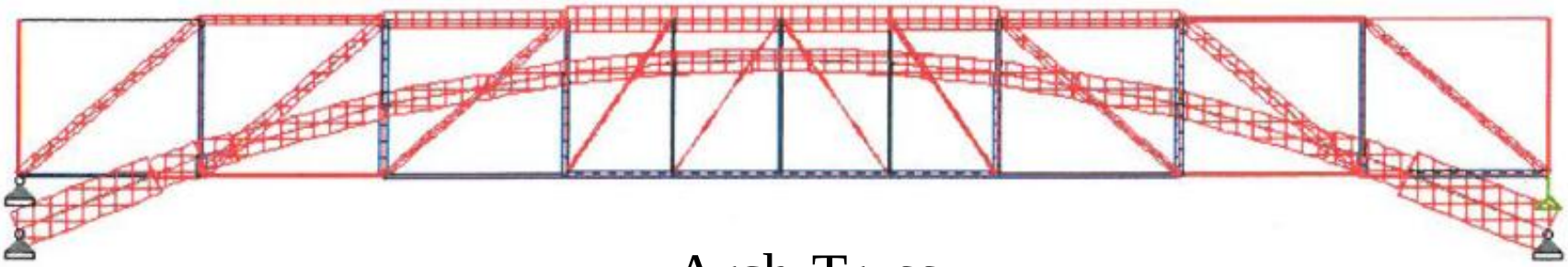


- Ends of diagonals and ends of posts pinned (free to rotate)
- Chord members and arches continuous
- Multiple kingpost modeled as pinned

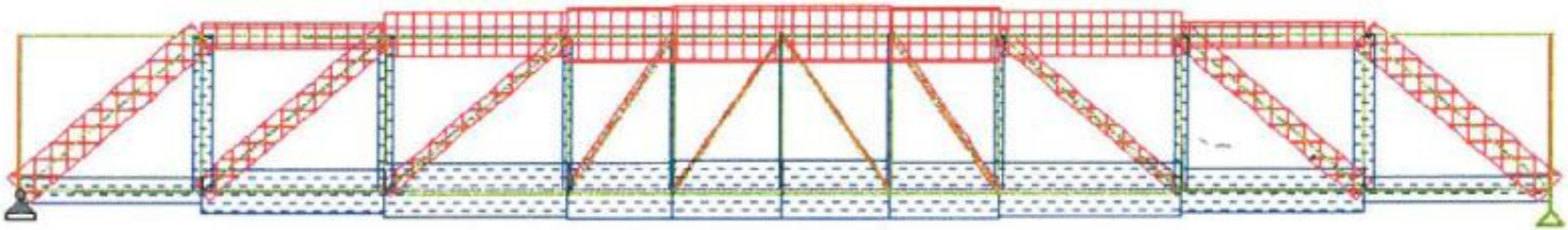
Loads

- **Dead loads:** approximated by field measurements and using white oak density of 43 pcf (MOE 1.4M psi)
- **Live load:** Pedestrian load of 85 psf (AASHTO)
- **Snow Load:** 35 psf
- **Wind Load:** 12.5 psf based on wind velocity on 100 mph (ASCE 7)
- **Load Combination:** [dead load + wind+live+snow)*0.75] (ASCE 7)

Stress Distribution



Arch-Truss



Truss

Repair / Solutions

Dapped lower chords to permit laminated arches to extend forces directly into the abutments

