Rehabilitation, Repair, and Reconstruction of the Walnut Street Bridge Hellertown, PA

Perry S. Green

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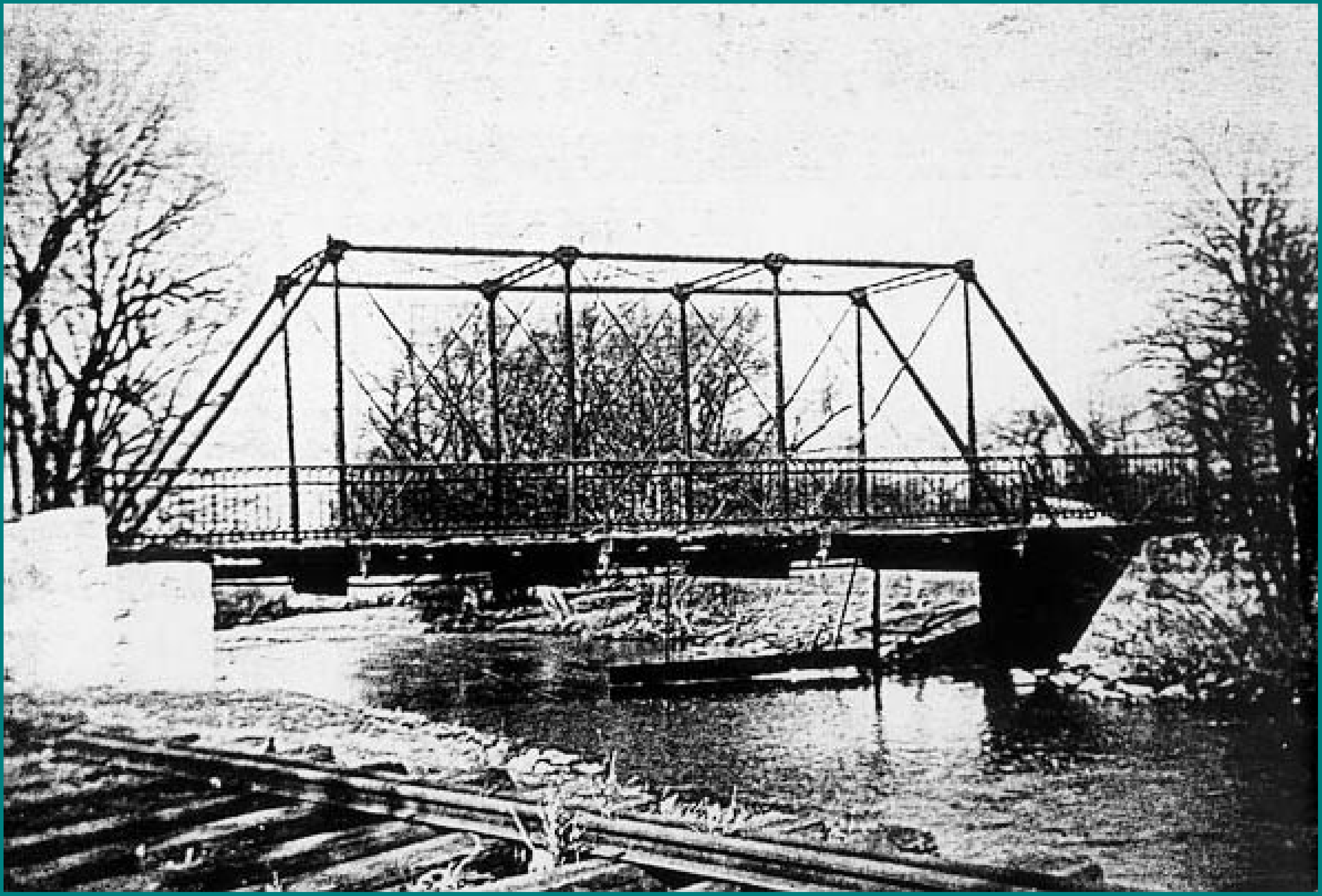
SIA Twenty-Seventh Annual Conference

Indianapolis, Indiana

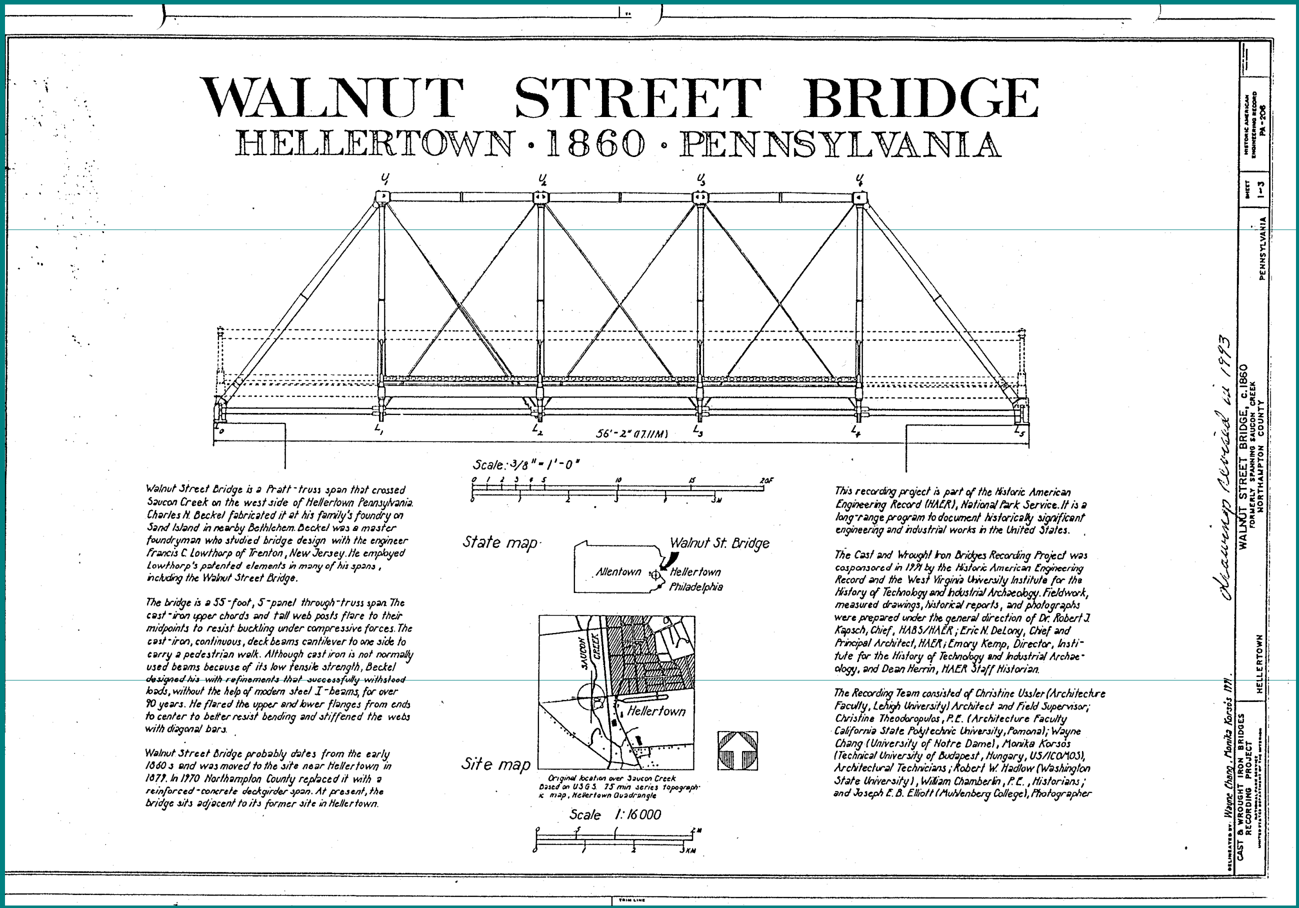
June 6, 1998

WALNUT STREET BRIDGE - 1915

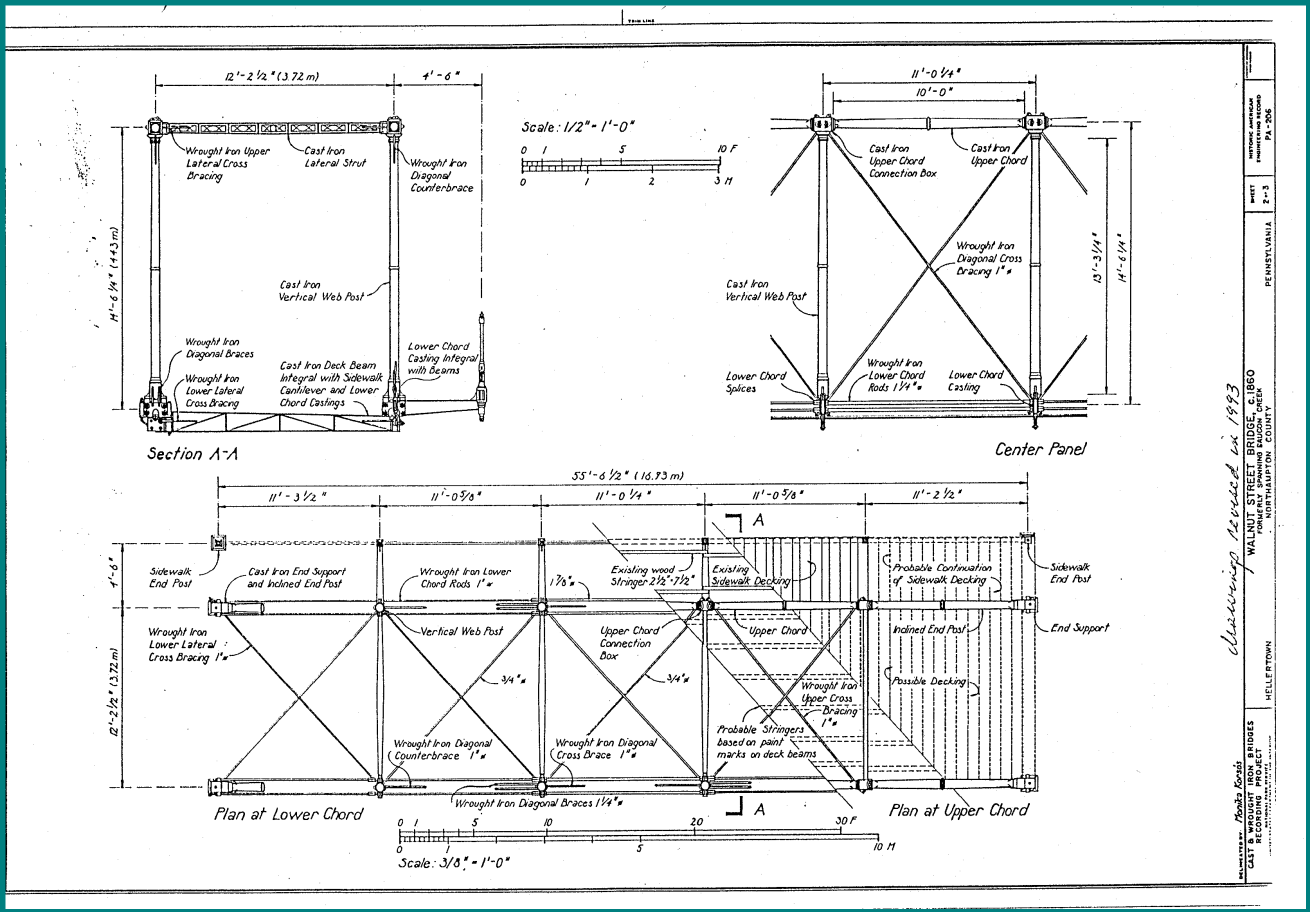


WALNUT STREET BRIDGE - 1970

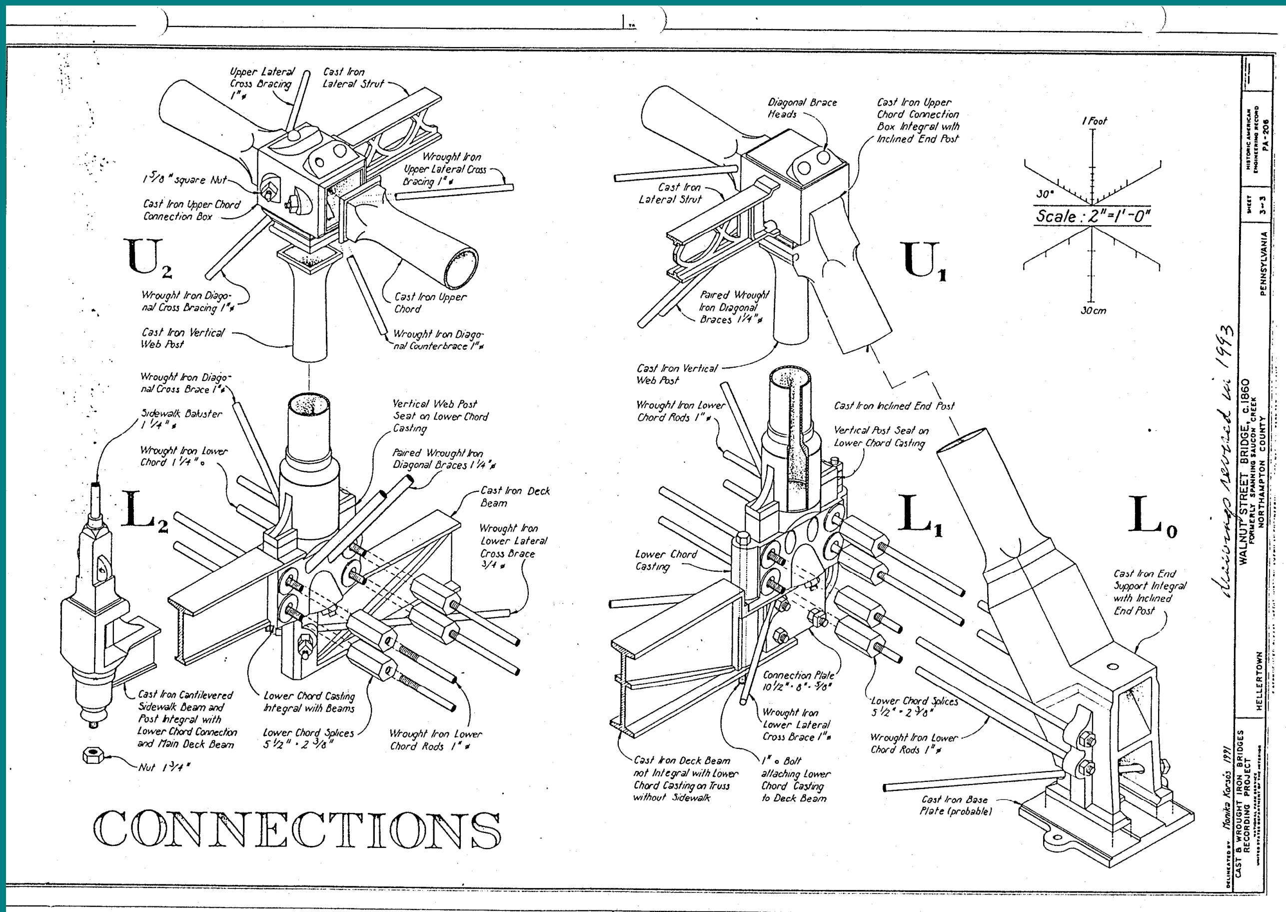
WALNUT STREET BRIDGE - 1991



WALNUT STREET BRIDGE - 1991



WALNUT STREET BRIDGE - 1991



PROJECT OVERVIEW

- Initial Bridge Survey
- Disassembling the Bridge
- Member Details
- Member Assessment
- New Construction
- Reassembling the Bridge
- Volunteers and Contributors

INITIAL BRIDGE SURVEY

- Previous Research and Documentation
- Overall Structural Condition Assessment
- Alternative Uses and Options

DISASSEMBLING THE BRIDGE

- September 23, 1994
  - Erect Scaffolding, Stabilize Trusses, Secure Connections
  - Block and Shore Up Endposts
  - Mark Members with Temporary ID's
- September 24, 1994
  - Remove First Member by Hand
  - Cut and Remove Wrought Iron Diagonals
  - Break Trusses Down into Triangular Modules
- September 25, 1994
  - Cut and Remove Remaining Wrought Iron Members
  - Remove Remaining Cast Iron Members
  - Place all Cast Iron Members in Storage

MEMBER DETAILS

- Permanent Member Identification
- Member Condition Assessment
- Uniqueness of Cast Iron Members
- Differences Between Like Cast Iron Members

MEMBER ASSESSMENT

- Visual Condition Assessment
- Material Property Testing
- Member Rehabilitation Alternatives
- Member Repair Options
- Member Replacement Options

NEW CONSTRUCTION

- Footings and Abutments
- Falsework Bridge
- Tension Chord and Bracing Members
- Coupling Nuts
- Verticals

REASSEMBLING THE BRIDGE

- Construct New Footings and Abutment Walls
- Erect Falsework Bridge
- Place Floorbeams and Casting Nodes
- Install Tension Chord Members
- Install Lower Chord Lateral Bracing Members
- Erect Trusses in Stable Triangular Modules
- Connect Trusses Together with Lateral Struts

REASSEMBLING THE BRIDGE

- Install Upper Chord Lateral Bracing Members
- Lower Bridge onto End Bearings
- Remove Falsework Bridge
- Paint Structure
- Place Wood Stringers and Decking
- Complete Concrete Backwalls
- Stone Face Abutment Walls

VOLUNTEERS

- **Lehigh University Graduate Students**

  William Bruin

  Robert Connor

  Perry Green

  Christopher Higgins

  Ian Hodgson

- **Hellertown Historical Society**

  Harry Boos

  Lorraine Cawley

  Alois Groegler

  Tom Henshaw

  Edward Hill

- **Hellertown Historical Society**

  Keith Hill

  Richard Hodge

  Grant Hoffert

  Albert Hoppes

  Joe Kach

  Robert Frederick

  Randy Frey

  Norman Mease

  Joseph Poltl

  Ronald Svites

  Vincent Winters

CONTRIBUTORS

- Architectural Iron Company, Milford, Pa.
- ATLSS - Lehigh University, Bethlehem, Pa.
- Bethlehem Steel Corporation, Bethlehem, Pa.
- Borough of Hellertown, Pa.
- Frank Casilio & Sons, Bethlehem, Pa.
- Chapparal Steel, Midlothian, Tx.
- Coatings For Industry, Souderton, Pa.
- Hellertown Borough Authority
- E. W. Hill & Sons, Inc., Hellertown, Pa.
- Kospiah Construction, Allentown, Pa.
- Alan Kunsman Roofing, Freemansburg, Pa.
- Modern Sandblasting, Hellertown, Pa.
- F. A. Rohrbach Concrete, Allentown, Pa.

Rehabilitation of a Nineteenth Century Cast and Wrought Iron Bridge

Perry S. Green

University of Florida, Gainesville, FL

Robert J. Connor

Lehigh University, Bethlehem, PA

Christopher C. Higgins

Clarkson University, Potsdam, NY

1999 STRUCTURES CONGRESS

New Orleans, LA

April 19, 1999

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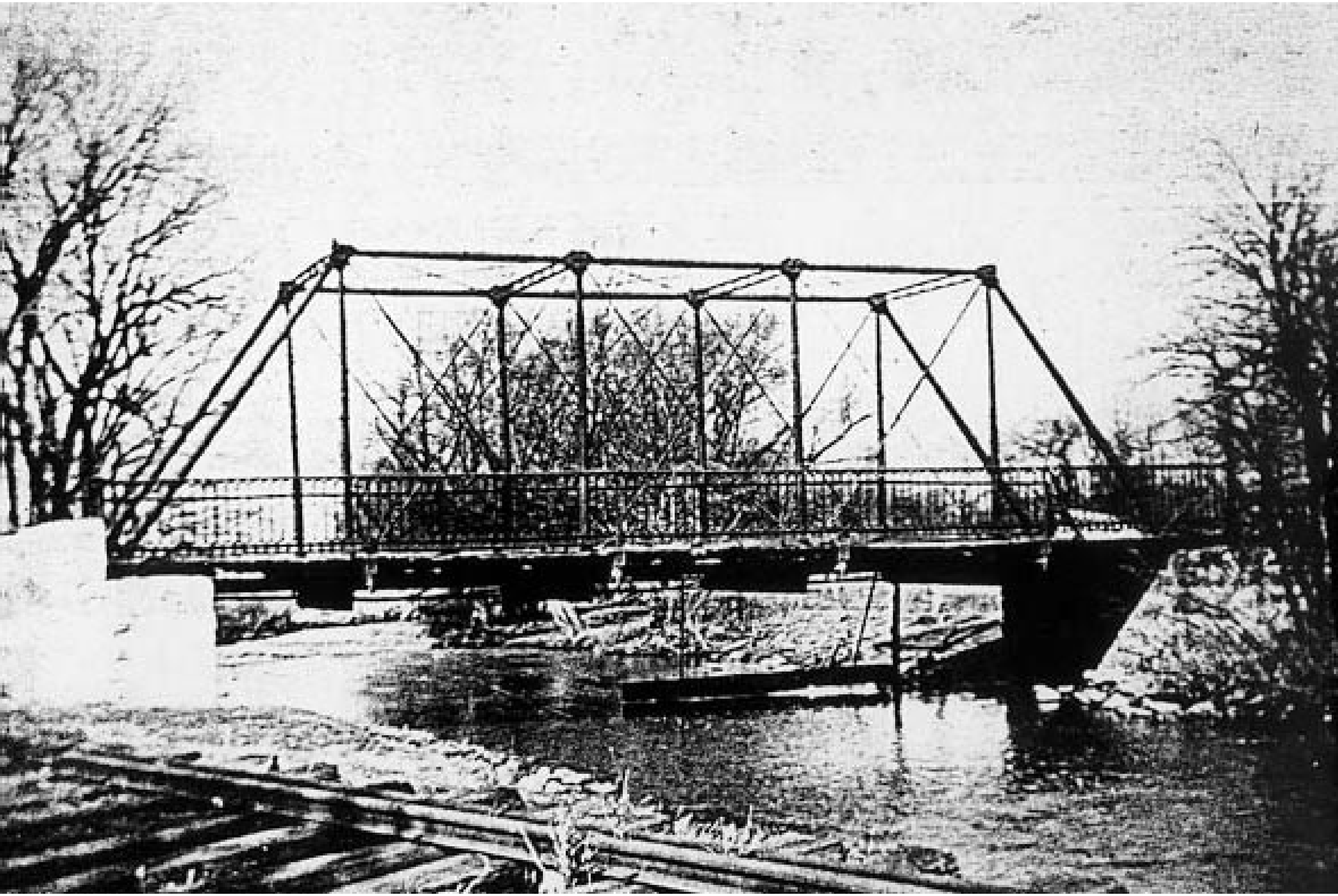
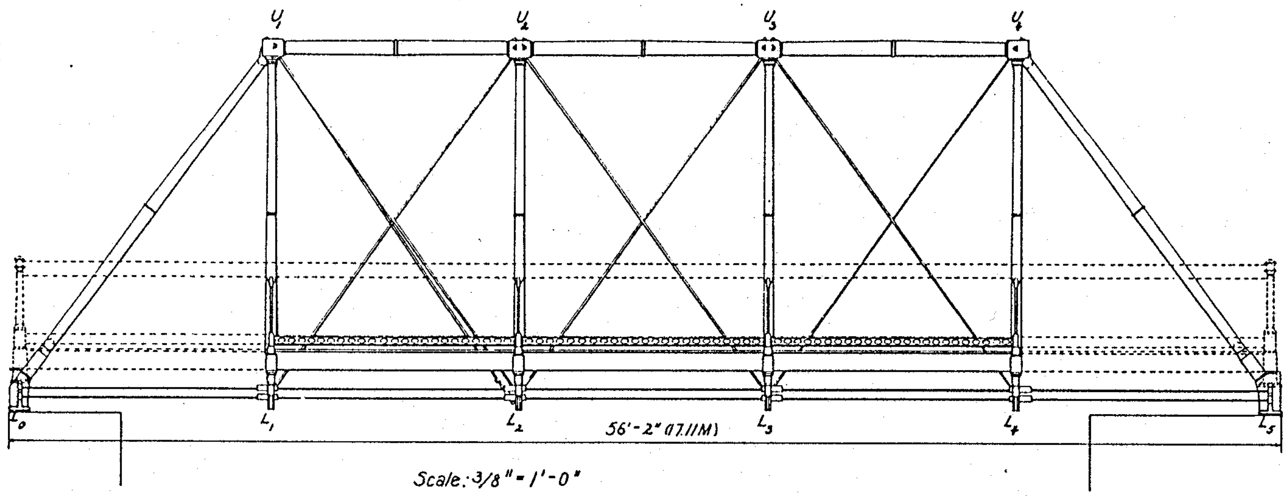
WALNUT STREET BRIDGE

- **Location:** Formerly crossing Saucon Creek on Walnut Street, Hellertown, Northampton County, PA
- **Date Built:** circa 1860; Original location unknown
- **Fabricator:** Charles N. Beckel, Beckel Iron Foundry and Machine Shop, Sand Island, Bethlehem, PA
- **Owner:** Hellertown Historical Society
- **Significance:** Only extant high-truss span built by Beckel; Uses Francis C. Lowthorp's June 30, 1857 patented lower chord cast connection; Floorbeams fabricated from cast iron



WALNUT STREET BRIDGE

HELLERTOWN • 1860 • PENNSYLVANIA



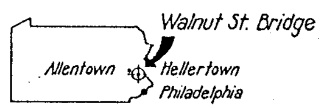
Scale: 3/8" = 1'-0"

Walnut Street Bridge is a Pratt-truss span that crossed Saucon Creek on the west side of Hellertown Pennsylvania. Charles N. Beckel fabricated it at his family's foundry on Sand Island in nearby Bethlehem. Beckel was a master foundryman who studied bridge design with the engineer Francis C. Lowthorp of Trenton, New Jersey. He employed Lowthorp's patented elements in many of his spans, including the Walnut Street Bridge.

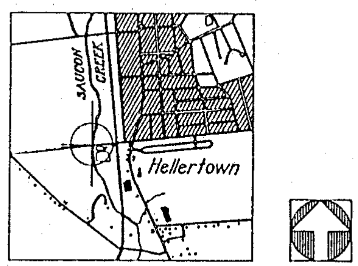
The bridge is a 55-foot, 5-panel through-truss span. The cast-iron upper chords and tall web posts flare to their midpoints to resist buckling under compressive forces. The cast-iron, continuous, deck beams cantilever to one side to carry a pedestrian walk. Although cast iron is not normally used beams because of its low tensile strength, Beckel designed his with refinements that successfully withstood loads, without the help of modern steel I-beams, for over 90 years. He flared the upper and lower flanges from ends to center to better resist bending and stiffened the webs with diagonal bars.

Walnut Street Bridge probably dates from the early 1860's and was moved to the site near Hellertown in 1879. In 1970 Northampton County replaced it with a reinforced-concrete deckgirder span. At present, the bridge sits adjacent to its former site in Hellertown.

