Kings Covered Bridge Rehabilitation

Somerset County, Pennsylvania

William Collins, RLA

Samer Petro, P.E
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1803</td>
<td>“Built” date on bridge (incorrect)</td>
</tr>
<tr>
<td>mid-1800’s</td>
<td>probable construction period</td>
</tr>
<tr>
<td>1906</td>
<td>“Rebuilt” date on bridge - likely</td>
</tr>
<tr>
<td>1930’s</td>
<td>bypassed with steel highway bridge</td>
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<tr>
<td>1930’s-2002</td>
<td>used as a King Family farm building</td>
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<tr>
<td>1996</td>
<td>PA funding for stabilization</td>
</tr>
<tr>
<td>Fall 2000</td>
<td>stabilization in place</td>
</tr>
<tr>
<td>2002</td>
<td>Saved by S. Alleghenies Conservancy</td>
</tr>
<tr>
<td>2008</td>
<td>Acquired – Middlecreek Township</td>
</tr>
<tr>
<td>2009</td>
<td>Completed – bridge and site</td>
</tr>
</tbody>
</table>
Superstructure

Note
bay spacing and repair rods

Multiple Kingpost Truss w/ Retrofitted Tied Arch

Kings Covered Bridge Rehabilitation
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

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Temporary Superstructure

Queenpost-tensioned trusses w/ needle beams

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Interior

Used as a barn after bypass

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Failures

Both lower chords, some posts, some tie beams

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Non-destructive Field Testing

Moisture testing

Technical Assistance

USDA Forest Service
Morgantown, WV
Forest Products Lab,
Madison, WI
Non-destructive Field Investigation / Testing

Resistance Drilling

Stress Wave Timer

Both chords had relative drilling resistance below 15%

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Destructive Testing

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

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Mapping

Lower chord segments

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Lower tie beam / tail of truss Post

Failure from compression force of truss brace

Lower Chord
Location of failure

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Horizontal thrust from broken chords, struts ceased to work
Bed timbers
Note deformation

Retrofitted Struts
Typical failure at seats
Arches

Nail-laminated retrofits

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Arches

Deformation and previous interventions

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Thrust Block at Portal Post
Bearing

Chord – abutment seat
Roof assembly

Mortised, pinned, and wedged horizontal X-bracing

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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

Kings Covered Bridge Rehabilitation
3-D rendering (STAAD Model) – Samer Petro, P.E.

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

**Goal of Analysis:**
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 king post 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
Dapped lower chords to permit laminated arches to extend forces into the abutment
Abutment Repairs

Excavate abutments, buttress with flowable backfill

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Repairs

Post splices and replacement

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Repairs

Post splice
Innovative GFRP rods embedded in epoxy

Traditional Chord “joggle” white oak
Engineering Results

Kings Covered Bridge
Somerset County, Pennsylvania

- Arch 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

First Annual Modjeski Award for Historic Preservation
Preservation Pennsylvania

Kings Covered Bridge Rehabilitation
### Budget

<table>
<thead>
<tr>
<th>Amount</th>
<th>Description</th>
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<tbody>
<tr>
<td>$ 90,000</td>
<td>Stabilization - 1996 (Source – PA DCED)</td>
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<tr>
<td></td>
<td>Engineering, construction, funding strategy</td>
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<tr>
<td>$945,000</td>
<td>Rehabilitation</td>
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<tr>
<td></td>
<td>Engineering, construction, environmental (Sources)</td>
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<td>$595,000</td>
<td>FHWA Enhancements</td>
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<td>$340,000</td>
<td>FHWA National Covered Bridge</td>
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<tr>
<td>$ 10,000</td>
<td>Rockwood Area Historic Society</td>
</tr>
<tr>
<td>$1.035 M</td>
<td><strong>TOTAL</strong></td>
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Technical Team

**Prime Consultant** – Simone Collins Inc.

**Structural Engineer** – Samer Petro *(formerly at 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.

Kings Covered Bridge Rehabilitation
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
Contact

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