Abutment Repairs

Excavated abutments, buttressed with flowable backfill

Truss Repairs

Post splices and replacement

Truss Repairs

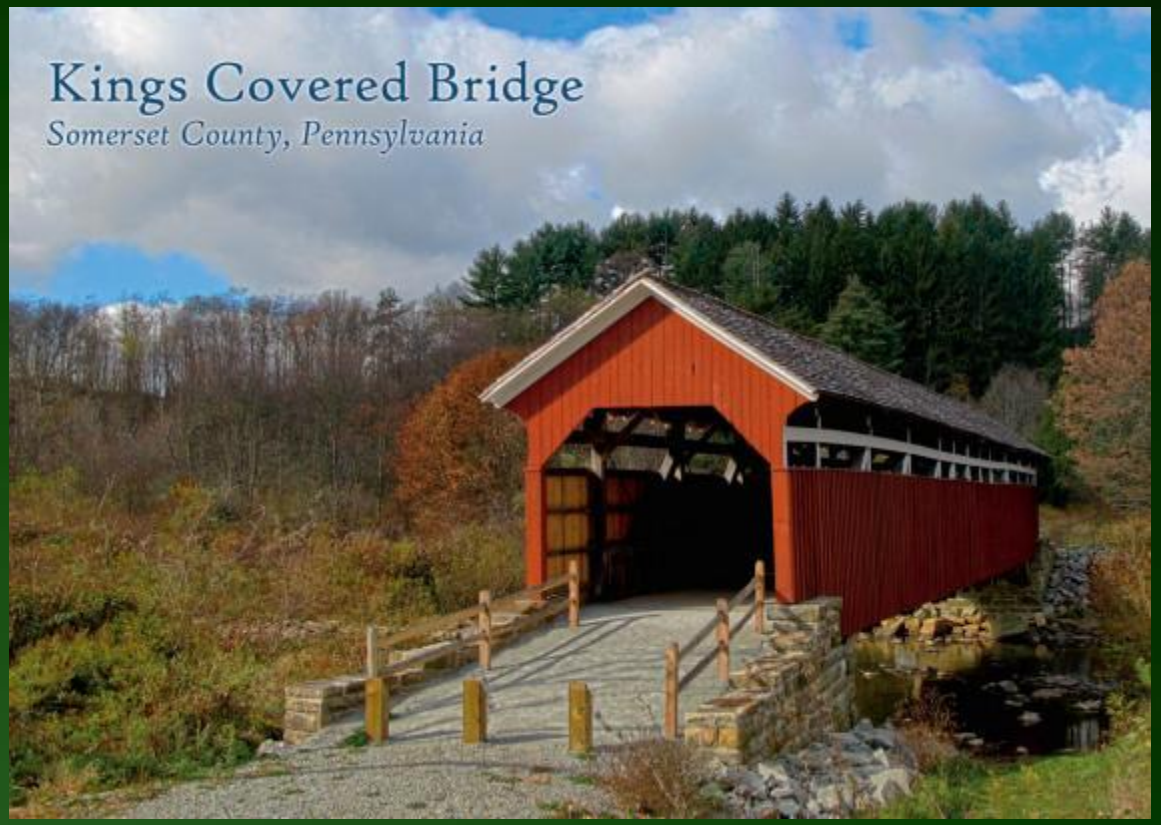
Post splice

Innovative GFRP rods embedded in epoxy

Chord

Traditional white oak “joggle”

Engineering Results



- Arches: are structurally dominant
- Trusses: lower chord in tension and max @ mid-span (expected)
- Arch-truss system: maximum compressive forces in arches at ends
- All member stresses well below allowable values
- Deflections due to dead and live loads below AASHTO limits

Completion

Before – *stabilized*

After – *restored*

Modjeski Award for Historic Preservation, 2008

Preservation Pennsylvania

Completion

Before

After

Budget

$ 90,000	**Stabilization - 1996** (Source – PA DCED)
	Engineering, construction, funding strategy
$945,000	**Rehabilitation**
	Engineering, construction, environmental
	(Sources)
	$595,000 FHWA Enhancements
	$340,000 FHWA National Covered Bridge
	$ 10,000 Rockwood Area Historic Society
$1.035 M	**TOTAL**

Technical Team

Prime Consultant – Simone Collins Inc.

Structural Engineer – Samer Petro *(formerly of Gannett Fleming Inc. now at Herbert Rowland Grubic)*

Historic Consultant – Dr. Emory Kemp

Stabilization Engineer – DCF Engineering Inc.

Scientific Investigation – Forest Products Laboratory

Stabilization Contractor – Arnold M. Graton Assoc.

Rehabilitation Contractor – Allegheny Restoration

Surveyor – Paul C. Rizzo Inc.

Permit Assistance - Somerset Conservation District.

Project Partners

Client – Southern Alleghenies Conservancy

Funding Partner – Federal Highway Administration

Funding Partner – Pennsylvania Commonwealth (PennDOT and DCNR)

Funding Partner – Rockwood Area Historic Society

Funding Partner – Somerset County

Project Administration – PennDOT

Ultimate Owner – Middlecreek Township

Steward / Donor – King Family

Contacts

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