State map



Site map



Original location over Saucon Creek
Based on U.S.G.S. 7.5 min series Topographic map, Hellertown Quadrangle

Scale 1:16000

This recording project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States.

The Cast and Wrought Iron Bridges Recording Project was cosponsored in 1991 by the Historic American Engineering Record and the West Virginia University Institute for the History of Technology and Industrial Archaeology. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Dr. Robert J. Kapsch, Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; Emory Kemp, Director, Institute for the History of Technology and Industrial Archaeology, and Dean Herrin, HAER Staff Historian.

The Recording Team consisted of Christine Ussler (Architecture Faculty, Lehigh University) Architect and Field Supervisor; Christine Theodoropulos, P.E. (Architecture Faculty California State Polytechnic University, Pomona); Wayne Chang (University of Notre Dame), Monika Korsós (Technical University of Budapest, Hungary, US/ICOMOS), Architectural Technicians; Robert W. Hadlow (Washington State University), William Chamberlin, P.E., Historians; and Joseph E. B. Elliott (Muhlenberg College), Photographer

Drawings Revised in 1993

DELINEATED BY: Wayne Chang, Monika Korsós 1991.

CAST & WROUGHT IRON BRIDGES RECORDING PROJECT
NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

HELLERTOWN

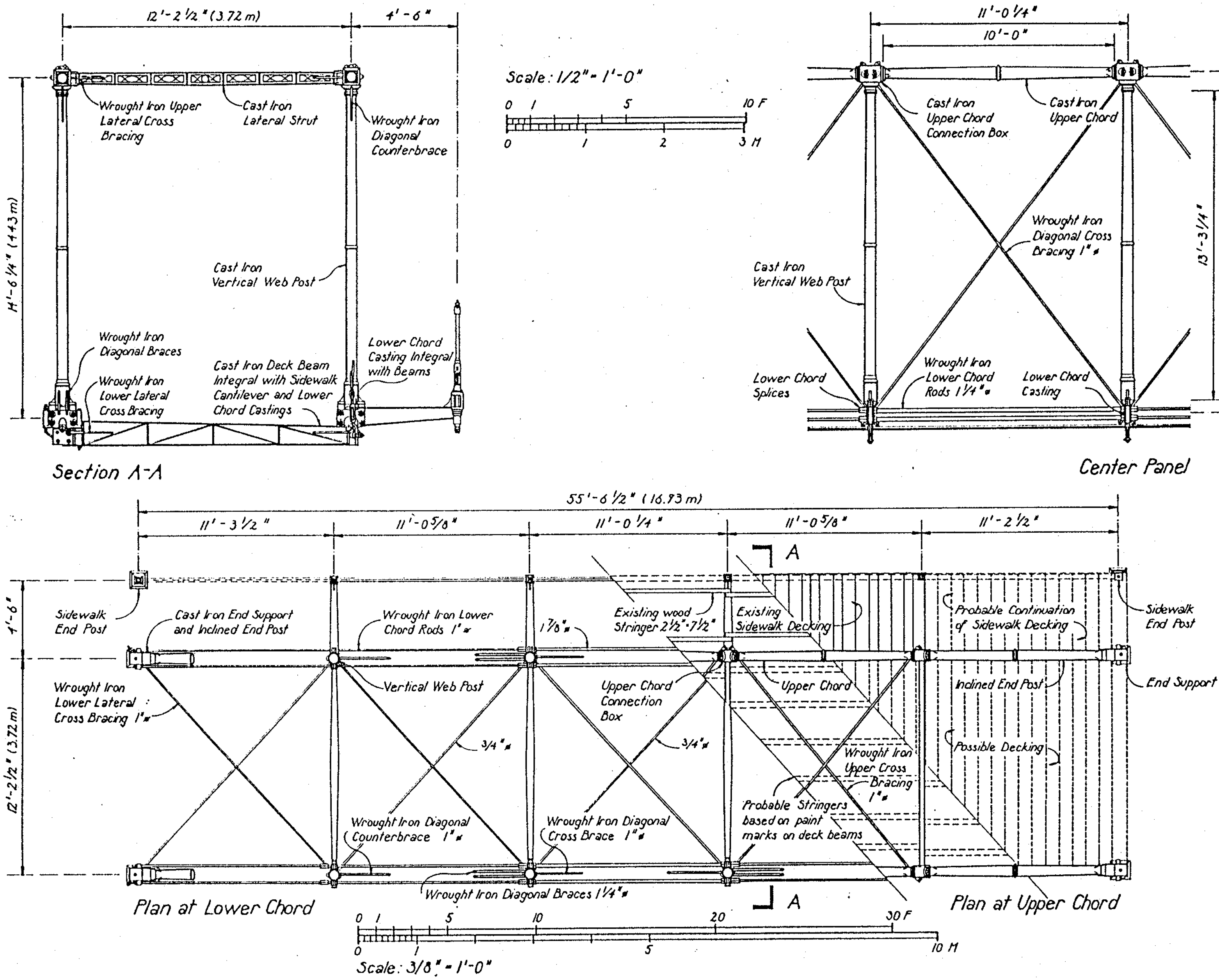
WALNUT STREET BRIDGE, C.1860
FORMERLY SPANNING SAUCON CREEK
NORTHAMPTON COUNTY

PENNSYLVANIA

SHEET 1-3

HISTORIC AMERICAN ENGINEERING RECORD PA-206

TRIM LINE



Drawing revised in 1993

DELINEATED BY: Monika Korsós

CAST & WROUGHT IRON BRIDGES RECORDING PROJECT

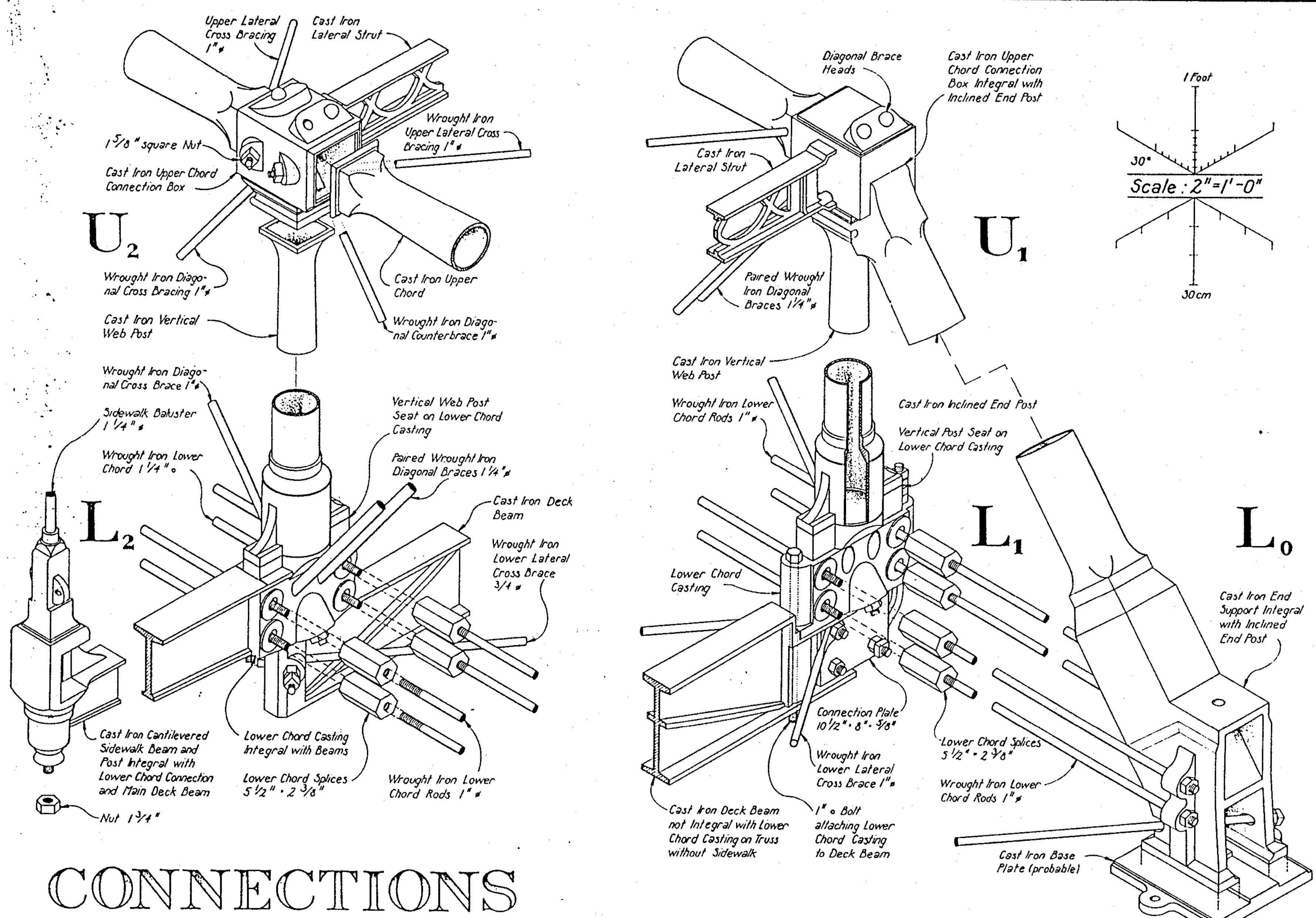
HELLERTOWN

WALNUT STREET BRIDGE, c.1860
FORMERLY SPANNING SAUCON CREEK
NORTHAMPTON COUNTY

PENNSYLVANIA

SHEET 2 of 3

HISTORIC AMERICAN ENGINEERING RECORD
PA-206



CONNECTIONS

drawings revised in 1993

DELINEATED BY Monika Korsós 1991

CAST & WROUGHT IRON BRIDGES RECORDING PROJECT

NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

HELLERTOWN

WALNUT STREET BRIDGE, c.1860
FORMERLY SPANNING SAUCON CREEK
NORTHAMPTON COUNTY

PENNSYLVANIA

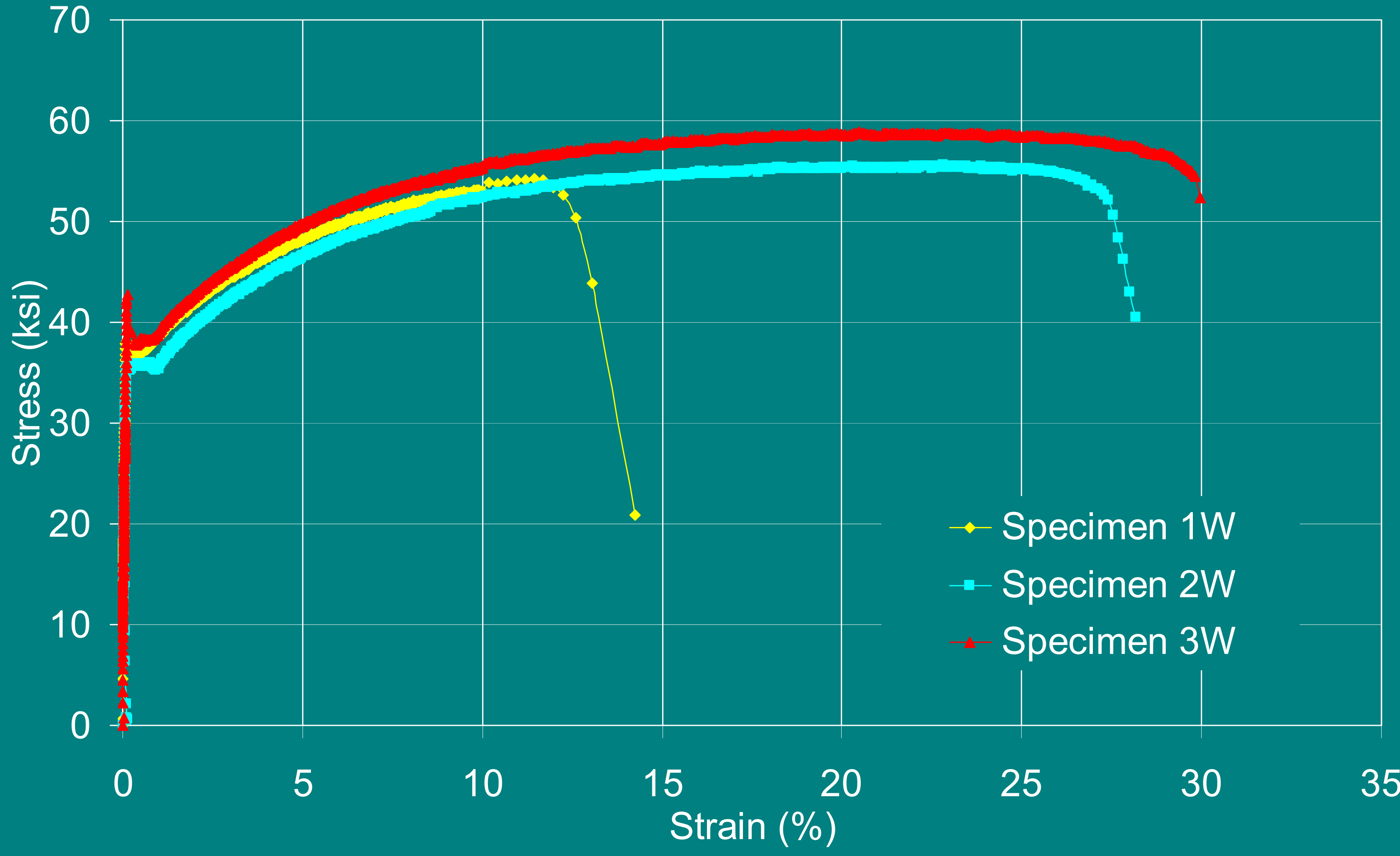
SHEET 3-3

HISTORIC AMERICAN ENGINEERING RECORD PA-206

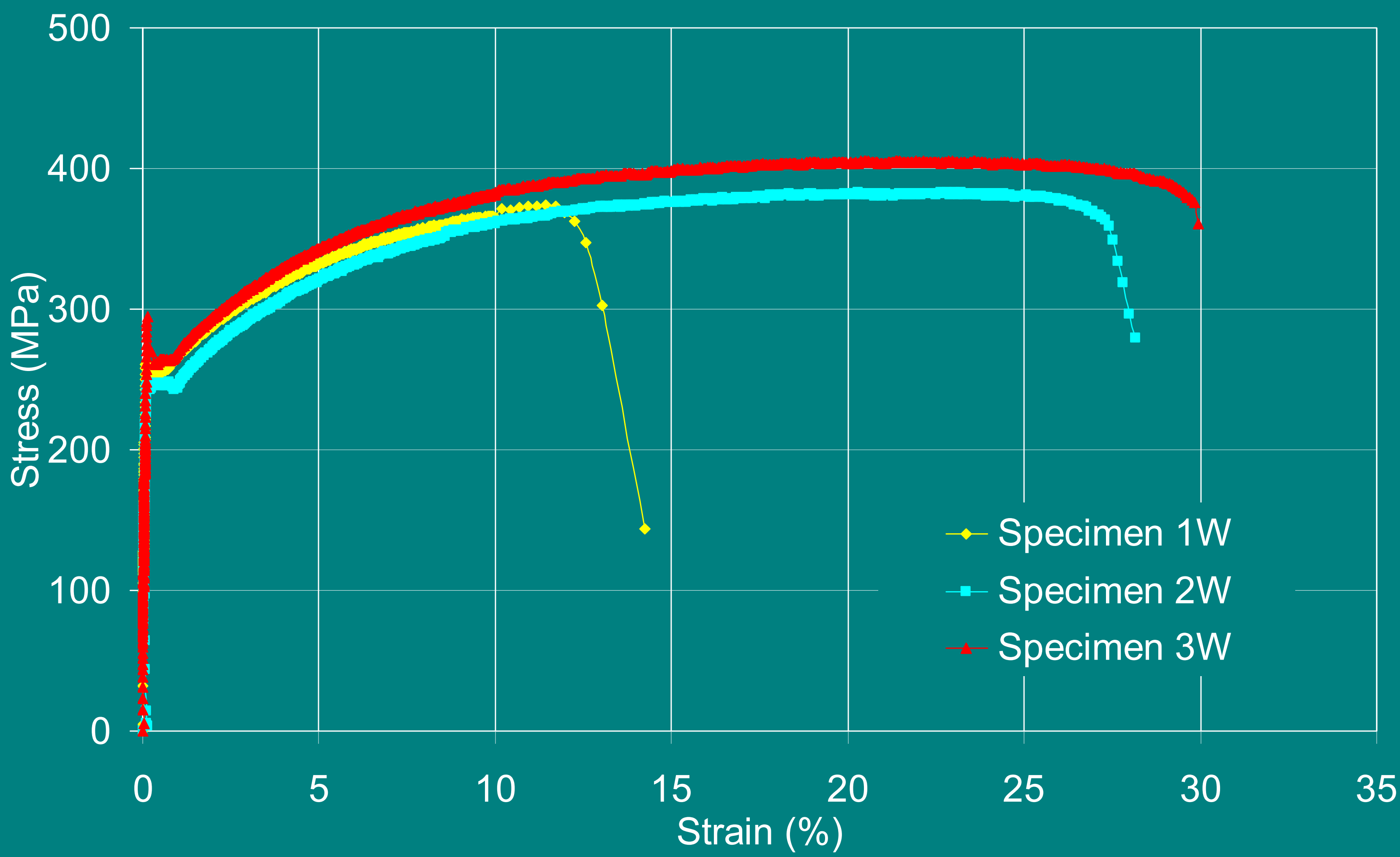
MATERIAL PROPERTY TESTING

- ASTM E8-94a — Standard Test Methods of Tension Testing of Metallic Materials
- ASTM E9-89a — Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature
- ASTM E23-94b — Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
- ASTM E290-92 — Standard Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials

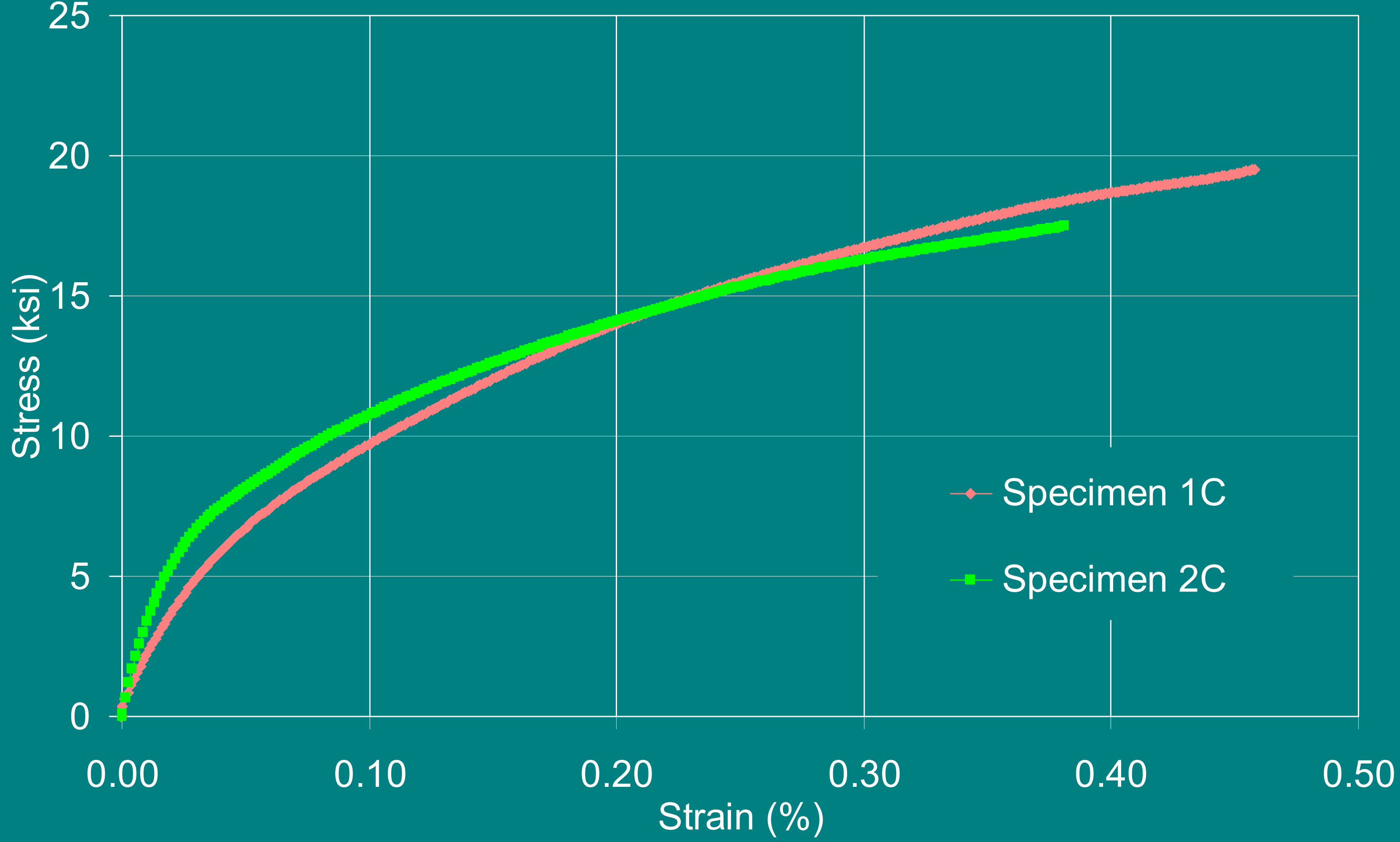
WROUGHT IRON TENSION BEHAVIOR



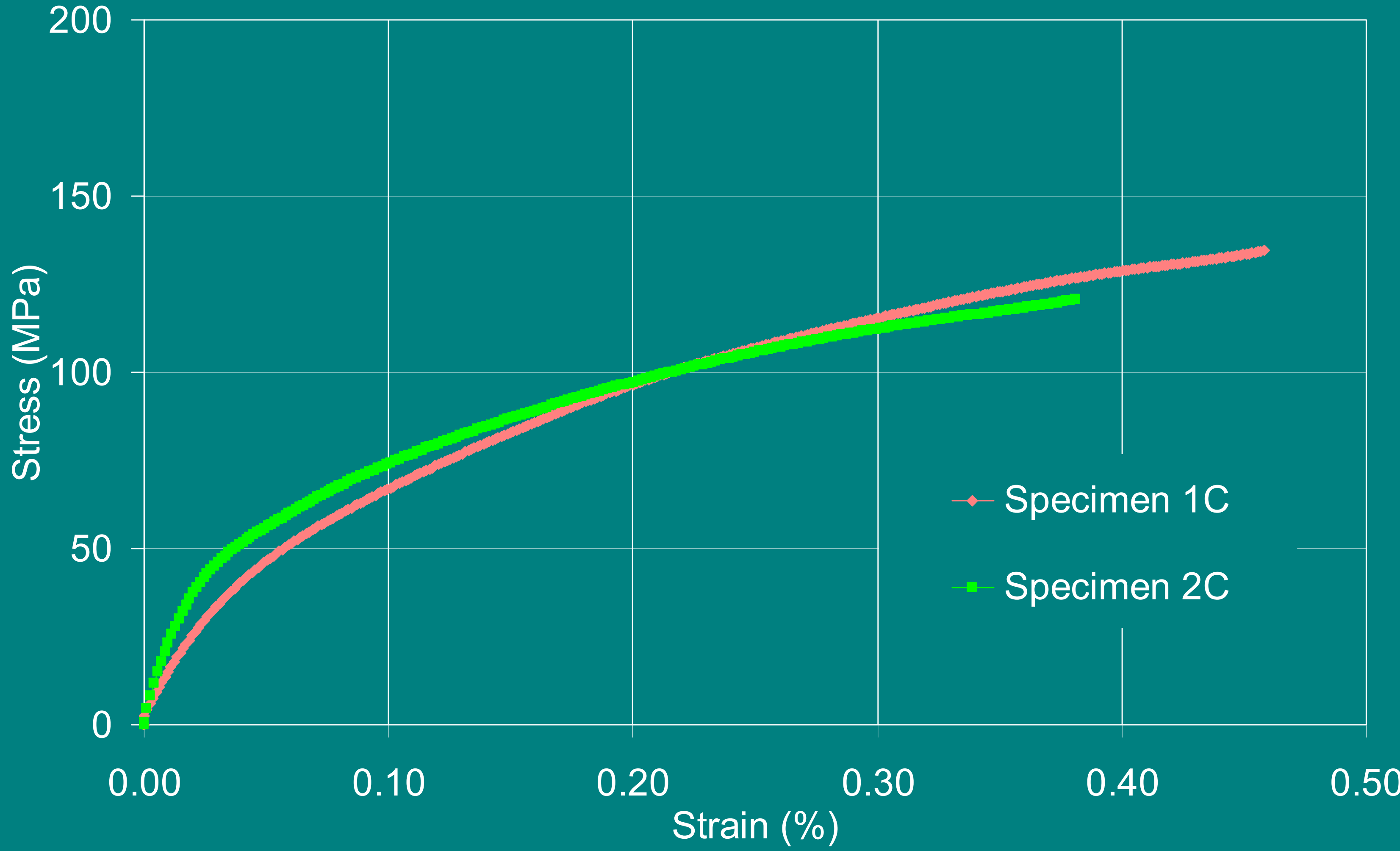
WROUGHT IRON TENSION BEHAVIOR



CAST IRON TENSION BEHAVIOR



CAST IRON TENSION BEHAVIOR



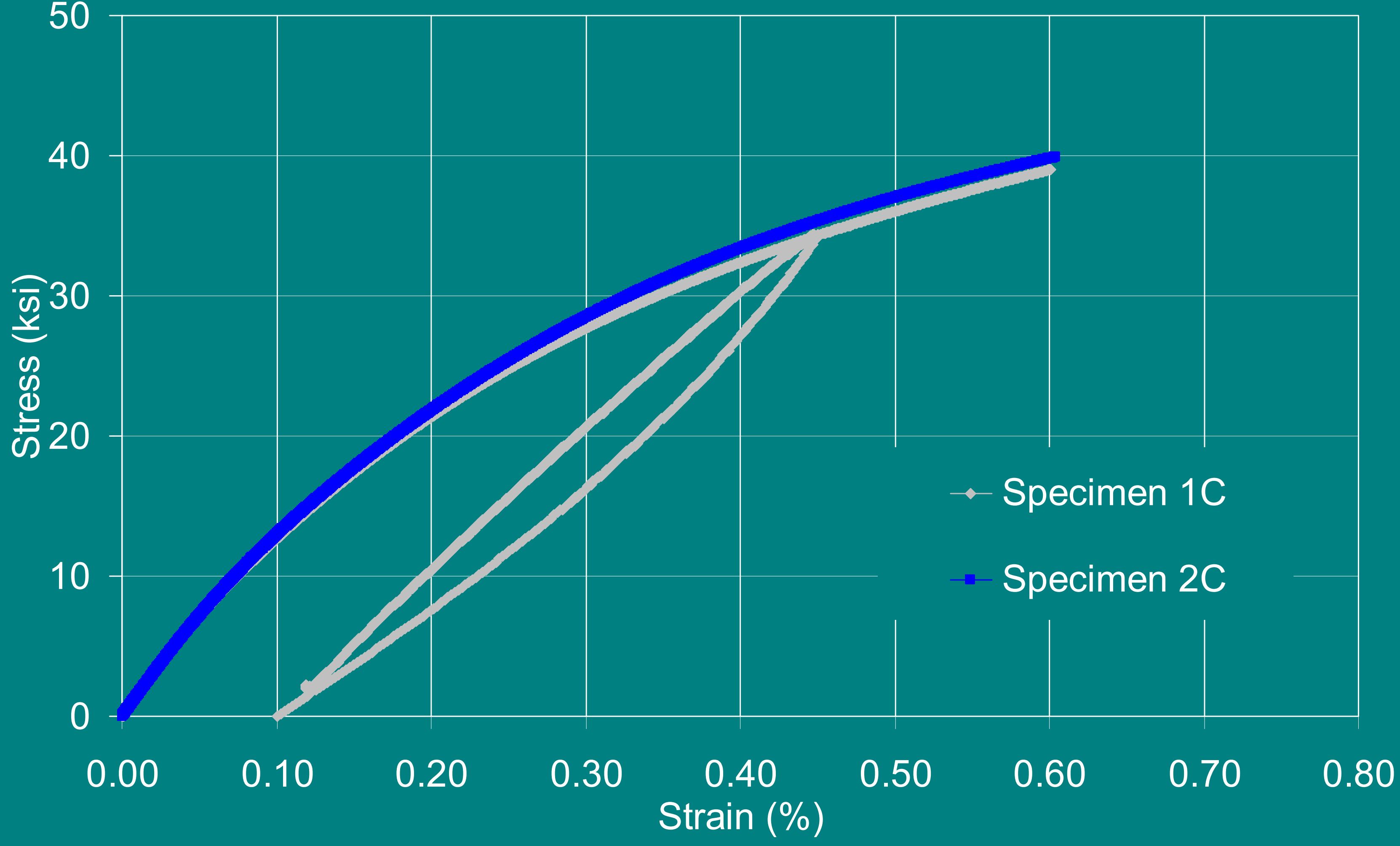
TENSILE PROPERTIES OF MATERIALS

Specimen ID	Diameter (in.)	Area ($in.^2$)	σ_y (ksi)	σ_u (ksi)	ε_u (in./in.)
Wrought Iron					
1W	0.498	0.195	38.1	54.3	0.1421
2W	0.498	0.195	35.7	55.6	0.2817
3W	0.499	0.196	42.7	58.8	0.2996
Cast Iron					
1C	0.502	0.198	NA	19.5	0.0046
2C	0.499	0.196	NA	17.6	0.0038

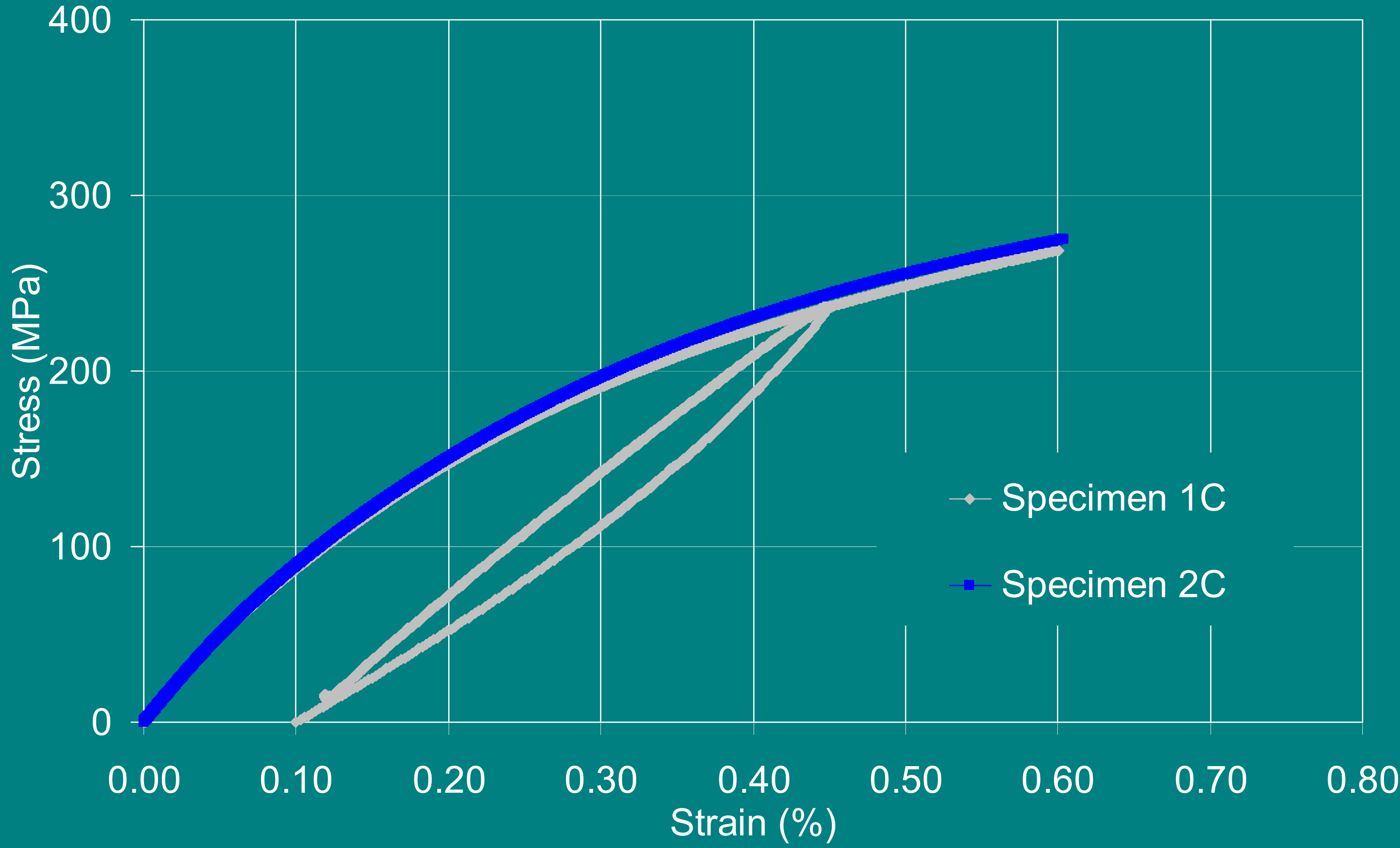
TENSILE PROPERTIES OF MATERIALS

Specimen ID	Diameter (mm)	Area (mm^2)	σ_y (MPa)	σ_u (MPa)	ε_u (mm/mm)
Wrought Iron					
1W	12.65	125.8	262.7	374.4	0.1421
2W	12.65	125.8	246.2	383.4	0.2817
3W	12.67	126.4	294.4	405.4	0.2996
Cast Iron					
1C	12.75	127.7	NA	134.5	0.0046
2C	12.67	126.4	NA	121.4	0.0038

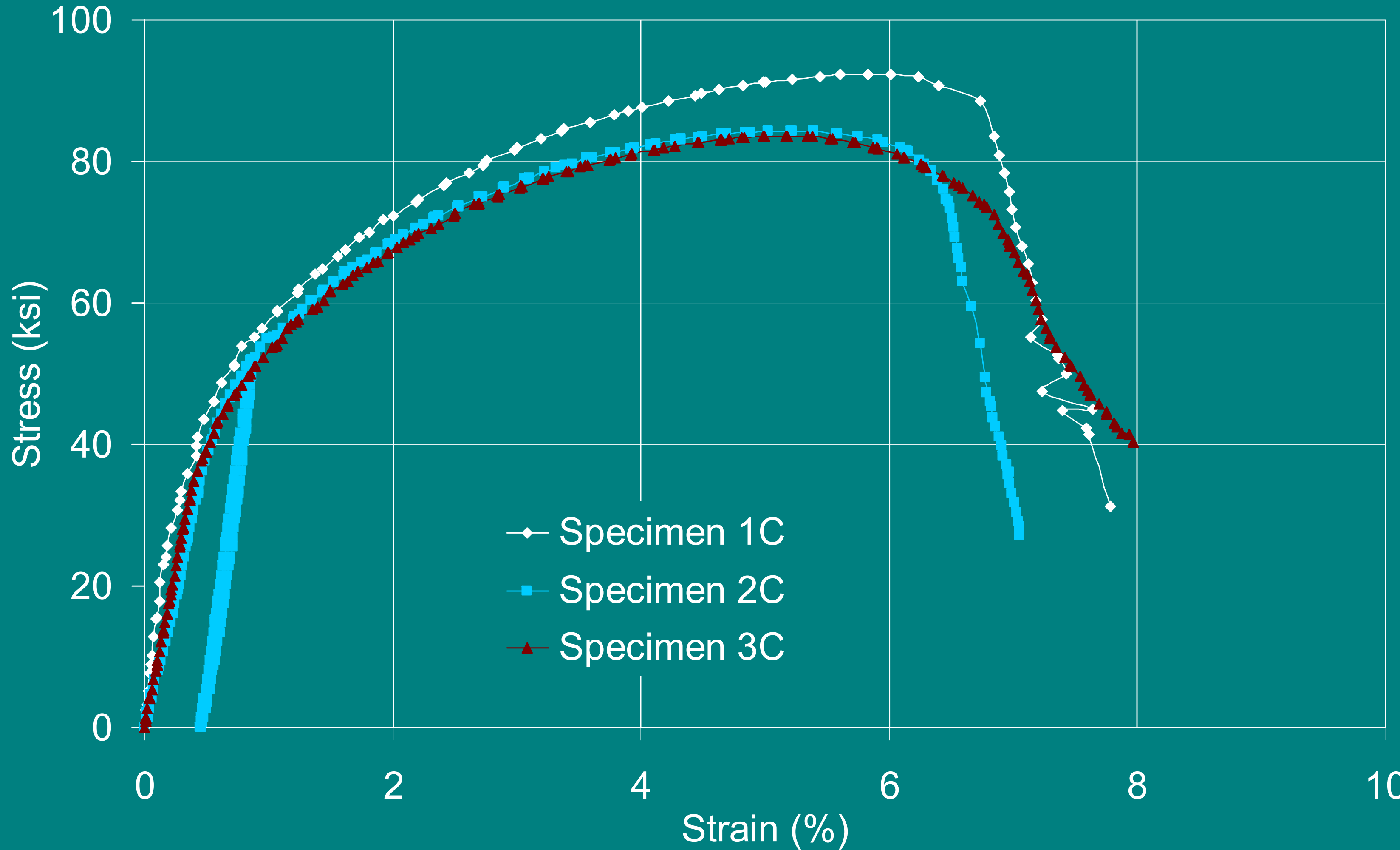
CAST IRON FLEXURAL BEHAVIOR



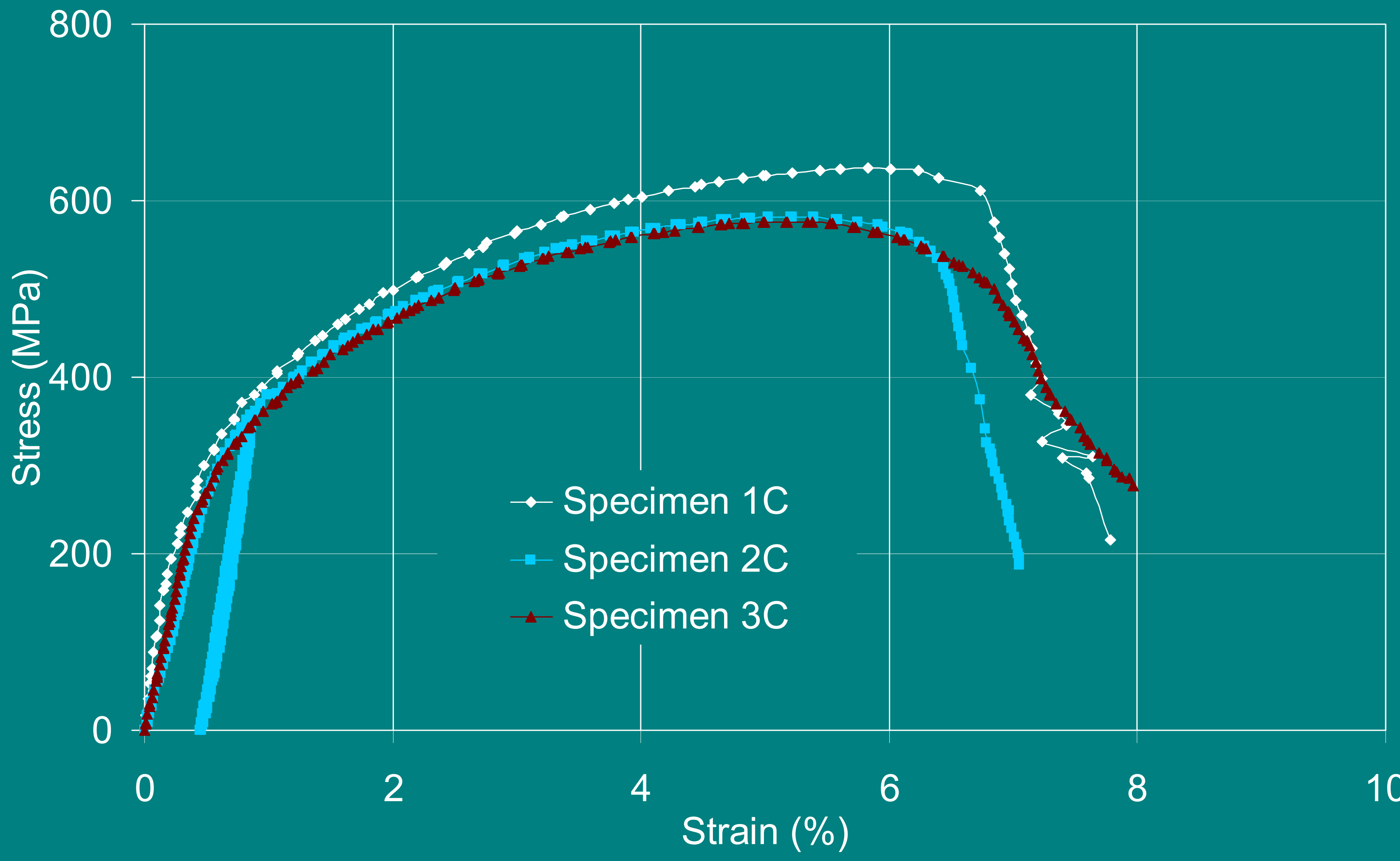
CAST IRON FLEXURAL BEHAVIOR



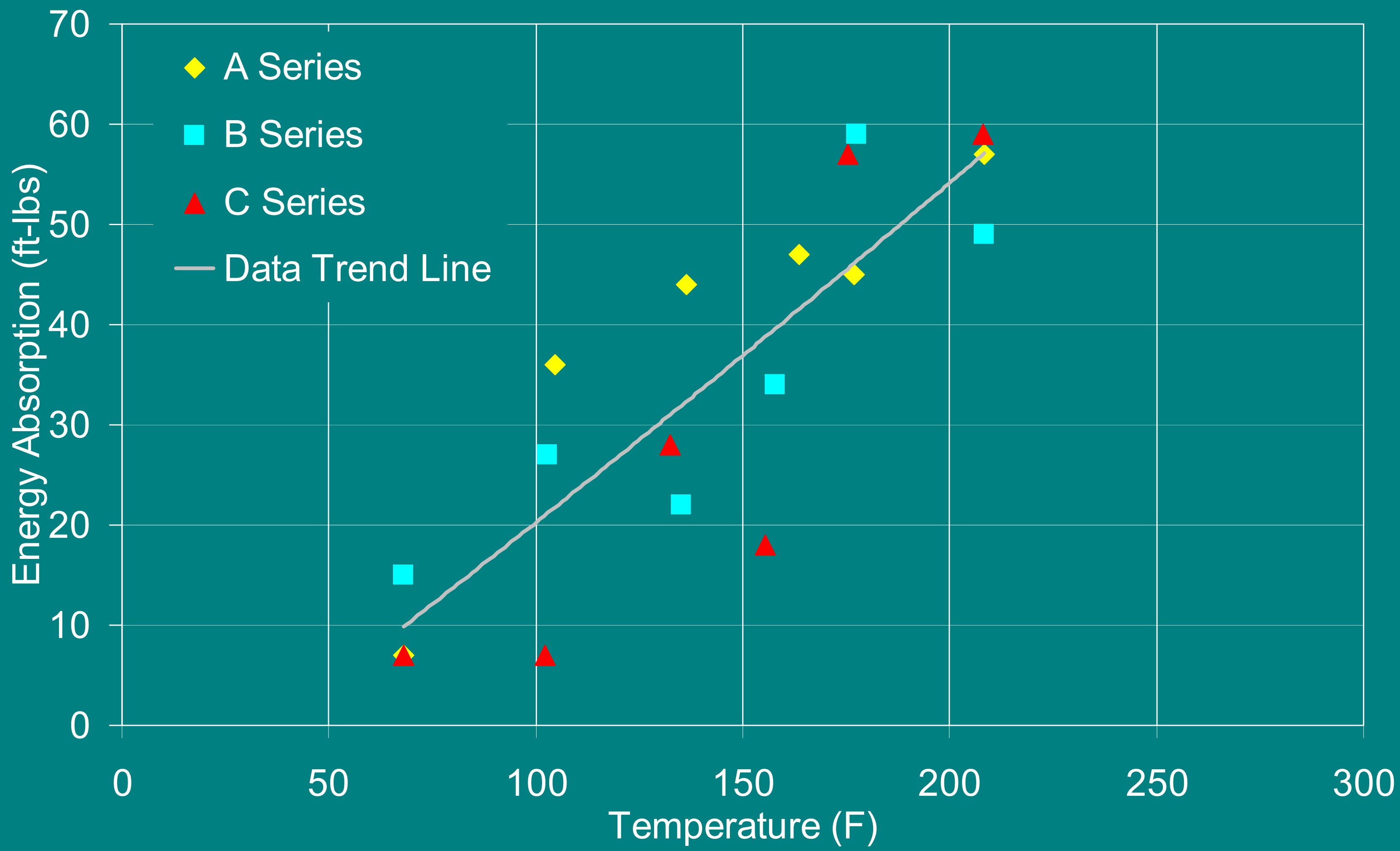
CAST IRON COMPRESSION BEHAVIOR



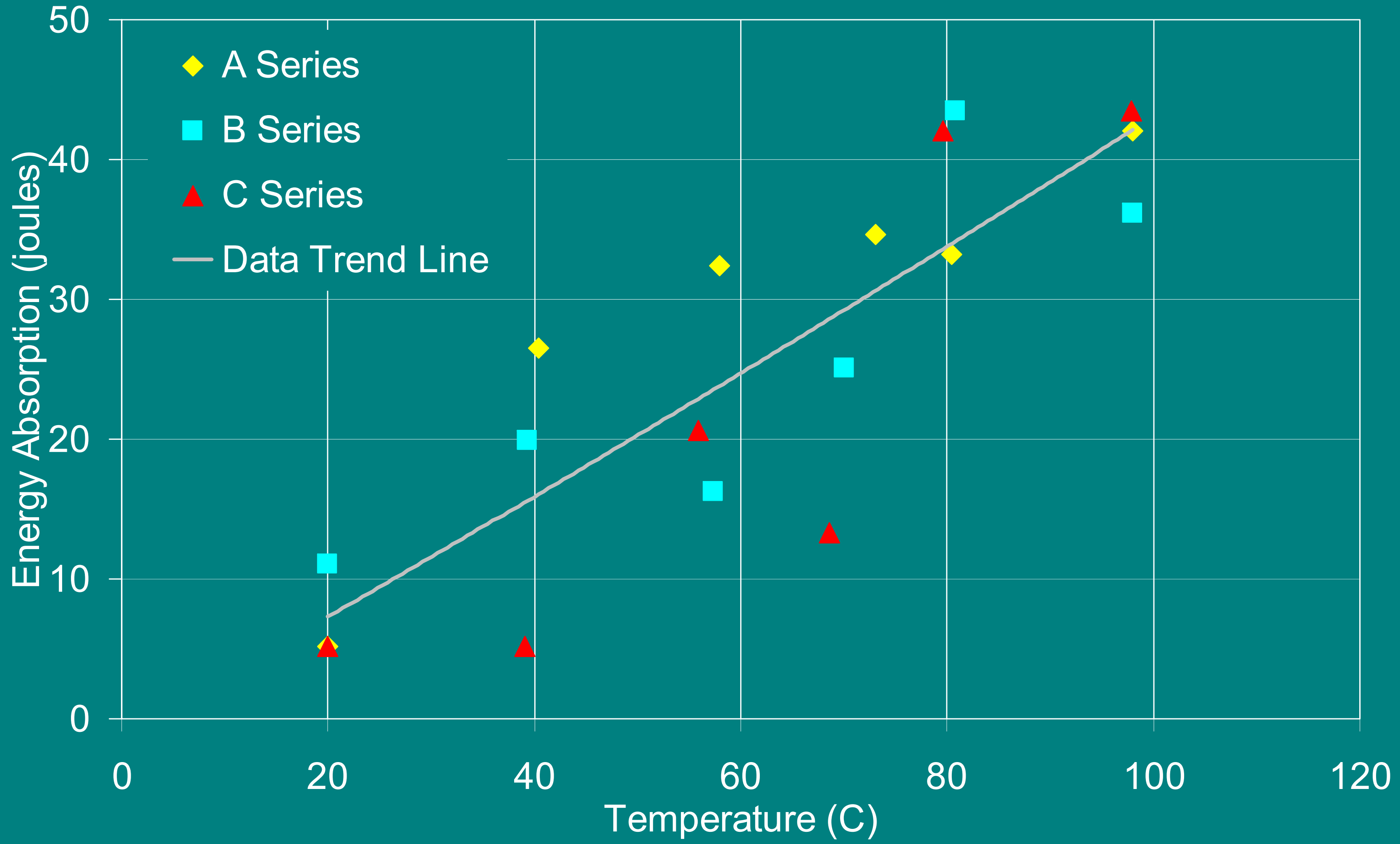
CAST IRON COMPRESSION BEHAVIOR



WROUGHT IRON CHARPY IMPACT TESTS



WROUGHT IRON CHARPY IMPACT TESTS



DISASSEMBLING THE BRIDGE

- **September 23, 1994**
  - Erected Scaffolding, Stabilized Trusses, Secured Connections
  - Blocked and Shored Up Endposts
  - Marked Members with Temporary ID's
- **September 24, 1994**
  - Removed First Cast Iron Member by Hand
  - Cut and Removed Wrought Iron Diagonals
  - Broke Trusses Down into Triangular Modules
- **September 25, 1994**
  - Cut and Removed Remaining Wrought Iron Members
  - Removed Remaining Cast Iron Members
  - Placed all Cast Iron Members in Storage

MAJOR PROJECT MILESTONES

- **Fall 1994**
  - Disassembled Bridge
  - Performed Member-by-Member Condition Assessment
- **Summer 1995**
  - Set Final Alignment for New Location of Bridge
  - Cleared Site and Dug East Footing Location
  - Constructed East Footing and Abutment Wall
- **Fall 1995**
  - Dug West Footing Location
  - Constructed West Footing and Abutment Wall

MAJOR PROJECT MILESTONES

- **Spring/Summer/Fall 1996**
  - Fabricated and Threaded 72 New Tension Chord/Bracing Members
  - Painted All Cast Iron Members
- **Spring/Summer 1997**
  - Issued Contract for Fabrication of three New Cast Iron Verticals
  - Designed and Fabricated Falsework Bridge
- **Fall 1997**
  - Erected Falsework Bridge between Abutment Walls
  - Initially Placed Floorbeams and Casting Nodes on Falsework
  - Installed Bottom Tension Chord Members

MAJOR PROJECT MILESTONES

- **Summer 1998**
  - Delivered Tension Chord/Bracing Members to the Site
  - Painted Tension Chord/Bracing Members
  - Fabricated Four Tension Chord End Restraint Plates; Two Bearing Plates; Pieces for Lateral Strut Repairs
  - Completed Nonstructural Weld Repairs on Lateral Struts
  - Completed Collar Repairs on Verticals and Upper Chord Members; Connection Detail Repairs for Lateral Struts
  - Finished Back Wall and Wing Wall Designs

REASSEMBLING THE BRIDGE

- **September 8-10, 1998**
  - Made Final Floorbeam Alignments
  - Installed Working Deck and Erected Scaffolding
  - Reviewed Final Construction Sequence
- **September 14, 1998**
  - Erected Downstream and Upstream Trusses in Stable Triangular Modules Starting from West Abutment
  - Connected Trusses Together with Lateral Strut
  - Installed Second Verticals and First Upper Chord Members
  - Connected Trusses with Lateral Strut and Installed Sway Bracing
  - Repeated Above Sequence Starting from East Abutment

REASSEMBLING THE BRIDGE

- **September 15, 1998**
  - Installed Remaining Two Upper Chord Members
  - Placed Upper Sway Bracing Between Trusses
  - Placed Lower Sway Bracing Between Trusses
  - Tensioned Fully All Bracing Members
  - Adjusted Bracing Lengths and Squared Truss Panels
- **September 22, 1998**
  - Lowered Falsework Bridge Girders onto End Bearings Allowing Trusses Carry Full Dead Load of Structure
- **Fall 1998**
  - Placed Wood Stringers and Decking on Bridge
  - Completed Concrete Backwalls

VOLUNTEERS

- **Lehigh University Graduate Students**

William Bruin
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Ian Hodgson
Paul Tsakopoulos

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Joe Kach
Robert Frederick
Randy Frey
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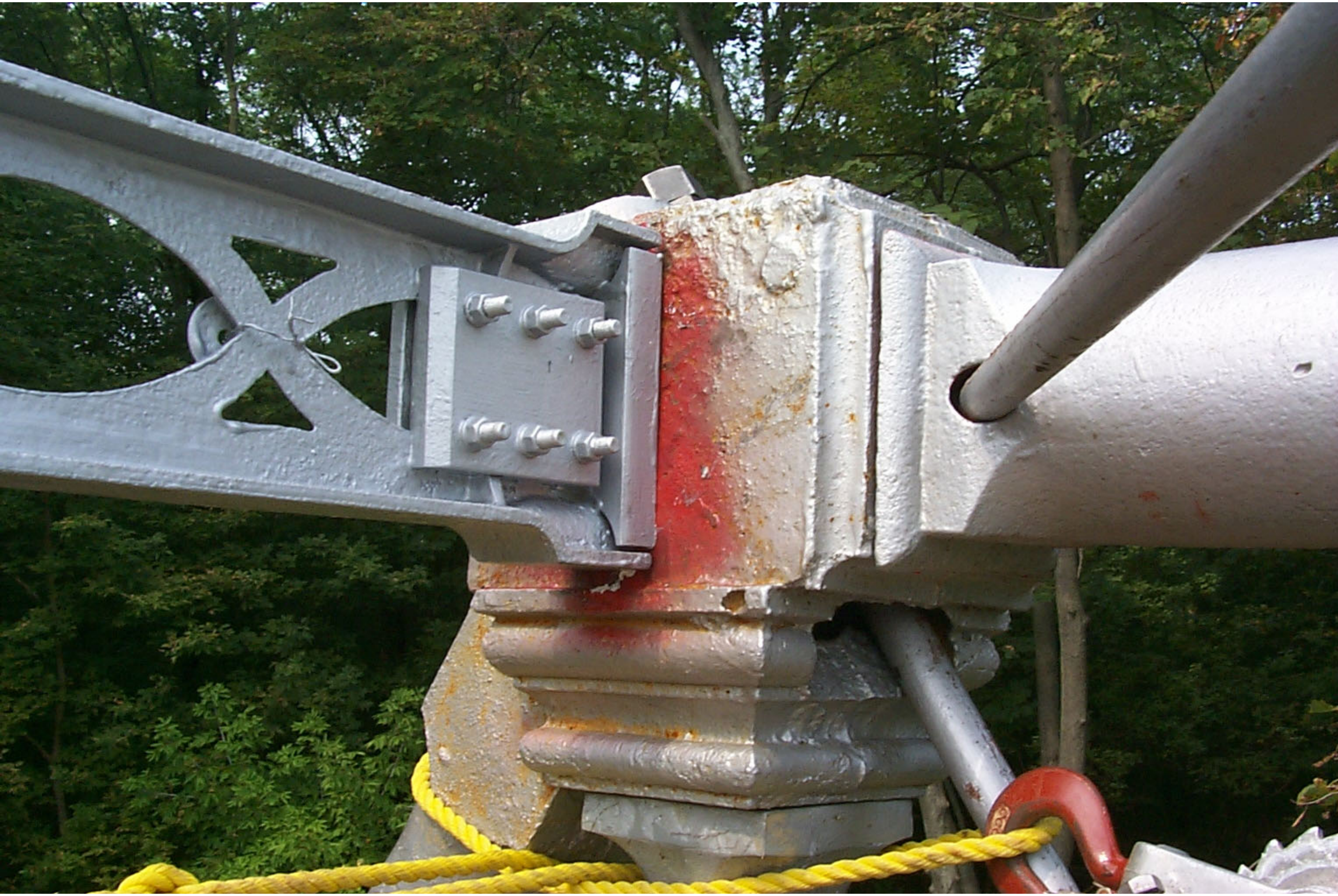
Joseph Poltl
Ronald Svites
Vincent Winters


4
4T
3*
2B
1*
T


TEST PANEL



Preservation of Historic Bridges – A Civil Engineer's Role

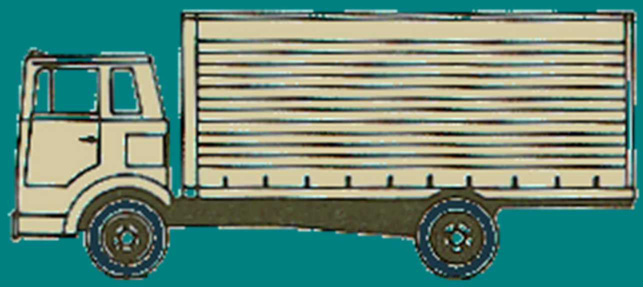
Perry S. Green, PhD
Technical Director
Steel Joist Institute

South Dakota School of Mines and Technology
January 25, 2005

A Civil Engineer's Role in Transportation Engineering

- Planning Engineers
- Design Engineers
- Highway Engineers
- Hydraulic Engineers
- Geotechnical Engineers
- Construction Engineers
- General Civil Engineers
- Structural Engineers
- And others

AASHTO Design Loads



Standard H Truck

H15 30 kips

H20 40 kips

Standard HS Truck

HS15 54 kips

HS20 72 kips

HS25 90 kips

Current Design Practice

BRIDGE RATINGS

TABLE G0.0 - FHWA CONDITION RATINGS	
CODE	**DESCRIPTION**
N	NOT APPLICABLE
9	EXCELLENT CONDITION
8	VERY GOOD CONDITION - no problems noted.
7	GOOD CONDITION - some minor problems.
6	SATISFACTORY CONDITION - structural elements show some minor deterioration.
5	FAIR CONDITION - all primary structural elements are sound but may have minor section loss, cracking, spalling or scour.
4	POOR CONDITION - advanced section loss, deterioration, spalling or scour.
3	SERIOUS CONDITION - loss of section, deterioration, spalling or scour have seriously affected primary structural components. Local failures are possible. Fatigue cracks in steel or shear cracks in concrete may be present.
2	CRITICAL CONDITION - advanced deterioration of primary structural elements. Fatigue cracks in steel or shear cracks in concrete may be present or scour may have removed substructure support. Unless closely monitored it may be necessary to close the bridge until corrective action is taken.
1	"IMMINENT" FAILURE CONDITION - major deterioration or section loss present in critical structural components or obvious vertical or horizontal movement affecting structure stability. Bridge is closed to traffic but corrective action may put back in light service.
0	FAILED CONDITION - out of service - beyond corrective action.


WEIGHT
LIMIT
11
TONS


12'-4"
CLEARANCE
WEIGHT
LIMIT
4
TONS
BRIDGE
CLOSED

Rehabilitation, Repair, Reuse or Replacement of Historic Bridges

- **We must exhaust all alternatives to the rehabilitation, repair, and reuse of historic bridges before replacement is warranted.**
- **We need to be able to apply today's high technology materials in the rehabilitation and repair of historic structures, but at the same time assure that the historic nature of the structure is not compromised.**
- **We must have a good understanding of the behavior of the materials used in the construction of historic structures in order to properly evaluate them.**

Case Studies – Personal Involvement

- **Walnut Street Bridge**
  Northampton County, Hellertown, PA
- **Eck Road Bridge**
  Wyoming County, Bennington, NY
- **Henszey's Wrought Iron Bridge**
  Berks County, Wanamakers, PA

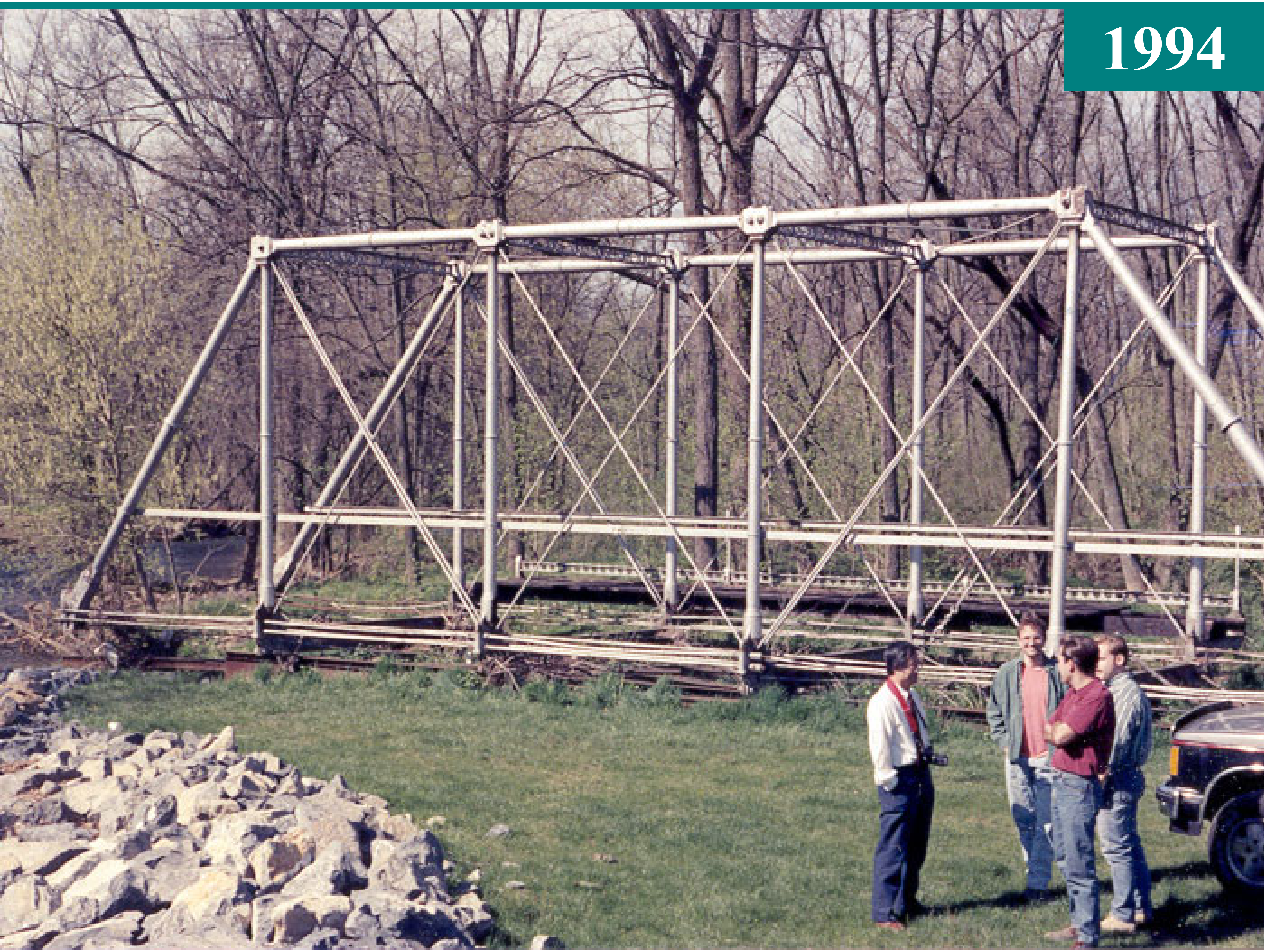
Case Study – Walnut Street Bridge

- **Location:** Formerly crossing Saucon Creek on Walnut Street, Hellertown, Northampton County, PA
- **Description:** 55 ft. single-span Pratt through truss
- **Date Built:** Circa 1860; Original location unknown
- **Fabricator:** Charles N. Beckel, Beckel Iron Foundry and Machine Shop, Sand Island, Bethlehem, PA
- **Owner:** Hellertown Historical Society
- **Significance:** Only extant high-truss span built by Beckel;

  Uses Francis C. Lowthorp's June 30, 1857 Patented lower chord cast connection;

  Floor beams fabricated from cast iron


1970

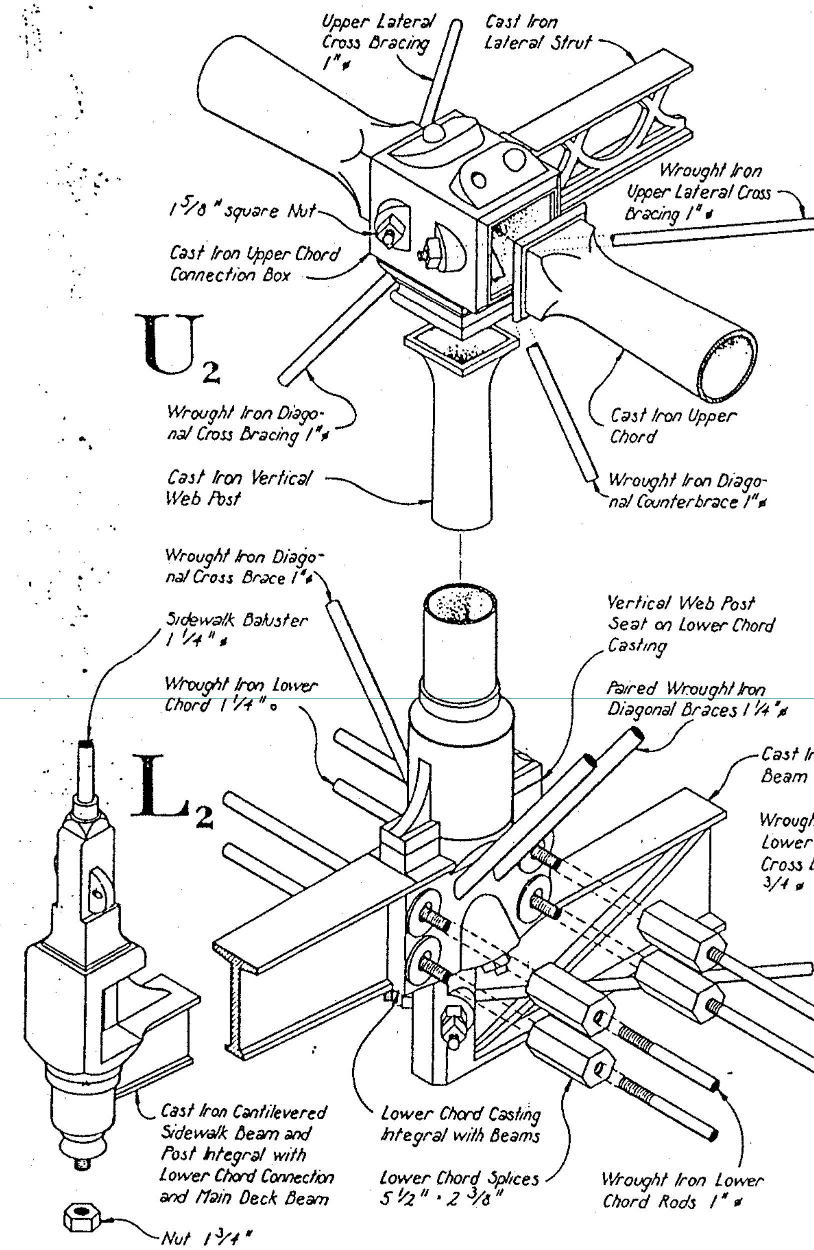


1994

Major Project Milestones

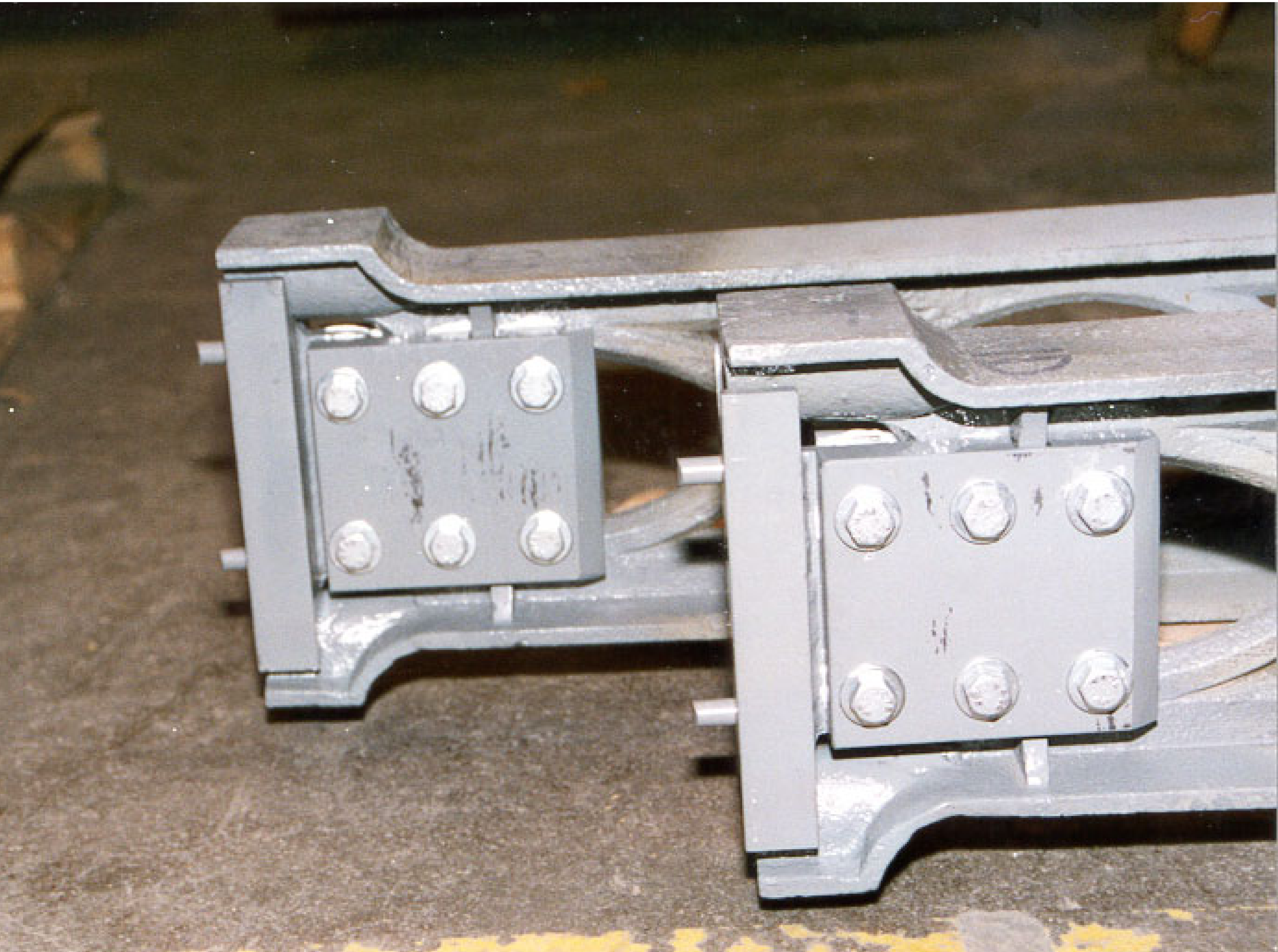
- **September 23-25, 1994** Disassembled bridge
- **Summer 1995** Set final alignment, cleared, dug and constructed East abutment
- **Fall 1995** Dug and constructed West abutment
- **Spring-Fall 1996** Fabricated and threaded new tension chord and bracing members
- **Spring-Summer 1997** Designed and fabricated falsework bridge; issued contract for new castings
- **Fall 1997** Erected falsework bridge; placed floorbeams, casting nodes, tension chord members
- **Summer 1998** Completed all miscellaneous fabrication and member repairs
- **September 8-10, 1998** Made final floorbeam alignments; installed working deck and erected scaffolding
- **September 14-15, 1998** Reassembled bridge
- **September 22, 1998** Lowered falsework bridge; trusses carrying load
- **Fall 1998** Placed wood stringers and decking; completed concrete backwalls


JUNE, 30, 1857.



CONNECTIONS


4
T
4D
3*
T
3D
2B
T
2D
1*
T




TEST PANEL

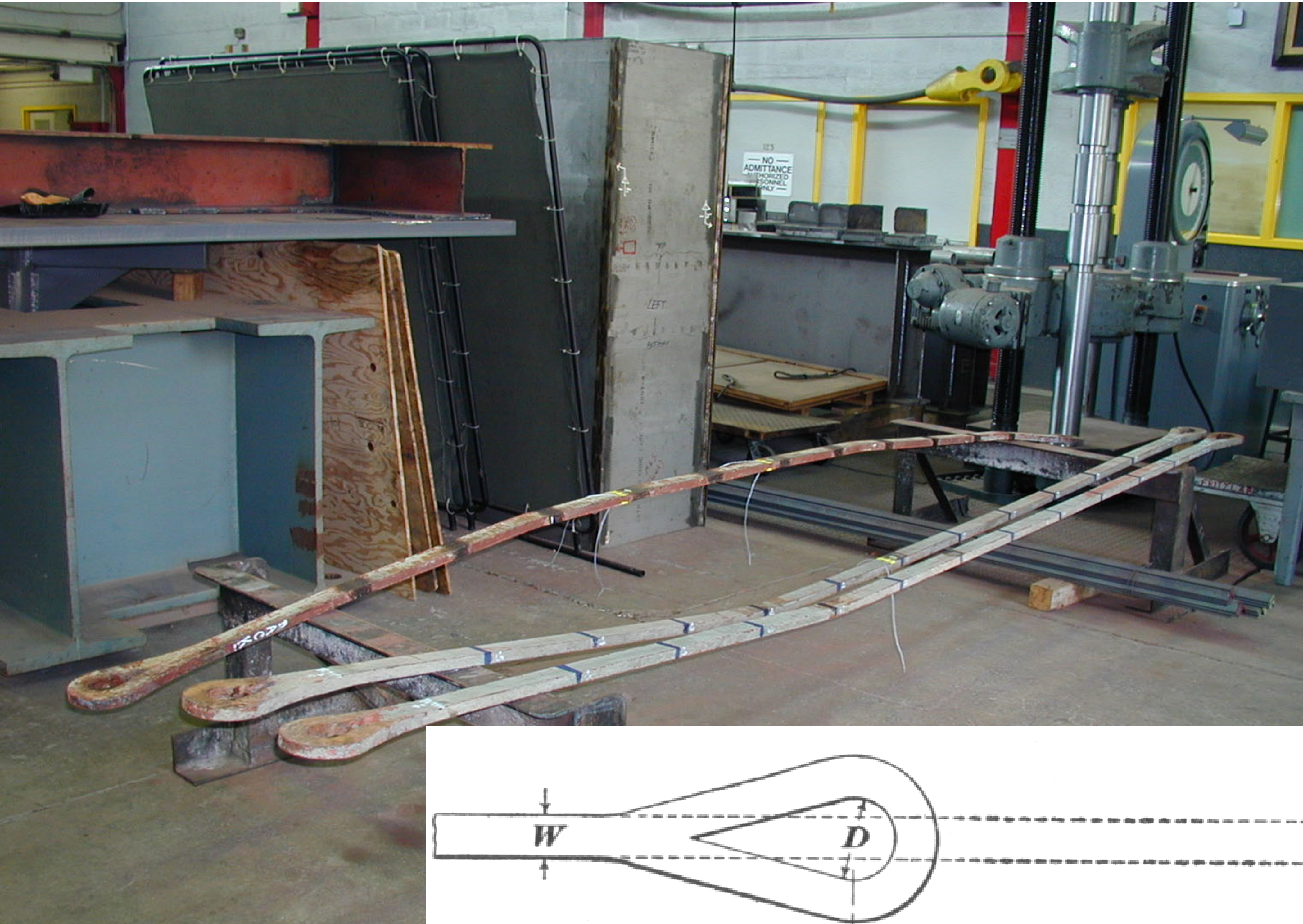
Case Study – Eck Road Bridge

- **Location:** Formerly crossing Tonawanda Creek on Eck Road, Bennington, Wyoming County, NY
- **Description:** 83 ft. single-span Pratt through truss
- **Date Built:** Circa 1900; Original location unknown; Placed at this site in 1910
- **Fabricator:** Unknown, possibly the Wrought Iron Bridge Co. or the Canton Bridge Co.
- **Owner:** New York Department of Transportation
- **Significance:** Wrought Iron Tension Eyebars were Loop-ended as Compared to Later Forged Head Eyebars

Major Project Milestones

- The Eck Road Bridge was damaged during the flood of July 8, 1998
- After Inspection by NYDOT the bridge was closed and subsequently demolished February 9, 2000
- Four full-length looped-end eyebars (A, B, C, D) were salvaged from the lower tension chord of the bridge
- The mechanical properties of the wrought iron looped-end eyebars were to be evaluated; No full-length eyebar tests had been conducted since 1975 when a bridge study was conducted for the Iowa DOT
- The test results are to provide a better estimate of wrought iron material properties: σ_y , σ_{ult} , and E

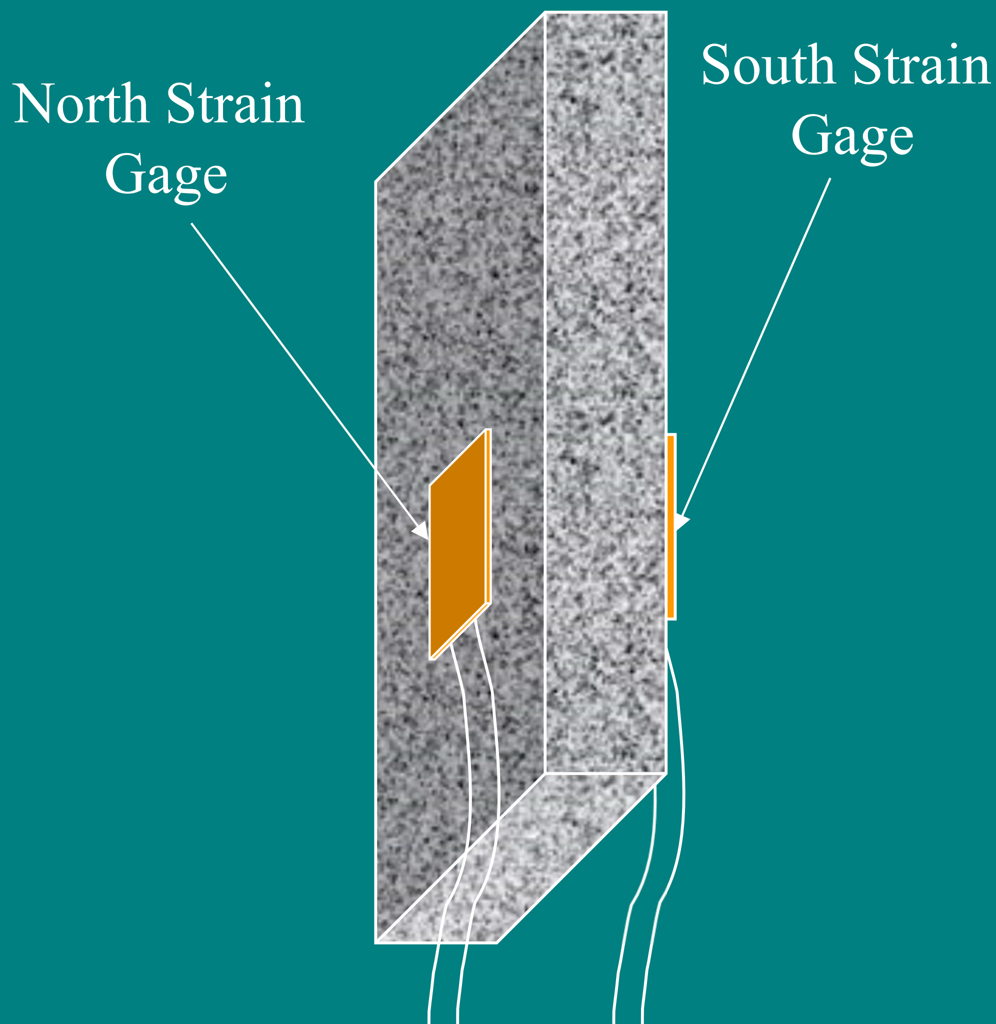

DEAD
END


NO
ADMITTANCE
W
D
L

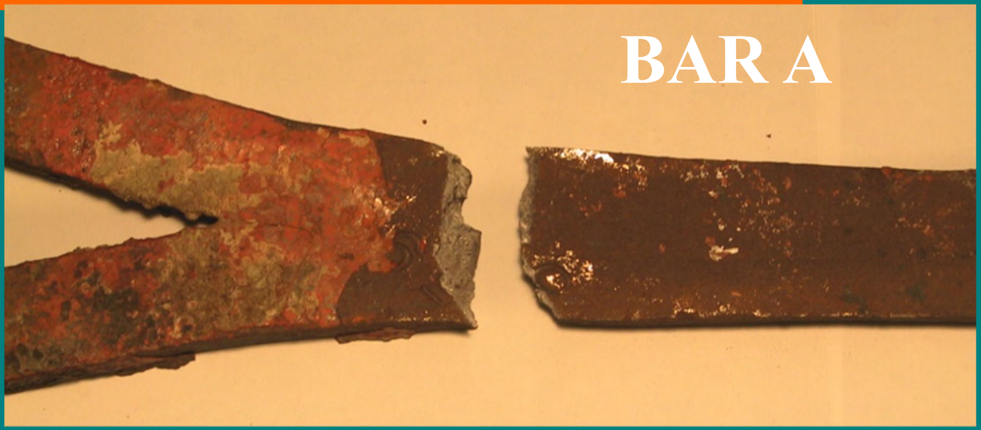
Full-length Eyebar Tests

- Tested as true pin-ended members in an 800 kip Riehle testing machine; Specimen gage length was ~170 inches
- Overall specimen elongation was measured with a string potentiometer; Local specimen strain data was collected by pairs of strain gages located at midheight and at 2 ft. below midheight; Load data was collected from a calibrated load cell attached to the balance arm of the testing machine
- Tests were conducted at an approximate constant displacement rate

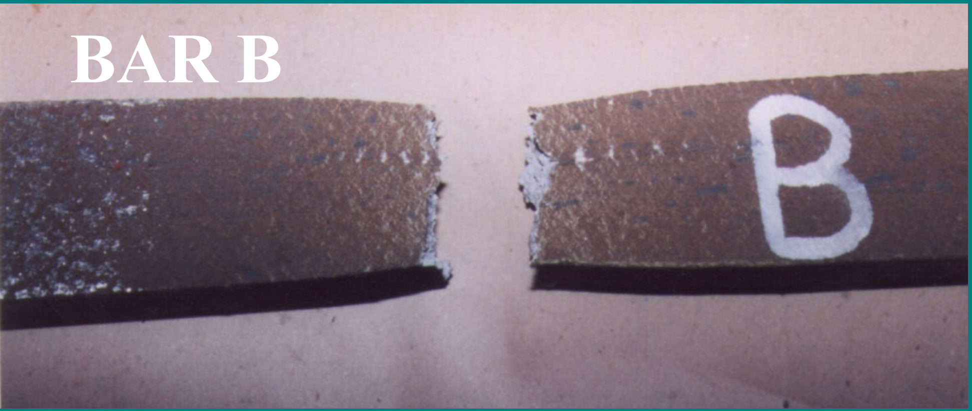
Full-length Eyebar Tests



Test Results – Visual Evaluation



- Failed near looped-end
- Minor necking occurred
- Improper forging
- Silicate orientation

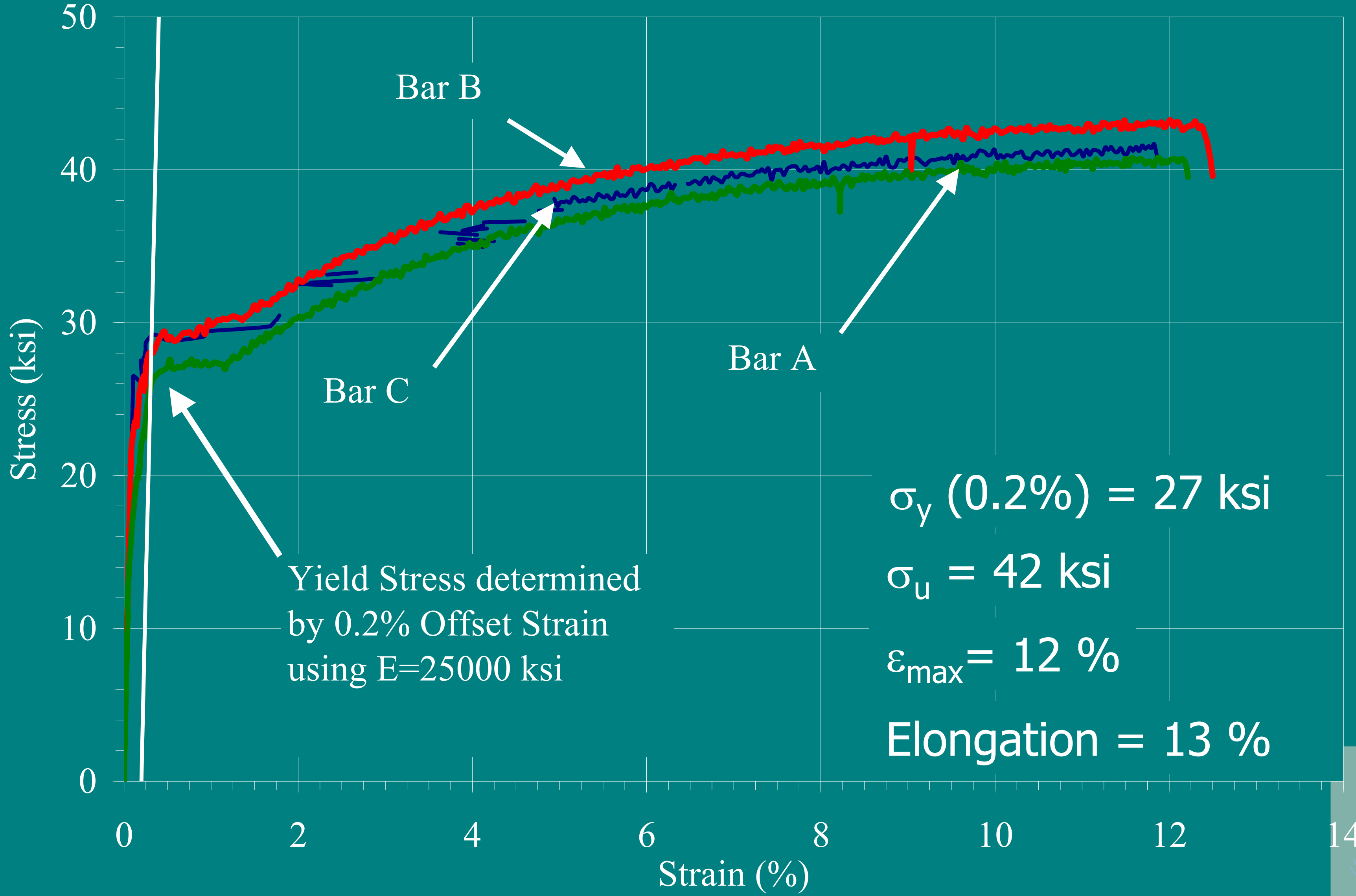


- Failed 6'-6" from mid-height
- Exhibited necking
- 43% reduction in x-sect. area
- 12.6% incr. in overall length

- Failed 0'-7" from mid-height
- 31% reduction in x-sect. area
- 13.3% incr. in overall length

Full-length Eyebar Test Results

Average Stress vs. Strain Results



σ_y (0.2%) = 27 ksi

σ_u = 42 ksi

ε_{max}= 12 %

Elongation = 13 %

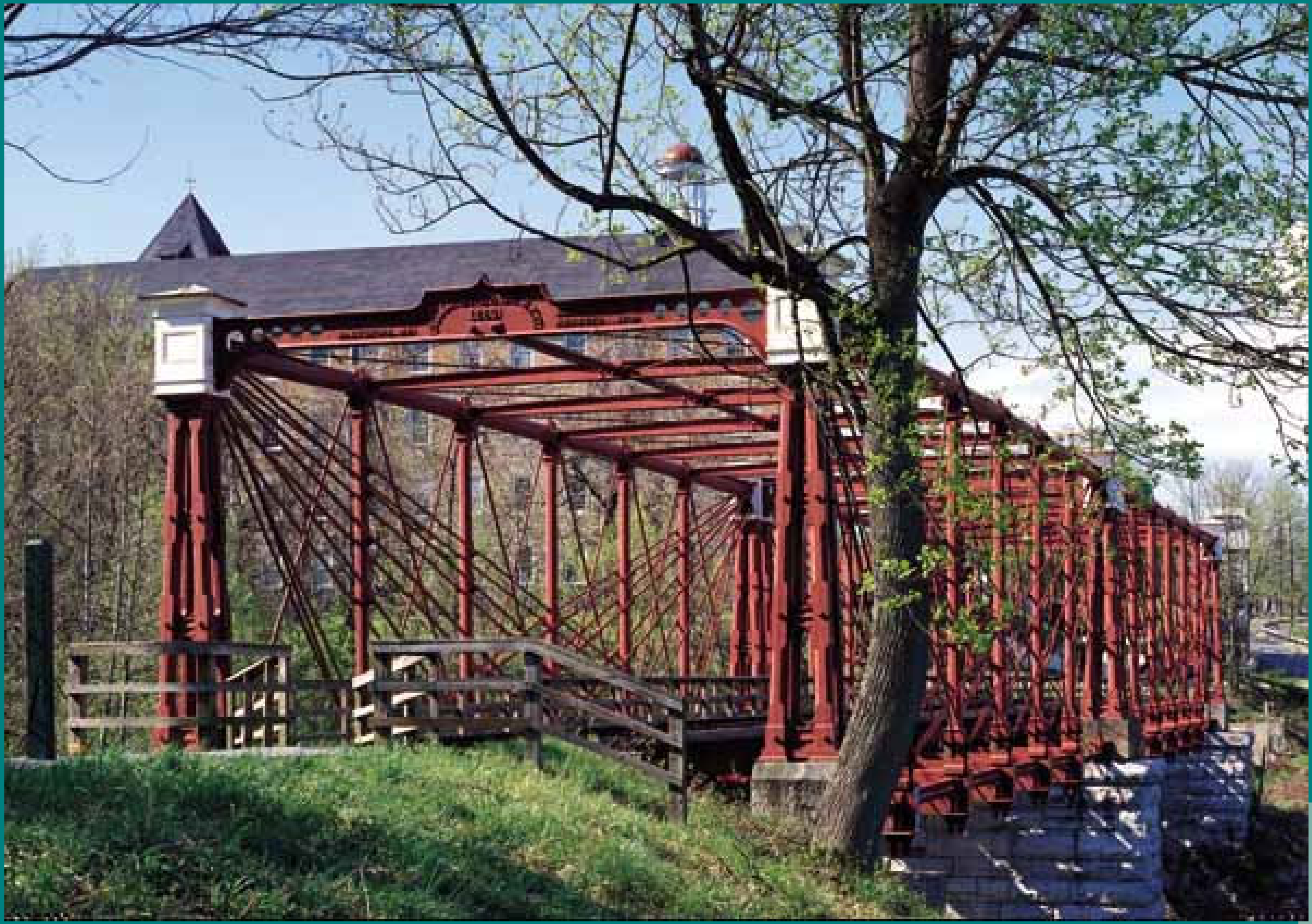
Case Study – Henszey's Bridge

- **Location:** Formerly crossing Ontelaunee Creek on King's Road, Wanamakers, Berks County, PA
- **Description:** Approx. 100 ft. Single span bowstring arch
- **Date Built:** Circa 1869; Original location Slatington, PA
- **Designer:** Joseph G. Henszey
- **Builder:** Continental Bridge Co., Philadelphia, PA
- **Owner:** Pennsylvania Department of Transportation
- **Significance:** Only extant bridge designed by Henszey; Sold to Central Pennsylvania College to be used as a pedestrian bridge on campus






Restoration of Historic Bridges
Bollman Truss Bridge – Savage, MD



Rehabilitation of Historic Bridges

Neshanic Station Bridge - Neshanic Station, NJ

Rehabilitation of Historic Bridges
Faust Street Bridge – New Braunfels, TX

Abandonment of Historic Bridges
Apalahoochee River Bridge – Jennings, FL

Preservation of Historic Bridges?

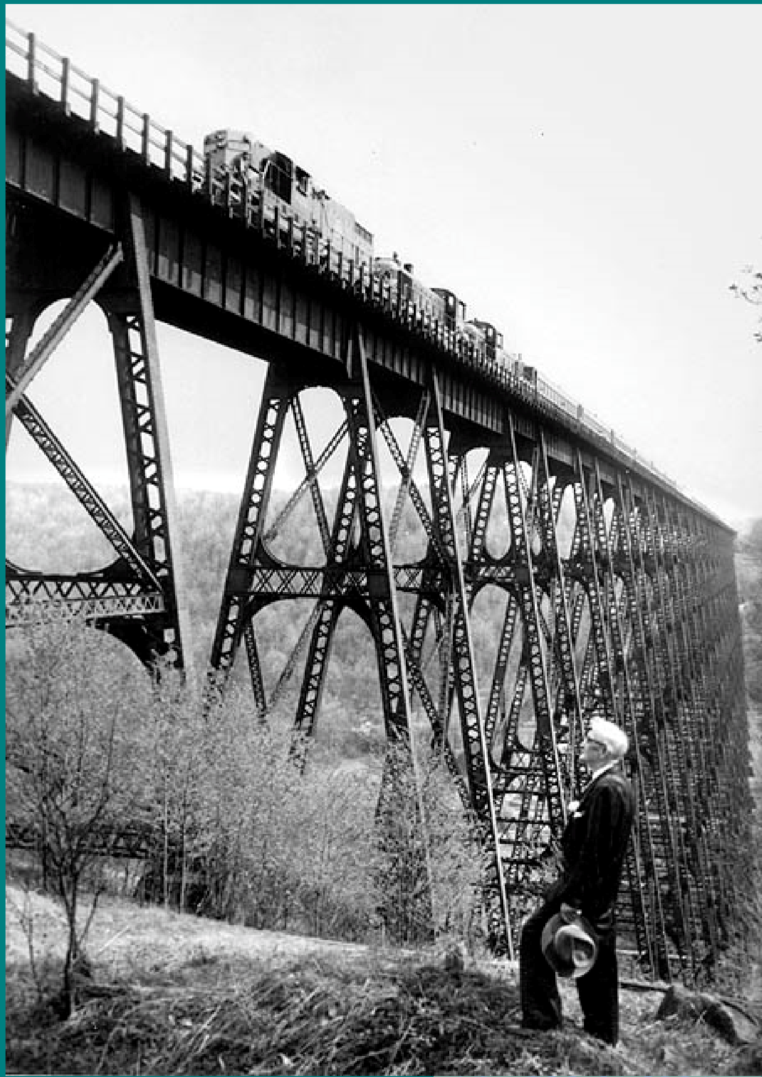
Haupt Truss Bridge – Altoona, PA

Preservation of Historic Bridges?
Blountstown Bridge – Blountstown, FL

Replacement of Historic Bridges
Blountstown Bridge – Blountstown, FL

Destruction of Historic Bridges

Kinzua Viaduct – Mt. Jewett, PA



Destruction of Historic Bridges
Kinzua Viaduct – Mt. Jewett, PA

Destruction of Historic Bridges
Kinzua Viaduct – Mt. Jewett, PA

Preservation of Historic Bridges – What Will be Your Role?

Thank You

Rehabilitation of a Nineteenth Century Cast and Wrought Iron Bridge

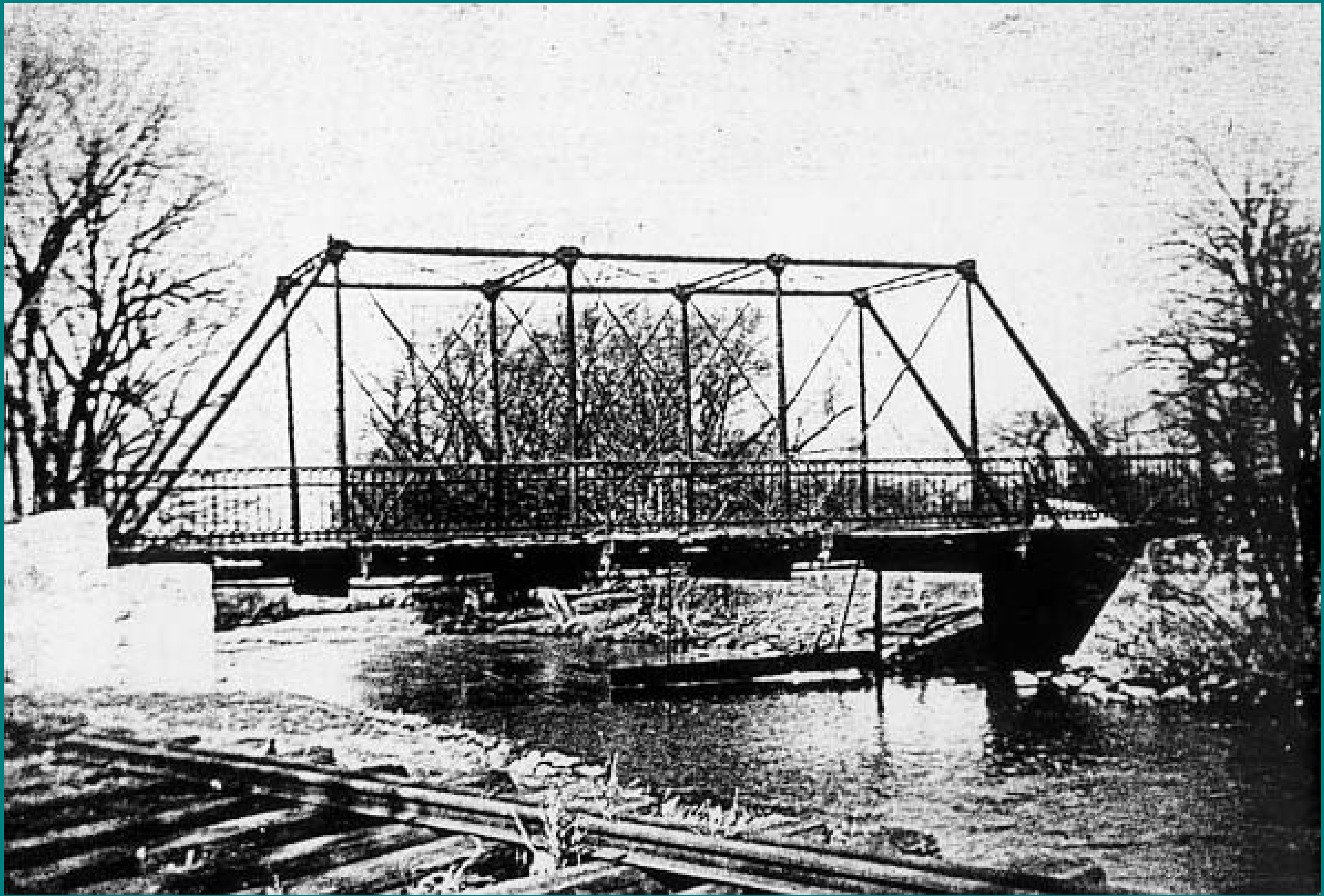
Perry S. Green, PhD, PE

Southern Nuclear Company (BPC)

Waynesboro, GA

BACKGROUND AND OVERVIEW

WALNUT STREET BRIDGE 1915



WALNUT STREET BRIDGE PRIOR TO 1970

WALNUT STREET BRIDGE 1970

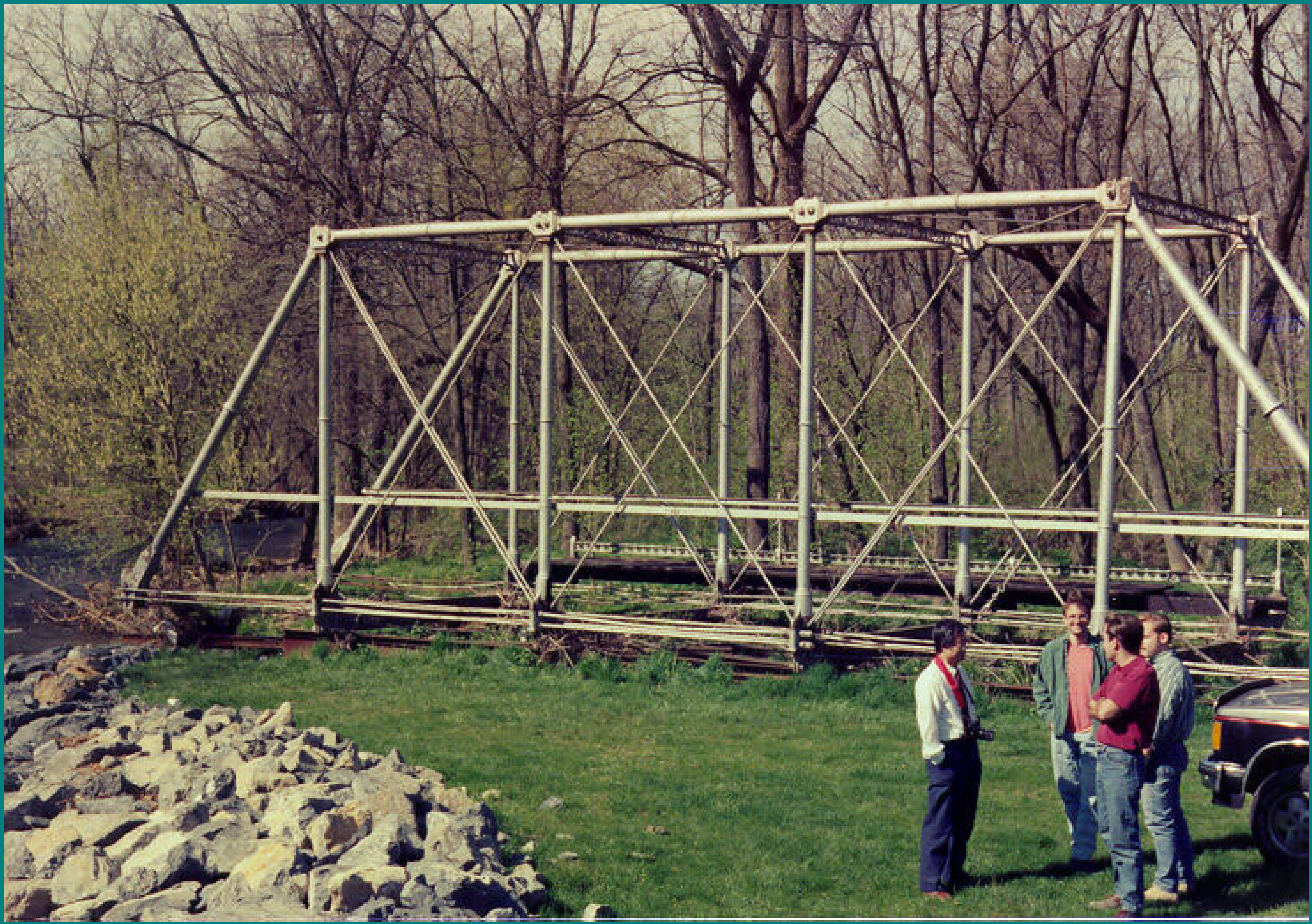
PROJECT OVERVIEW

The Walnut Street Bridge, located in Hellertown, Pa. is a single span (1@55ft) cast and wrought iron Pratt truss bridge built around 1860. The structure was fabricated in Bethlehem, PA at the Beckel Iron Foundry located on what is now known as Sand Island. The bridge carried Walnut Street (which was no more than a dirt road) over Saucon Creek from about 1860 to 1970. In that year the bridge was declared structurally deficient and functionally obsolete and was replaced with a two span steel girder bridge located on the same alignment. Fortunately, due to the foresight of some individuals, the truss was not demolished during construction of the new bridge, but rather lifted by crane as a single unit and placed approximately 150 ft. from its original location along side the creek. The truss remained there untouched and neglected for approximately 25 years.

PROJECT OVERVIEW

In April 1994, the site was visited by Lehigh University Graduate students William Bruin, Robert Connor, Christopher Higgins, Civil Engineering Professor Ben T. Yen and myself as part of an "extended" field trip for a bridge design class that Dr. Yen was teaching. During this initial visit, we observed what appeared to be a "typical" old truss bridge with little historical or engineering significance. However, upon closer examination and research, it quickly became clear that the bridge possessed many unique and interesting engineering details and was historically significant to the engineering community as well as to the Lehigh Valley.

WALNUT STREET BRIDGE 1994



PROJECT OVERVIEW

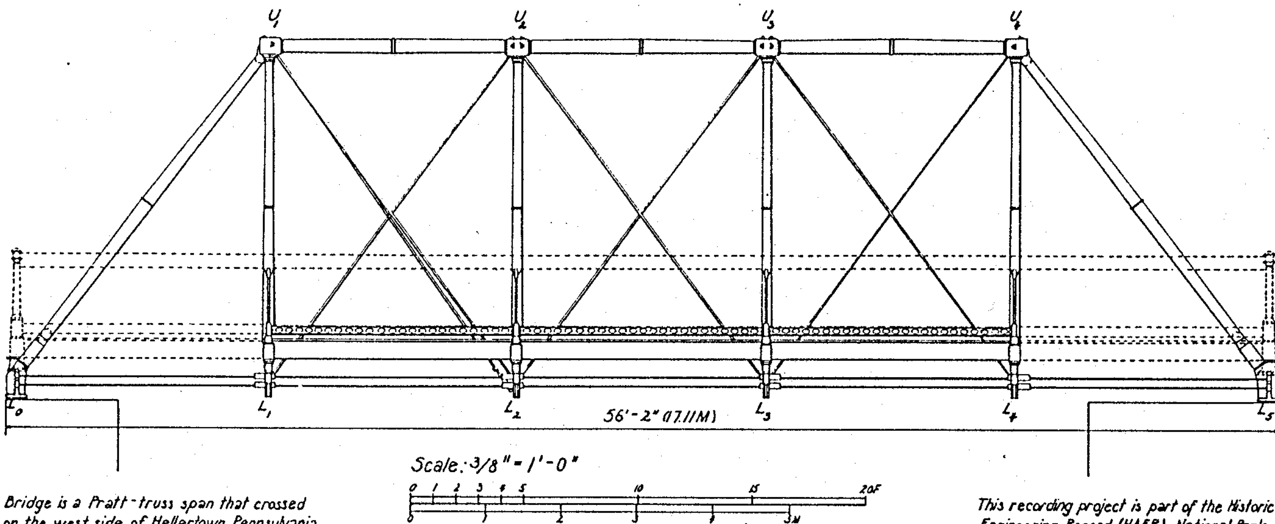
With this in mind, we looked into the possibility of doing something to preserve this valuable piece of civil engineering history that was slowly deteriorating. Soon after our first visit to the site, we returned to perform a thorough bridge assessment. We presented our findings to the bridge owner, The Hellertown Historical Society, along with our recommendation that the bridge be restored to a fully functional pedestrian bridge. With the approval of the governing board of the HHS, our volunteer effort commenced.

WALNUT STREET BRIDGE

- **Location:** Formerly crossing Saucon Creek on Walnut Street, Hellertown, Northampton County, PA
- **Date Built:** Circa 1860; Original location unknown
- **Fabricator:** Charles N. Beckel, Beckel Iron Foundry and Machine Shop, Sand Island, Bethlehem, PA
- **Owner:** Hellertown Historical Society
- **Significance:** Only extant high-truss span built by Beckel; Uses Francis C. Lowthorp's June 30, 1857 patented lower chord cast connection; Endposts, Floorbeams, Top chord members, Upper lateral struts and Verticals cast from molten iron poured into sand molds

WALNUT STREET BRIDGE

HELLERTOWN · 1860 · PENNSYLVANIA



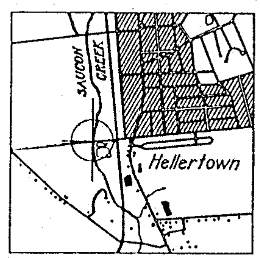
Walnut Street Bridge is a Pratt-truss span that crossed Saucon Creek on the west side of Hellertown, Pennsylvania. Charles N. Beckel fabricated it at his family's foundry on Sand Island in nearby Bethlehem. Beckel was a master foundryman who studied bridge design with the engineer Francis C. Lowthorp of Trenton, New Jersey. He employed Lowthorp's patented elements in many of his spans, including the Walnut Street Bridge.

The bridge is a 55-foot, 5-panel through-truss span. The cast-iron upper chords and tall web posts flare to their midpoints to resist buckling under compressive forces. The cast-iron, continuous, deck beams cantilever to one side to carry a pedestrian walk. Although cast iron is not normally used beams because of its low tensile strength, Beckel designed his with refinements that successfully withstood loads, without the help of modern steel I-beams, for over 90 years. He flared the upper and lower flanges from ends to center to better resist bending and stiffened the webs with diagonal bars.

Walnut Street Bridge probably dates from the early 1860s and was moved to the site near Hellertown in 1877. In 1970 Northampton County replaced it with a reinforced-concrete deckgirder span. At present, the bridge sits adjacent to its former site in Hellertown.

State map

Site map



Original location over Saucon Creek
Based on U.S.G.S. 7.5 min series topographic map, Hellertown Quadrangle

Scale 1: 16 000

This recording project is part of the Historic American Engineering Record (HAER), National Park Service. It is a long-range program to document historically significant engineering and industrial works in the United States.

The Cast and Wrought Iron Bridges Recording Project was cosponsored in 1991 by the Historic American Engineering Record and the West Virginia University Institute for the History of Technology and Industrial Archaeology. Fieldwork, measured drawings, historical reports, and photographs were prepared under the general direction of Dr. Robert J. Kapsch, Chief, HABS/HAER; Eric N. DeLony, Chief and Principal Architect, HAER; Emory Kemp, Director, Institute for the History of Technology and Industrial Archaeology, and Dean Herrin, HAER Staff Historian.

The Recording Team consisted of Christine Ussler (Architecture Faculty, Lehigh University) Architect and Field Supervisor; Christine Theodoropulos, P.E. (Architecture Faculty California State Polytechnic University, Pomona); Wayne Chang (University of Notre Dame), Monika Korsos (Technical University of Budapest, Hungary, US/ICOMOS), Architectural Technicians; Robert W. Hadlow (Washington State University), William Chamberlin, P.E., Historians; and Joseph E. B. Elliott (Muhlenberg College), Photographer

drawing revised in 1993

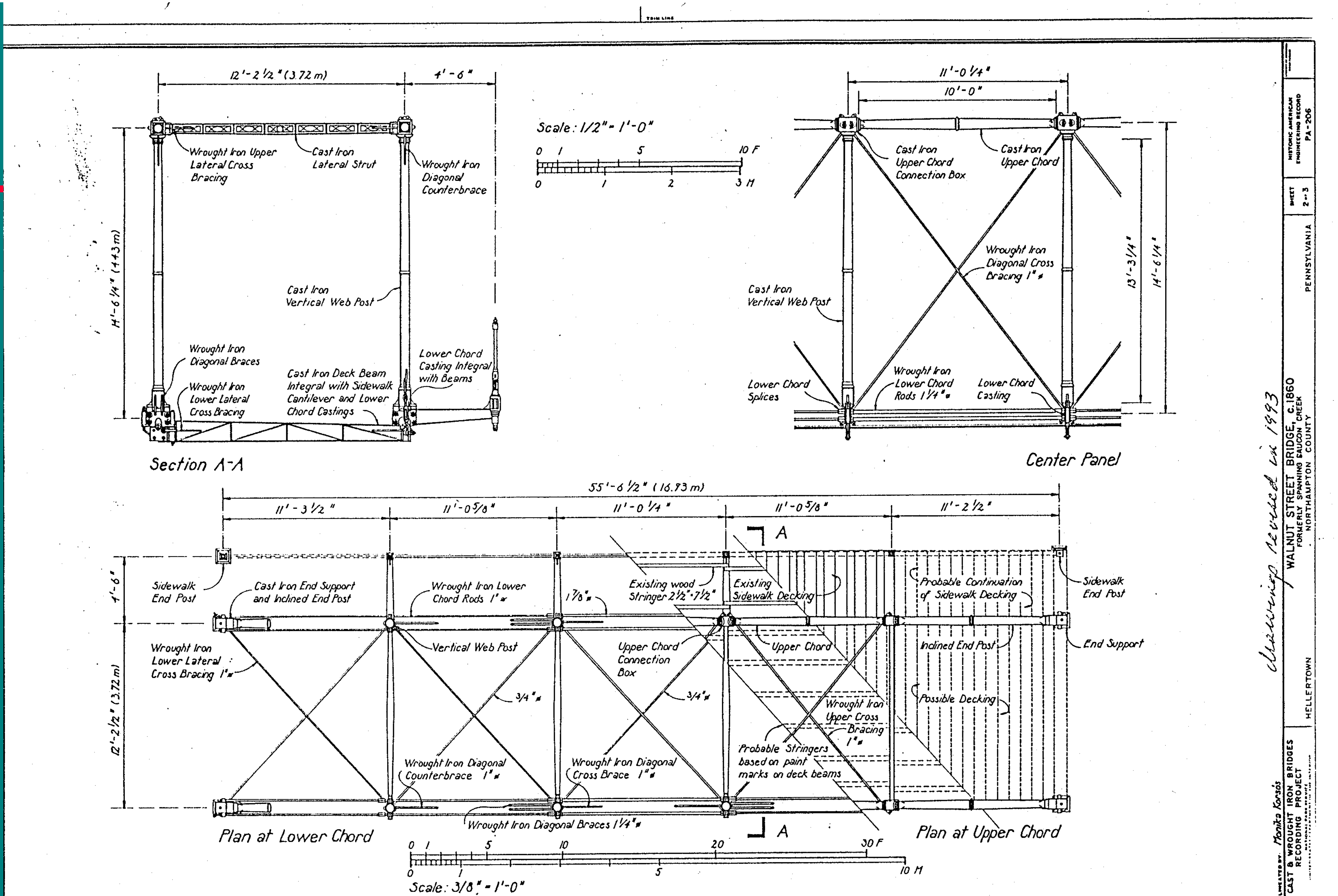
DELINEATED BY: Wayne Chang, Monika Korsos 1991.

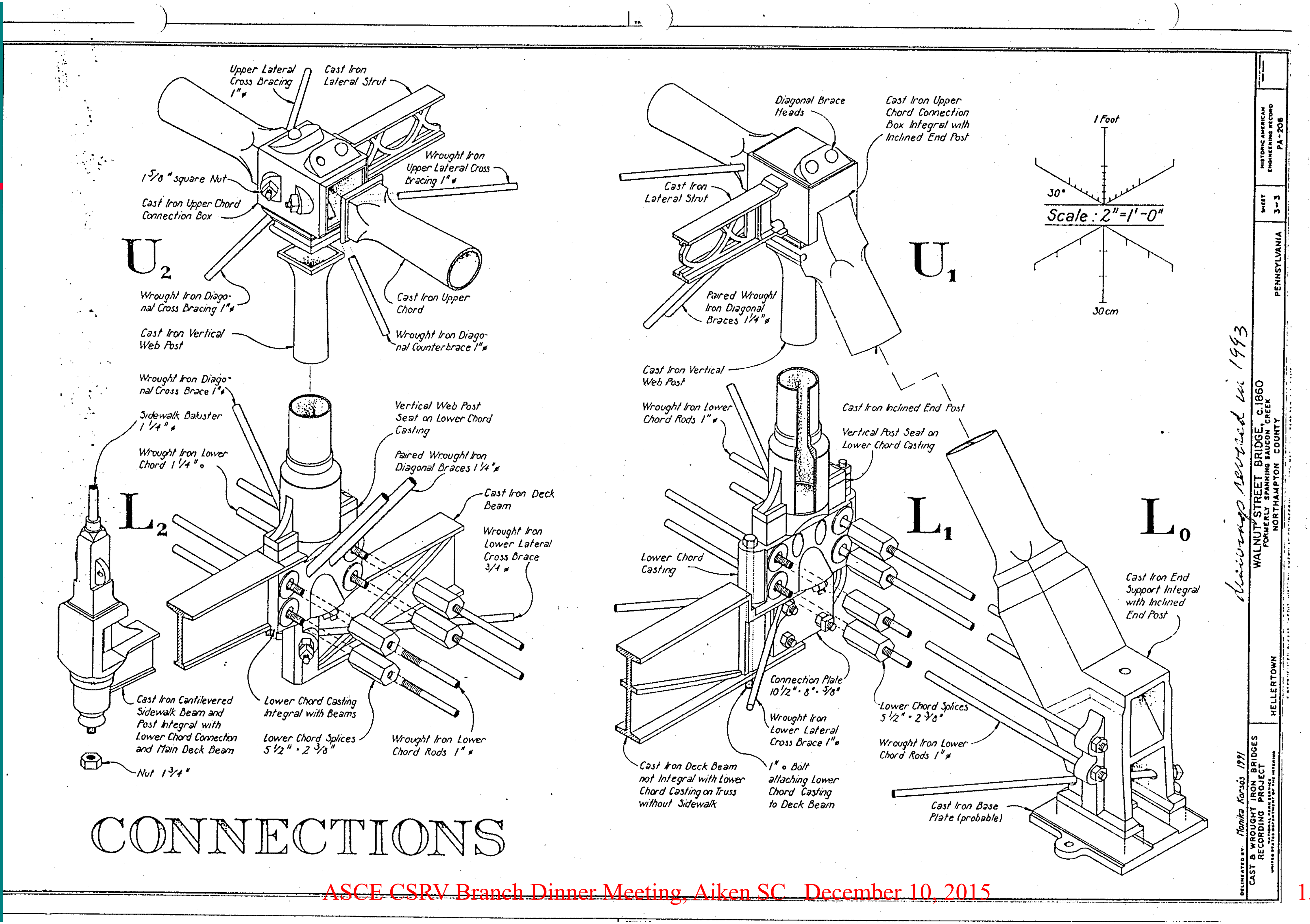
CAST & WROUGHT IRON BRIDGES RECORDING PROJECT

WALNUT STREET BRIDGE, c.1860
FORMERLY SPANNING SAUCON CREEK
HELLERTOWN NORTHAMPTON COUNTY PENNSYLVANIA

SHEET 1-3

HISTORIC AMERICAN ENGINEERING RECORD PA-206


Section A-A
Center Panel
Plan at Lower Chord
Plan at Upper Chord
Scale: 1/2" = 1'-0"
Scale: 3/8" = 1'-0"
WALNUT STREET BRIDGE, c.1860
FORMERLY SPANNING SAUCON CREEK
NORTHAMPTON COUNTY
HELLERTOWN
PENNSYLVANIA
CAST & WROUGHT IRON BRIDGES RECORDING PROJECT
HISTORIC AMERICAN ENGINEERING RECORD PA-206
Monika Korsós



Upper Lateral Cross Bracing 1"ø
Cast Iron Lateral Strut
1 5/8" square Nut
Cast Iron Upper Chord Connection Box
Wrought Iron Upper Lateral Cross Bracing 1"ø
U2
Wrought Iron Diagonal Cross Bracing 1"ø
Cast Iron Upper Chord
Cast Iron Vertical Web Post
Wrought Iron Diagonal Counterbrace 1"ø
Wrought Iron Diagonal Cross Brace 1"ø
Sidewalk Baluster 1 1/4"ø
Wrought Iron Lower Chord 1 1/4"
Vertical Web Post Seat on Lower Chord Casting
Paired Wrought Iron Diagonal Braces 1 1/4"ø
Cast Iron Deck Beam
Wrought Iron Lower Lateral Cross Brace 3/4"ø
L2
Cast Iron Cantilevered Sidewalk Beam and Post Integral with Lower Chord Connection and Main Deck Beam
Lower Chord Casting Integral with Beams
Lower Chord Splices 5 1/2" · 2 3/8"
Wrought Iron Lower Chord Rods 1"ø
Nut 1 3/4"
CONNECTIONS
Diagonal Brace Heads
Cast Iron Upper Chord Connection Box Integral with Inclined End Post
Cast Iron Lateral Strut
U1
Paired Wrought Iron Diagonal Braces 1 1/4"ø
Cast Iron Vertical Web Post
Wrought Iron Lower Chord Rods 1"ø
Cast Iron Inclined End Post
Vertical Post Seat on Lower Chord Casting
Lower Chord Casting
L1
L0
Cast Iron End Support Integral with Inclined End Post
Connection Plate 10 1/2" · 8" · 5/8"
Wrought Iron Lower Lateral Cross Brace 1"ø
Lower Chord Splices 5 1/2" · 2 3/8"
Wrought Iron Lower Chord Rods 1"ø
Cast Iron Deck Beam not Integral with Lower Chord Casting on Truss without Sidewalk
1" ø Bolt attaching Lower Chord Casting to Deck Beam
Cast Iron Base Plate (probable)
1 Foot
30°
Scale : 2"=1'-0"
30 cm
drawings revised in 1993
Monika Korsós 1991
CAST & WROUGHT IRON BRIDGES RECORDING PROJECT
WALNUT STREET BRIDGE, c.1860
FORMERLY SPANNING SAUCON CREEK
NORTHAMPTON COUNTY
HELLERTOWN
PENNSYLVANIA
3-3
PA-208

INITIAL BRIDGE SURVEY

- Spring and Early Summer 1994
  - An identification system for all the members was devised so that all the documentation produced related to the bridge rehabilitation would be consistent. Primarily this system was used for the cast iron members and therefore excluded the wrought iron bracing members as well as the lower tension chord. The DOWNSTREAM truss is the one with the separate cast iron joint blocks. The UPSTREAM truss has an integrally cast joint block leading to the pedestrian sidewalk.

INITIAL BRIDGE SURVEY

- ENDPOST – EP
- VERTICAL – V
- FLOORBEAM – FB
- UPPER CHORD – UC
- LATERAL STRUT – LS
- JOINTS are numbered L0 through L5 along the lower chord and U1 through U4 along the upper chord
- A typical member of the truss might be designated UC-U2-U3-DN
- A typical member spanning between the trusses would be designated by its joint location, LS-4

INITIAL BRIDGE SURVEY

INITIAL BRIDGE SURVEY

INITIAL BRIDGE SURVEY

INITIAL BRIDGE SURVEY

INITIAL BRIDGE SURVEY

INITIAL BRIDGE SURVEY

DISASSEMBLING THE BRIDGE

- September 23, 1994
  - Erected Scaffolding
  - Stabilized Trusses
  - Secured Connections
  - Blocked and Shored Up Endposts
  - Marked Members with Temporary Identification Tags

DISASSEMBLING THE BRIDGE

- September 24, 1994
  - Removed First Cast Iron Member by Hand
  - Cut and Removed Wrought Iron Diagonals
  - Broke Trusses Down into Triangular Modules

DISASSEMBLING THE BRIDGE

- September 25, 1994
  - Cut and Removed Remaining Wrought Iron Members
  - Removed Remaining Cast Iron Members
  - Placed all Cast Iron Members in Storage
- Fall 1994
  - Performed Member-by-Member Condition Assessment

DISASSEMBLING THE BRIDGE

DISASSEMBLING THE BRIDGE

DISASSEMBLING THE BRIDGE

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DISASSEMBLING THE BRIDGE

MEMBER ASSESSMENT

Shortly after the truss was disassembled and all the cast iron pieces moved to a secure area within the Historical Society's property a member by member condition assessment was undertaken. One can clearly see the amount of corrosion that has taken place at the vertical member-floorbeam connections, the amount of organic debris from bird's nests to wasp's nests found in the vertical column members, and the deterioration of the cast iron members especially at the joint interfaces where cast alignment collars have been slightly damaged to completely broken or sheared off.

MEMBER ASSESSMENT

MEMBER ASSESSMENT

MEMBER ASSESSMENT

MEMBER ASSESSMENT

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MEMBER ASSESSMENT

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MEMBER ASSESSMENT

MEMBER ASSESSMENT

MEMBER ASSESSMENT

MEMBER ASSESSMENT

MAJOR PROJECT MILESTONES

- **Summer 1995**
  - **Cleaned and Sandblasted All Cast Iron Members**
  - **Set Final Alignment for New Location of Bridge**
  - **Cleared Site and Dug East Footing Location**
  - **Constructed East Footing and Abutment Wall**
- **Fall 1995**
  - **Conducted Cast and Wrought Iron Materials Testing**
  - **Dug West Footing Location**
  - **Constructed West Footing and Abutment Wall**

MEMBER DETAILS

MEMBER DETAILS

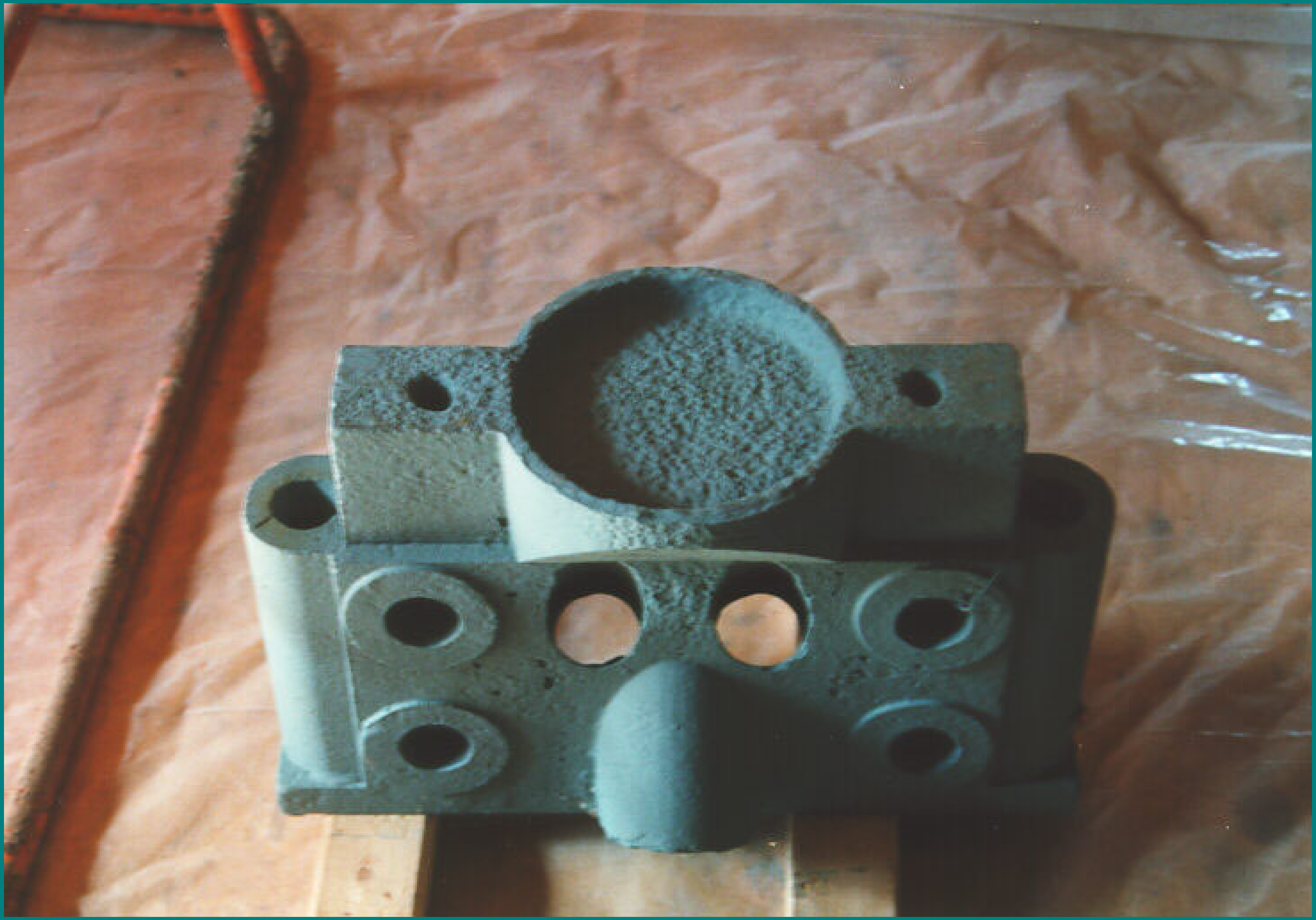
Two of the floorbeams immediately after sandblasting prior to being primed. Note the detail of the integrally cast vertical dogboned shaped stiffeners and bowstring shaped diagonal stiffeners as well as the nonprismatic shape of the member itself

MEMBER DETAILS

Closeup of one of the floorbeams clearly showing the patent date June 30, 1857

MEMBER DETAILS

Patented casting attributed to Francis Lowthorp used to carry the tension chord rods at the lower panel points of the truss where the verticals connected to the floor beams



UNITED STATES PATENT OFFICE.

FRANCIS C. LOWTHORP, OF TRENTON, NEW JERSEY.

IRON TRUSS-FRAME FOR BRIDGES.

Specification of Letters Patent No. 17,684, dated June 30, 1857.

To all whom it may concern:

Be it known that I, Francis C. Lowthorp, of the city of Trenton, county of Mercer, and State of New Jersey, have invented certain new and useful Improvements in the Construction of Iron Truss-Frames for Bridges; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawing and to the letters of reference marked thereon.

My invention relates to the construction of iron truss frames for bridges, and consists in so connecting lower chord rods, verticals, diagonals, and counter diagonals to a straining plate peculiarly formed and constructed for their reception, that the said lower chord rods may be simple, light, and straight, easily connected, adjusted, and detached, free from eyes and slots for receiving keys and other expensive forged work, and that the straining plate at the same time may not be submitted to any tensile strain and may admit of being connected simply and readily to the verticals and diagonals.

The whole is designed and constructed for the purpose of forming the lower chords of truss-frame bridges in the lightest possible manner compatible with appropriate strength, and of parts more simple and portable and less expensive than have been hitherto used for a like purpose.

In order to enable others skilled in the art to make and use my invention, I will now proceed to describe its construction and operation.

On reference to the drawing which forms a part of this specification: Figure 1, is a front elevation of sufficient of an iron truss-frame bridge to show my improvements. Fig. 2, a transverse section of a portion of the bridge, being a side view of Fig. 1, looking in the direction of the arrow. Fig. 3, a sectional elevation on the line 1—2, Fig. 2. Fig. 4, also a sectional elevation on the line 3—4, Fig. 2.

Similar letters refer to similar parts throughout the several views.

A is the lower portion of one of the vertical posts of the bridge and in the bottom of this post is a recess for the reception of the projection *a* on the straining plate B. Through the latter passes a pin C, to which are jointed the end of the main diagonals D, D, and D′, D′, and the counter diagonals E, E, the ends of the two main diagonals D′, D′, passing into the opening *b* of the straining plate. Through orifices in the latter also pass the screwed ends of the lower chord rods H, onto the points of which are screwed the lengthened nuts J, J, which also serve to receive the ends of the lower chord rods G′, G′.

The rods H are furnished with ordinary nuts I, I, which, together with the lengthened nuts J, J, serve to connect the opposite rods securely to the plate B.

Instead of the lengthened nuts J, J, I propose in some instances to use the ordinary well-known swivel nuts.

By the above-described mode of connecting the lower chord rods to the straining plate B, the said rods may be readily adjusted, detached and replaced, may (with the exception of their screwed ends), be perfectly plain, free from eyes, or slots for receiving keys, and other heavy and expensive forged work, thus enabling me to construct the lower chords of truss-frame bridges in a much superior manner (both as regards simplicity of workmanship, lightness of material, strength and portability of parts and ready connection of the same together) to those constructed in the usual manner.

It will be further seen that the straining plate for receiving the lower chord rods affords a simple and direct mode of attachment for the diagonals and verticals, and also that the straining plate is not submitted to that tensile strain which is unavoidable when the lower chords are attached in the usual manner.

I do not desire to confine myself to the precise form of straining plate described and illustrated, as the same may be adapted to receive a greater or lesser number of lower chord rods, or to any description or number of diagonals and verticals. But

What I claim, and desire to secure by Letters Patent, is—

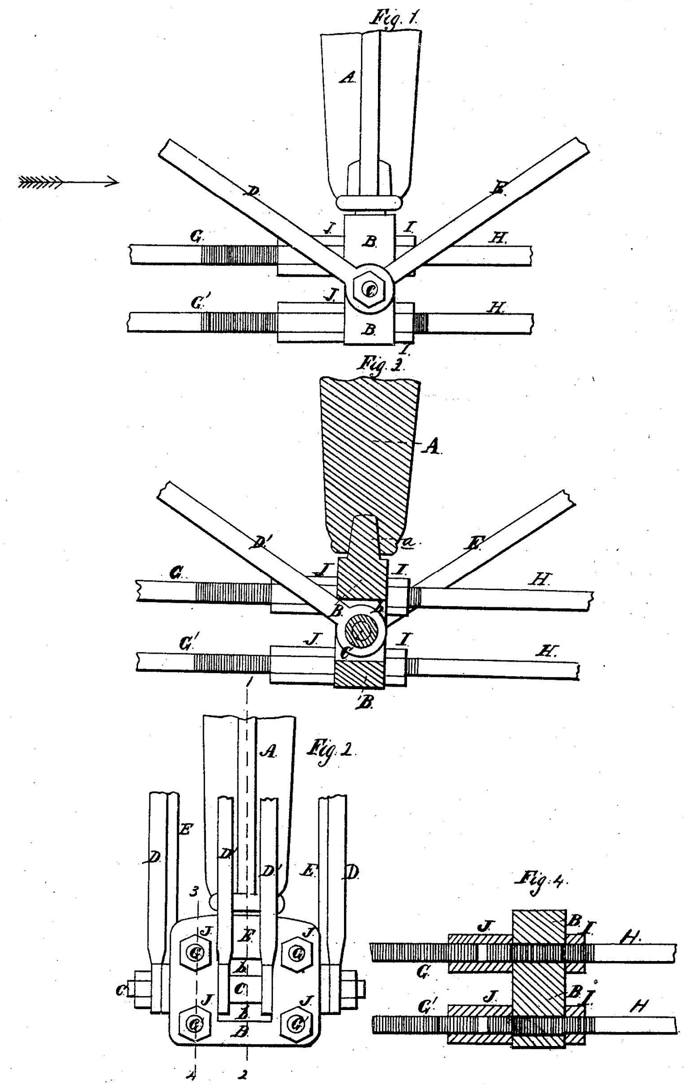
The straining plate B in combination with the rods G and H when the latter are connected to the plate, substantially in the manner herein set forth, and when the said plate is arranged to receive the vertical or verticals and diagonals of iron truss-frame bridges.

In testimony whereof, I have signed my name to this specification before two subscribing witnesses.

F. C. LOWTHORP.

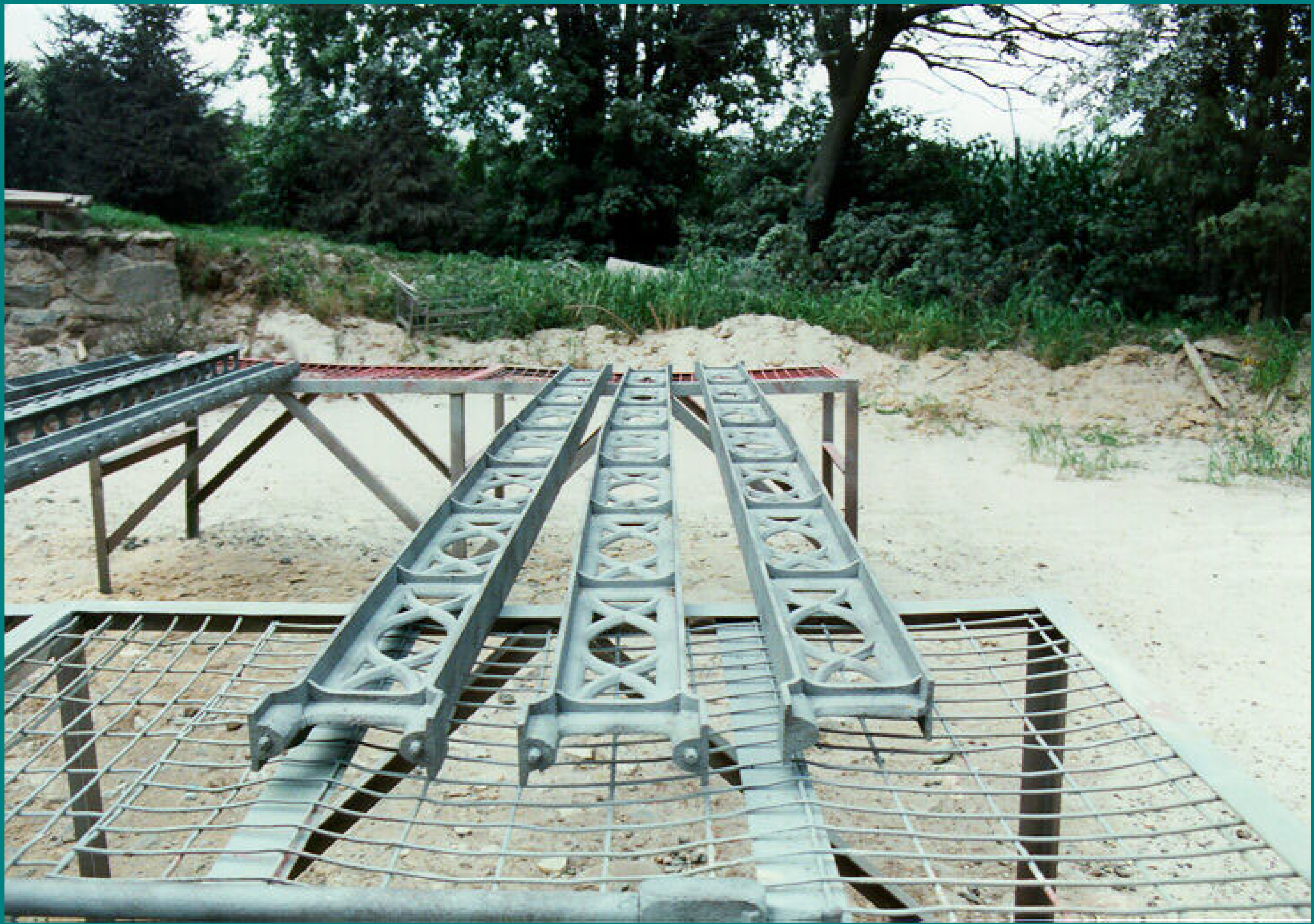
Witnesses:
Henry Howson,
William E. Walton.

F. C. Lowthorp.
Truss Bridge
No. 17,684. Patented Jun. 30, 1857.



MEMBER DETAILS

Three of the four lateral struts after sandblasting and being primed



MEMBER DETAILS

Four of the upper chord members after sandblasting prior to being primed

MEMBER DETAILS

MEMBER DETAILS

MATERIAL PROPERTIES TESTING

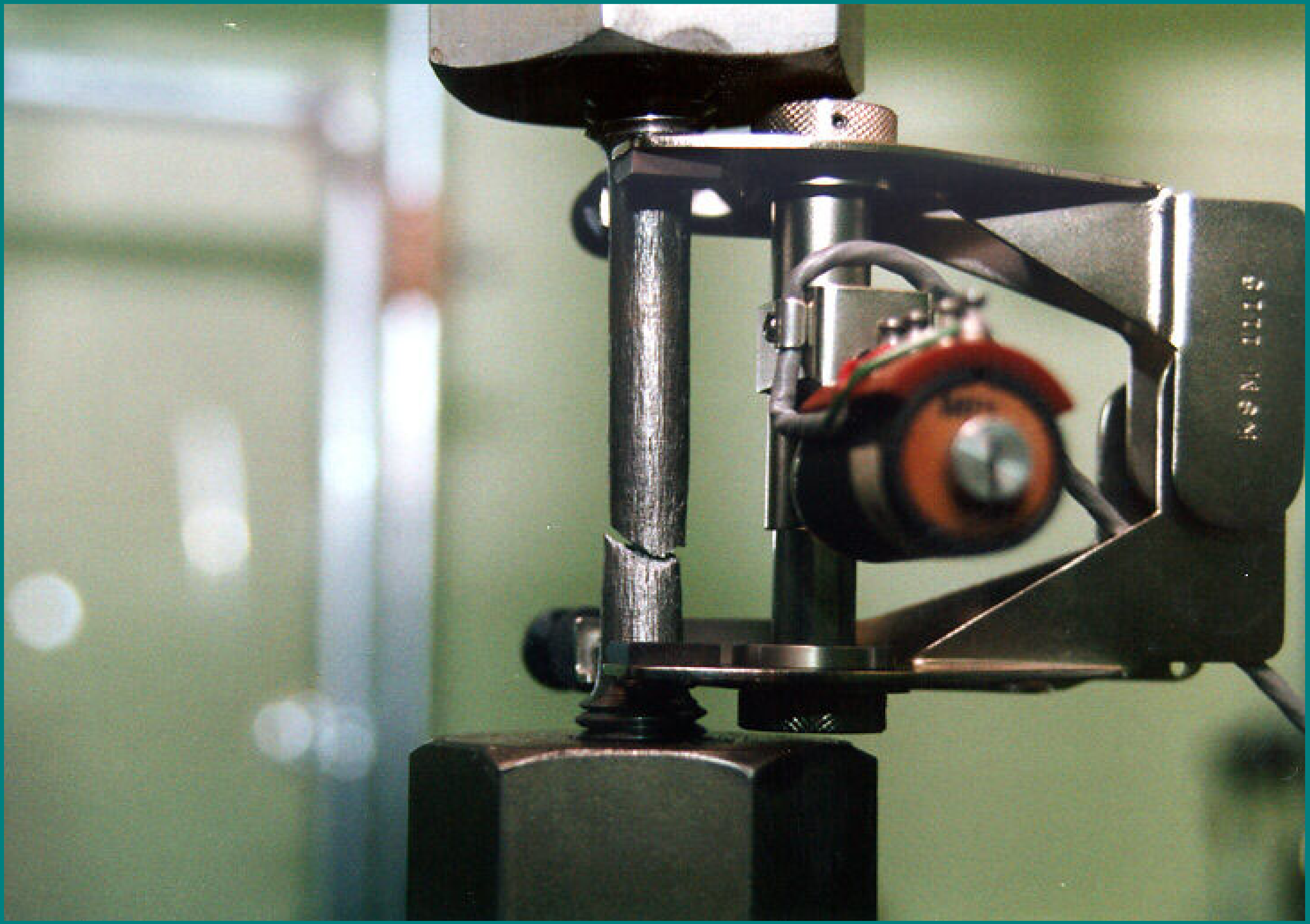
In order to gain a better understanding of the cast iron and wrought iron materials that were used in the Walnut Street Bridge a series of material properties tests were conducted. A nonstructural piece of cast iron was removed from Endpost EP-L0-U1-UP. From this piece, specimens were fabricated in accordance with the applicable ASTM specifications for determining tension and compression properties as well as toughness properties. Similar specimens were fabricated from several of the wrought iron bars that were removed from the bridge.

MATERIAL PROPERTY TESTING

ASTM E8	Standard Test Methods of Tension Testing of Metallic Materials
ASTM E9	Standard Test Methods of Compression Testing of Metallic Materials at Room Temperature
ASTM E23	Standard Test Methods for Notched Bar Impact Testing of Metallic Materials
ASTM E290	Standard Test Method for Semi-Guided Bend Test for Ductility of Metallic Materials

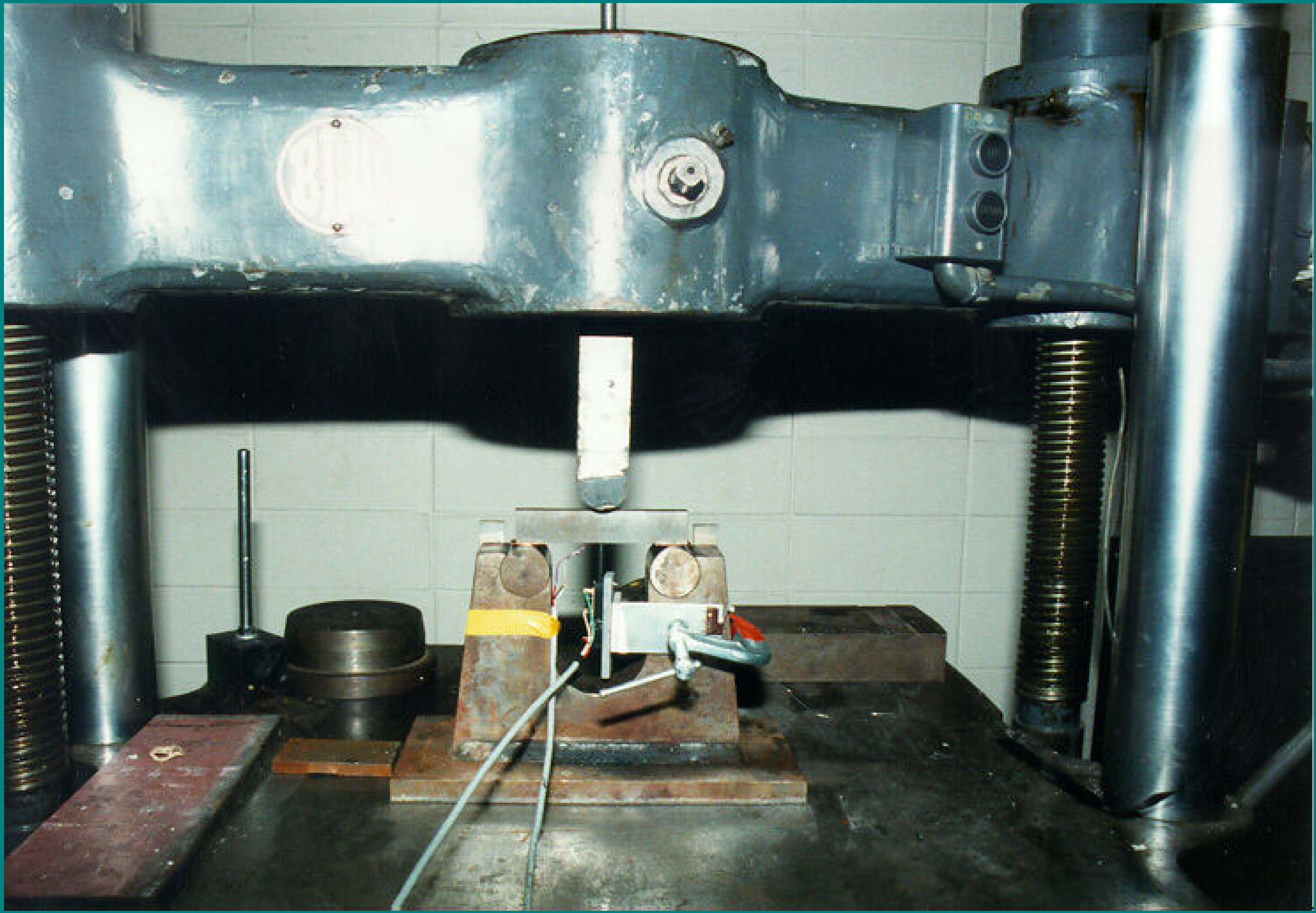
MATERIAL PROPERTIES TESTING

Wrought iron “505” tensile specimen at failure with 2" extensometer attached

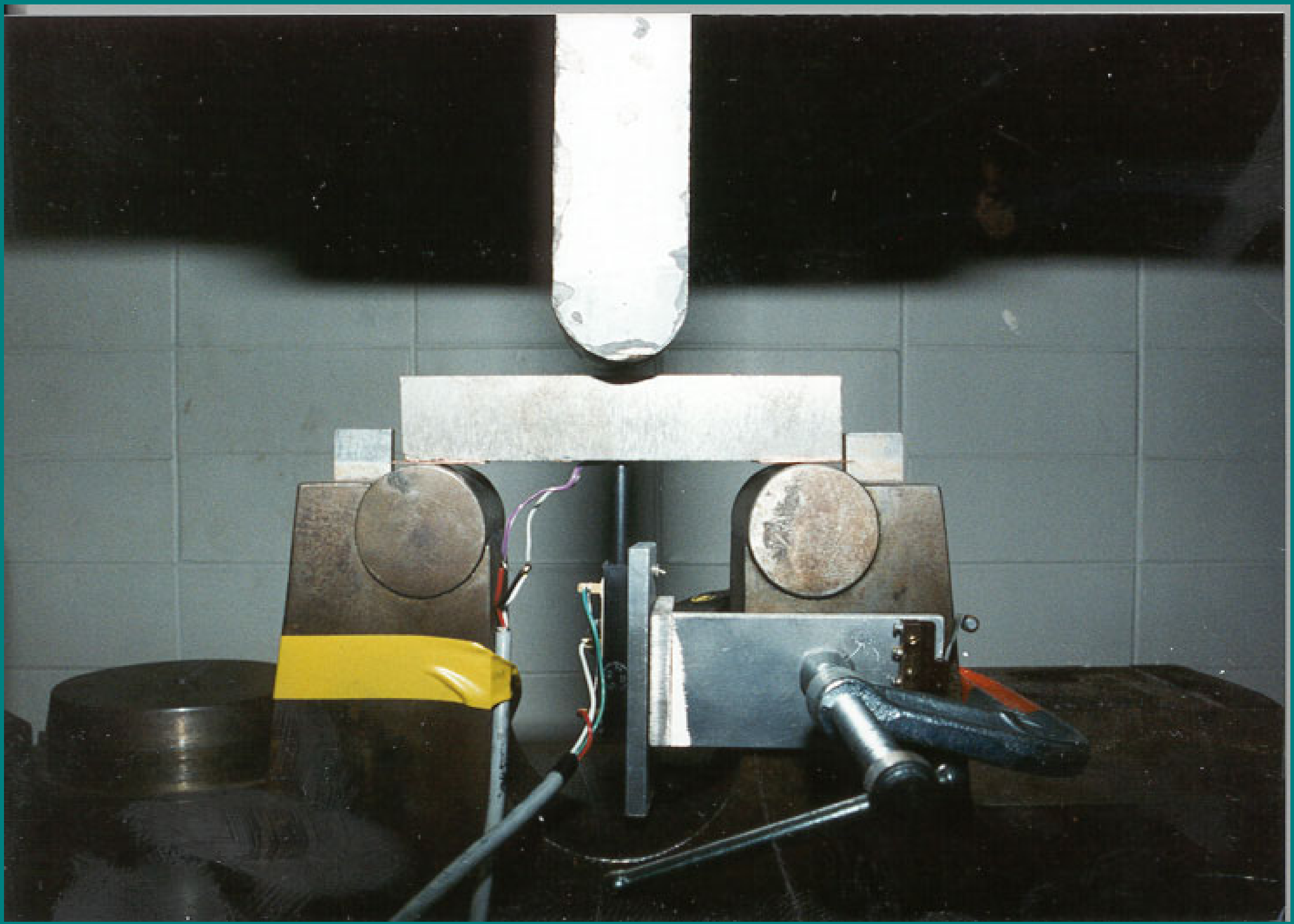


MATERIAL PROPERTIES TESTING

Cast iron bend specimen 6" long by 1/2" wide in 60 kip Baldwin Universal Testing machine prior to conducting test

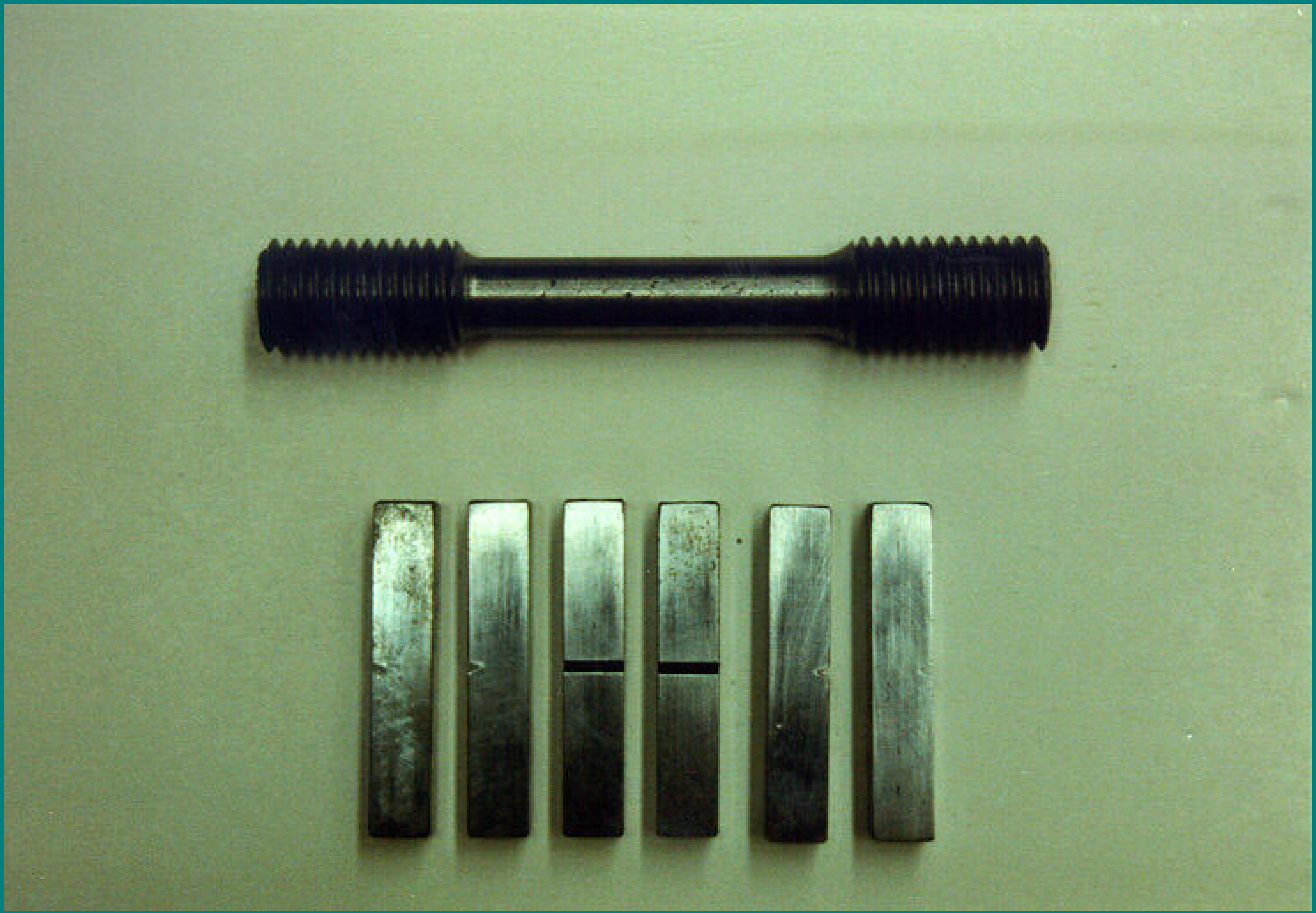


MATERIAL PROPERTIES TESTING

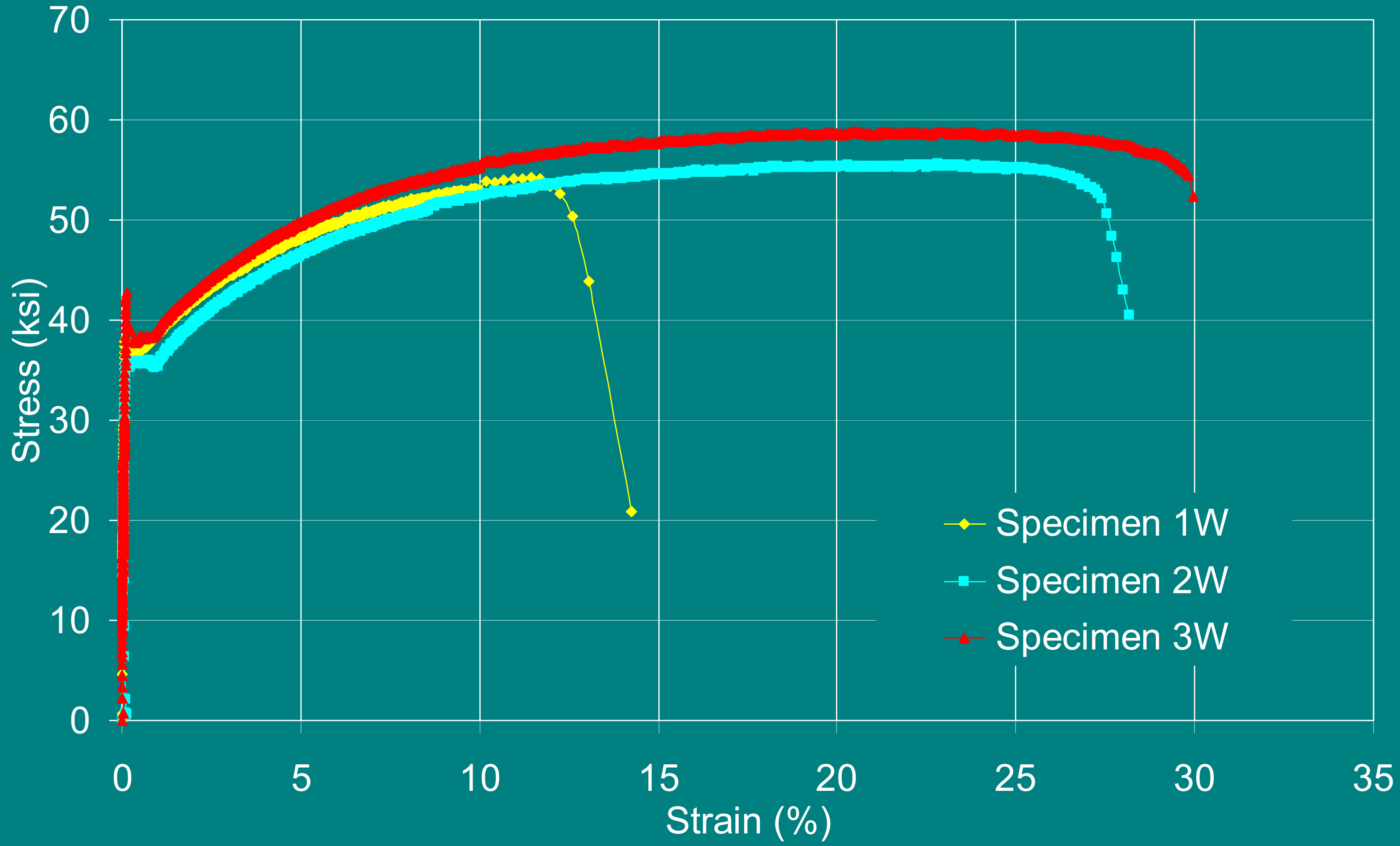


MATERIAL PROPERTIES TESTING

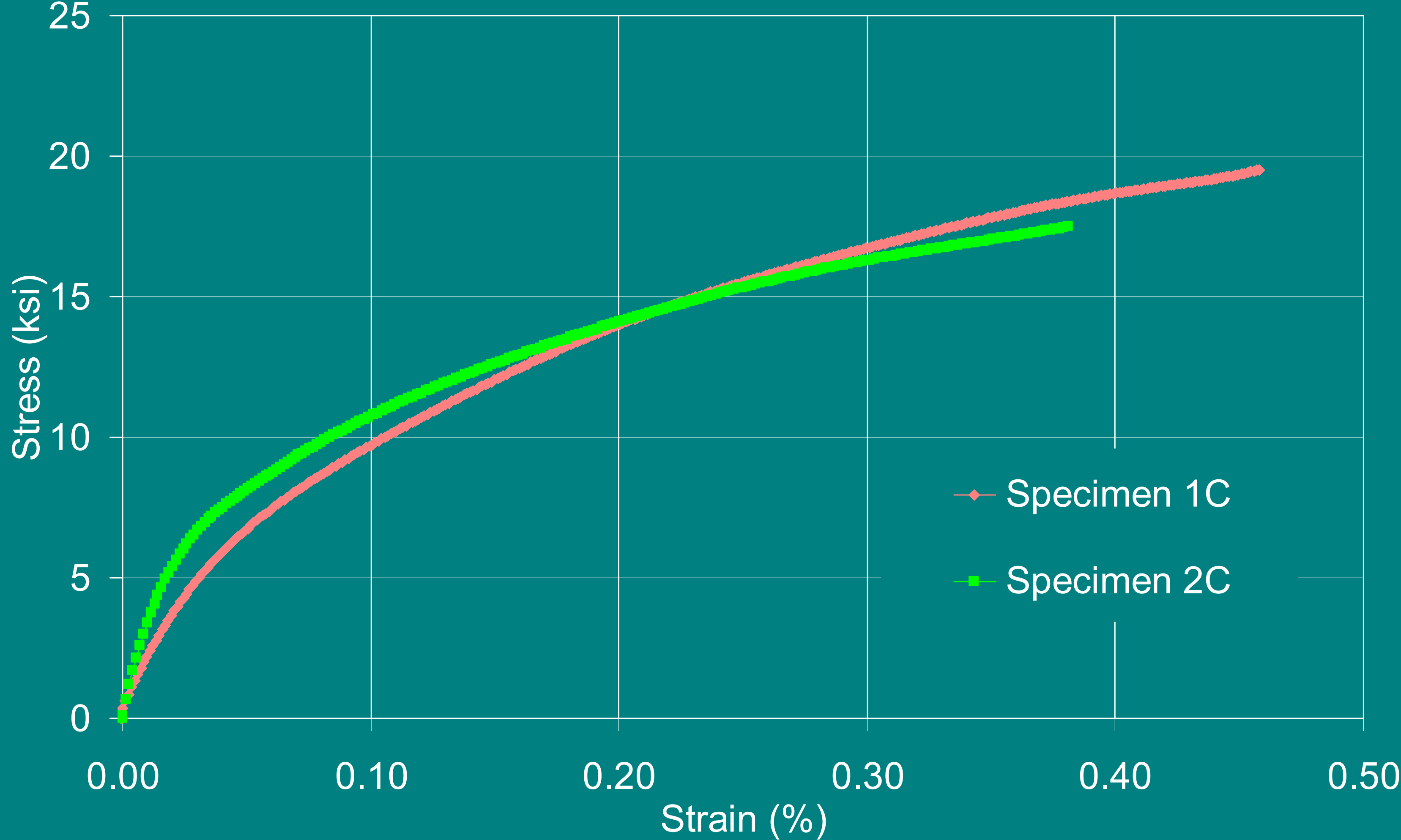
Cast iron “505” tensile specimen and six Charpy V-Notch specimens prior to testing



WROUGHT IRON TENSION BEHAVIOR



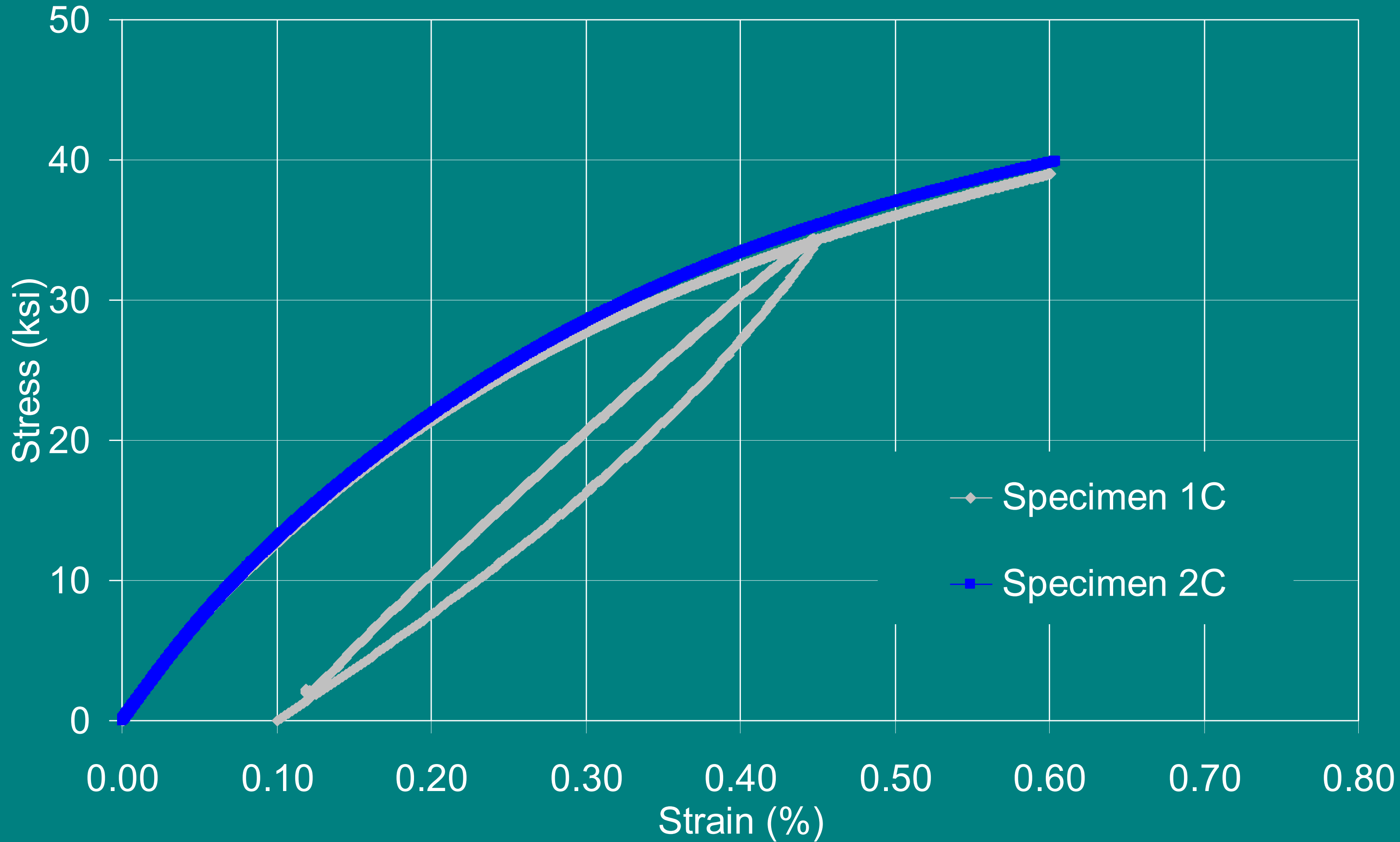
CAST IRON TENSION BEHAVIOR



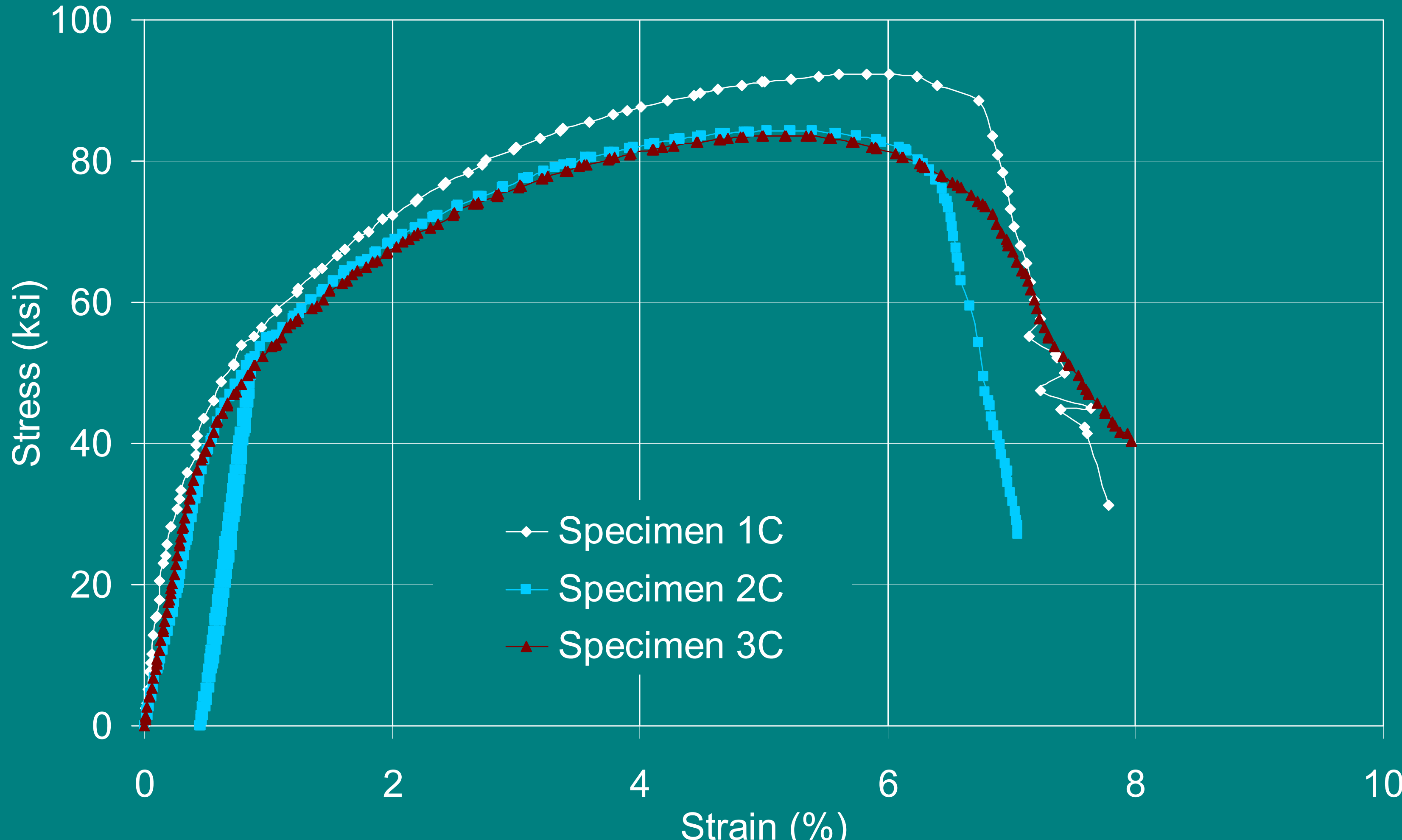
TENSION PROPERTIES OF MATERIALS

Specimen ID	Diameter (in.)	Area ($in.^2$)	σ_y (ksi)	σ_u (ksi)	ε_u (in./in.)
Wrought Iron					
1W	0.498	0.195	38.1	54.3	0.1421
2W	0.498	0.195	35.7	55.6	0.2817
3W	0.499	0.196	42.7	58.8	0.2996
Cast Iron					
1C	0.502	0.198	NA	19.5	0.0046
2C	0.499	0.196	NA	17.6	0.0038

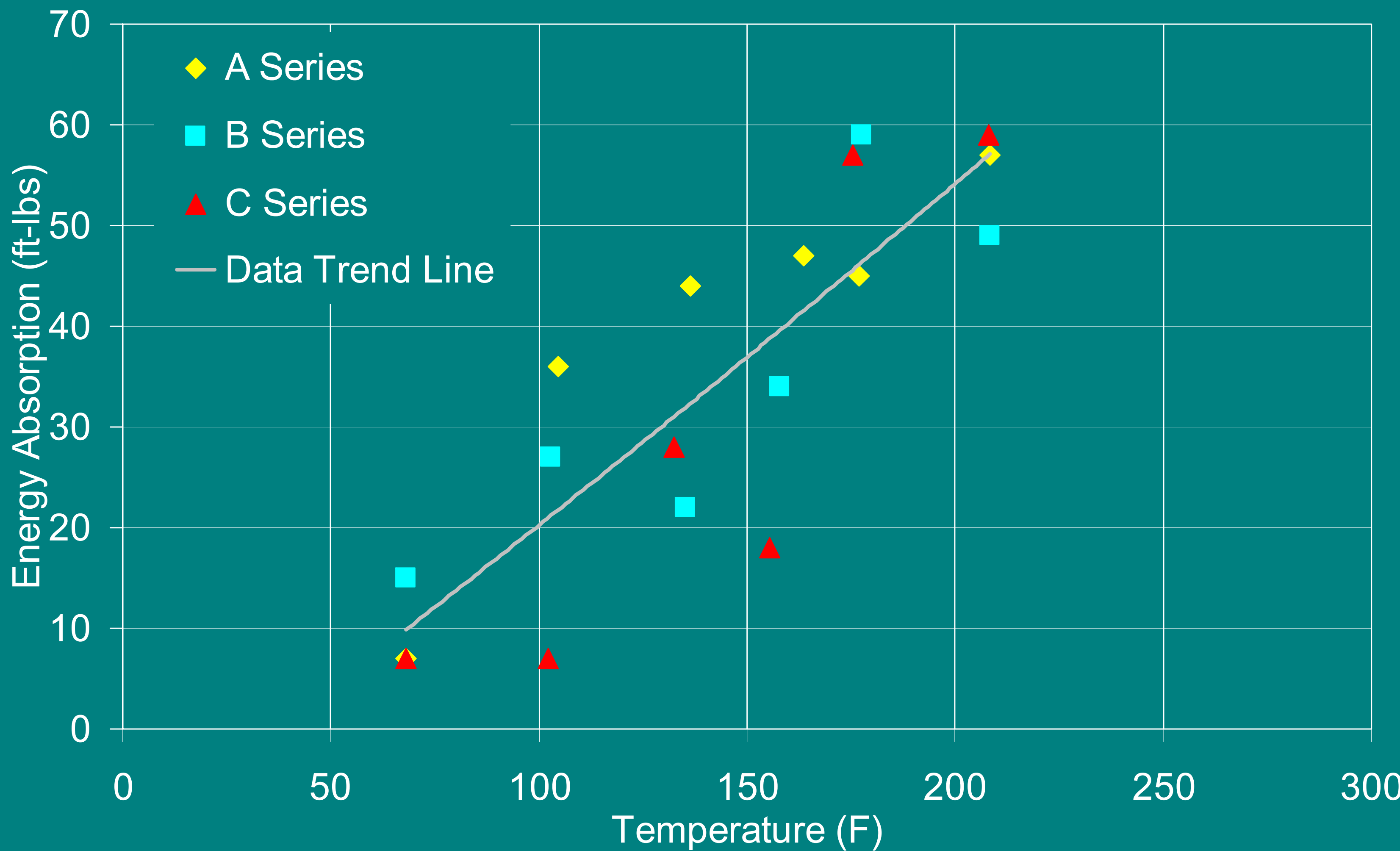
CAST IRON FLEXURAL BEHAVIOR



CAST IRON COMPRESSION BEHAVIOR



WROUGHT IRON CHARPY IMPACT TESTS



NEW CONSTRUCTION

The first major efforts in reassembling the bridge took place during both the Summer and Fall of 1995. In early June 1995 a new site was chosen for the bridge not more than 200 yards away from its original location. It was decided that a bridge of this stature had to be spanning some body of water otherwise it would look out of place in the setting chosen. Therefore, the bridge was to be placed at the trail head of a nature walk, crossing the mill race coming from Wagner's Grist Mill located almost directly adjacent to the bridge on the South side of Walnut Street. After the site location was approved by the governing board of the Hellertown Historical Society, the site was surveyed, trees cleared, and rough grading completed.

NEW CONSTRUCTION

While these items were progressing at the site, all of the cast iron members, which had been stored over the winter, were sandblasted inside and out and a coat of primer applied. Members in need of repair were transported to the ATLSS Center located on the Mountaintop Campus of Lehigh University.

Foundation and abutment wall design was completed and in Fall 1995 two new bridge abutments were constructed. All the labor utilized for this effort was volunteer, which included layout and bending of all the reinforcing bars, constructing the formwork, tying the rebar cages, and placing the concrete.

NEW CONSTRUCTION

NEW CONSTRUCTION EAST ABUTMENT

NEW CONSTRUCTION EAST ABUTMENT

NEW CONSTRUCTION EAST ABUTMENT

NEW CONSTRUCTION EAST ABUTMENT

NEW CONSTRUCTION EAST ABUTMENT

NEW CONSTRUCTION WEST ABUTMENT

NEW CONSTRUCTION WEST ABUTMENT

NEW CONSTRUCTION WEST ABUTMENT

NEW CONSTRUCTION WEST ABUTMENT

NEW CONSTRUCTION WEST ABUTMENT

MAJOR PROJECT MILESTONES

- Spring/Summer/Fall 1996
  - Painted All Cast Iron Members
  - Cut to Length and Threaded 72 New

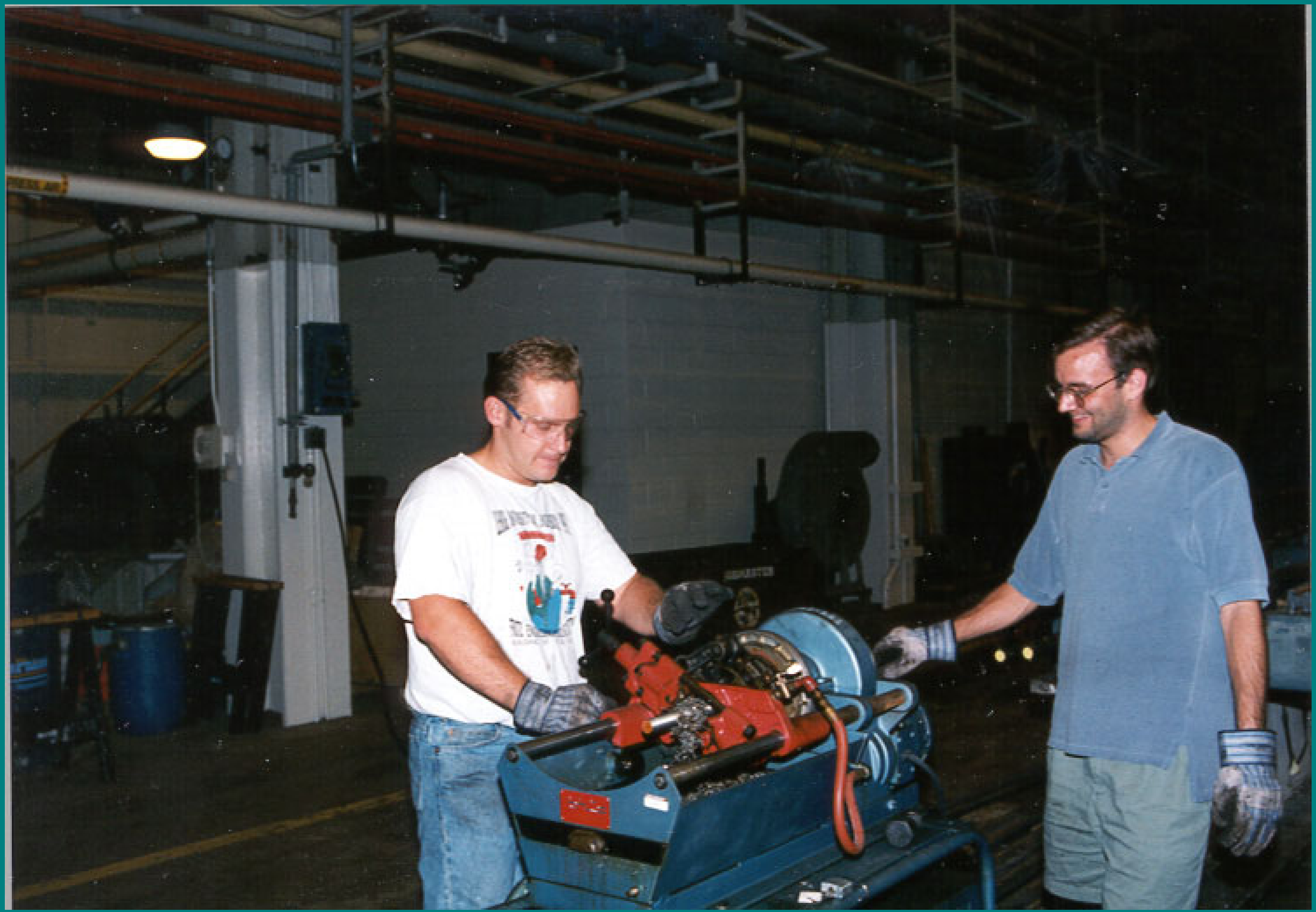
    ¾”, 1” and 1 ¼” Diameter Round Rod Tension Chord, Horizontal, and Vertical Bracing Members
  - Fabricated 16 New 1” to 1 ¼” Coupling Nuts 7” Long

MAJOR PROJECT MILESTONES

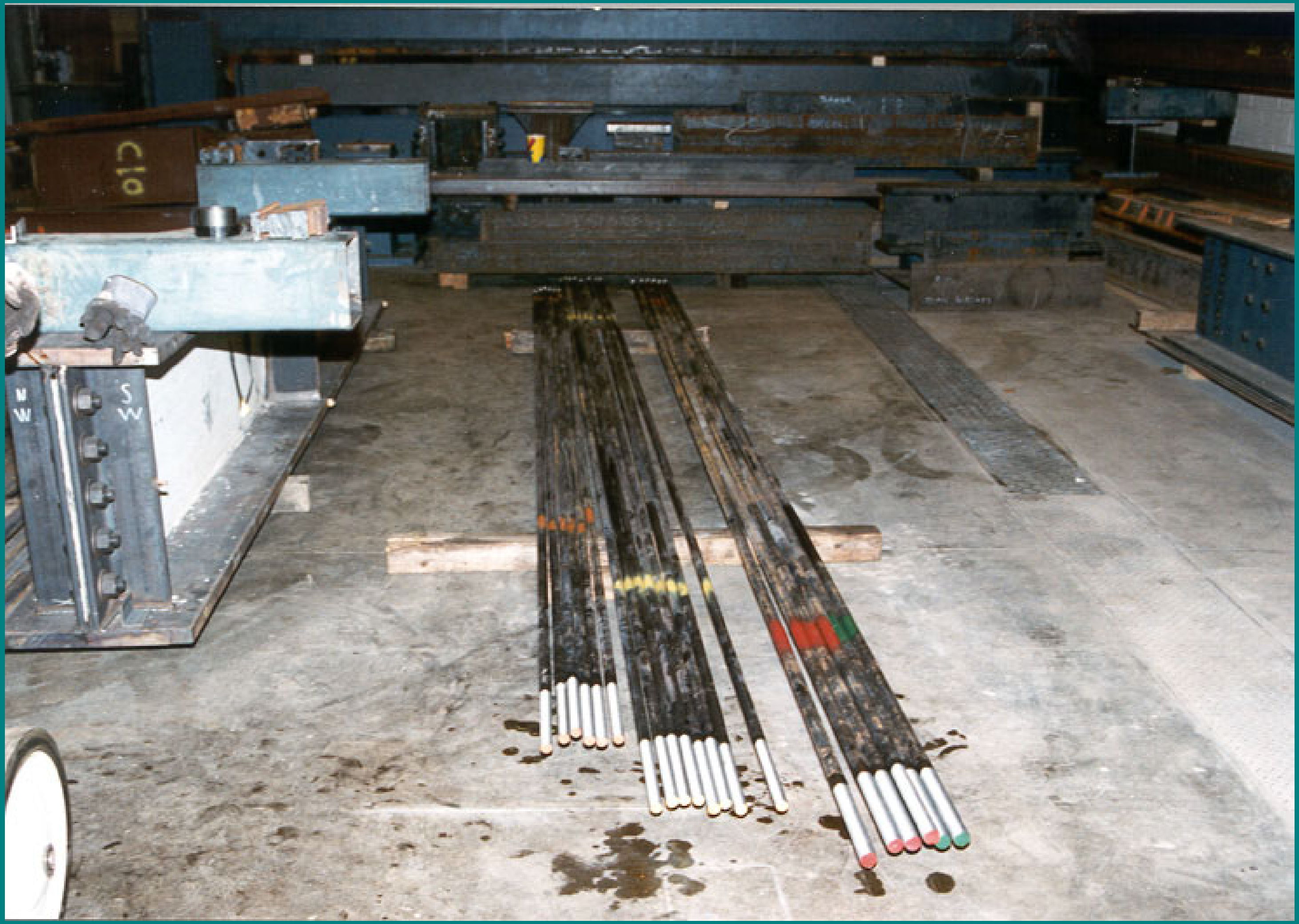
- Spring/Summer 1997
  - Issued Contract for Fabrication of Three New Cast Iron Vertical Members
  - Designed Temporary Falsework Bridge
  - Procured Steel Members for Falsework Bridge
  - Shop Fabricated All Structural Members and Required Falsework Bridge Shop and Field Connections

MEMBER REPLACEMENT

MEMBER REPLACEMENT



MEMBER REPLACEMENT



MEMBER REPLACEMENT

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MEMBER REPLACEMENT

MAJOR PROJECT MILESTONES

- **Fall 1997**
  - **Erected Falsework Bridge between Abutment Walls**
  - **Placed Floorbeams and Casting Nodes on Falsework**
  - **Installed Bottom Tension Chord Members**

SETTING FALSEWORK BRIDGE FLOORBEAMS TENSION CHORDS

SETTING FALSEWORK, FLOORBEAMS AND TENSION CHORDS

SETTING FALSEWORK, FLOORBEAMS AND TENSION CHORDS

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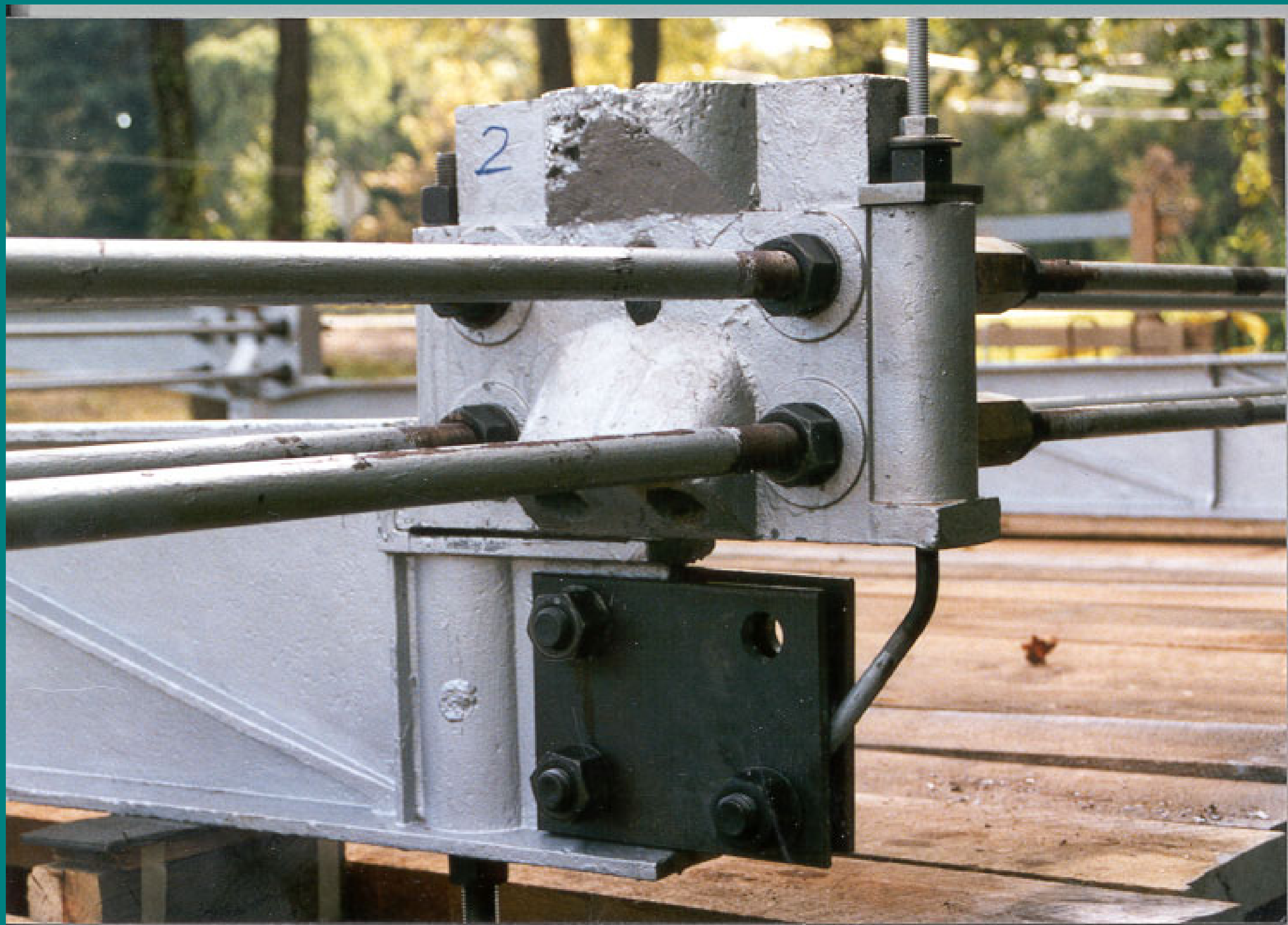
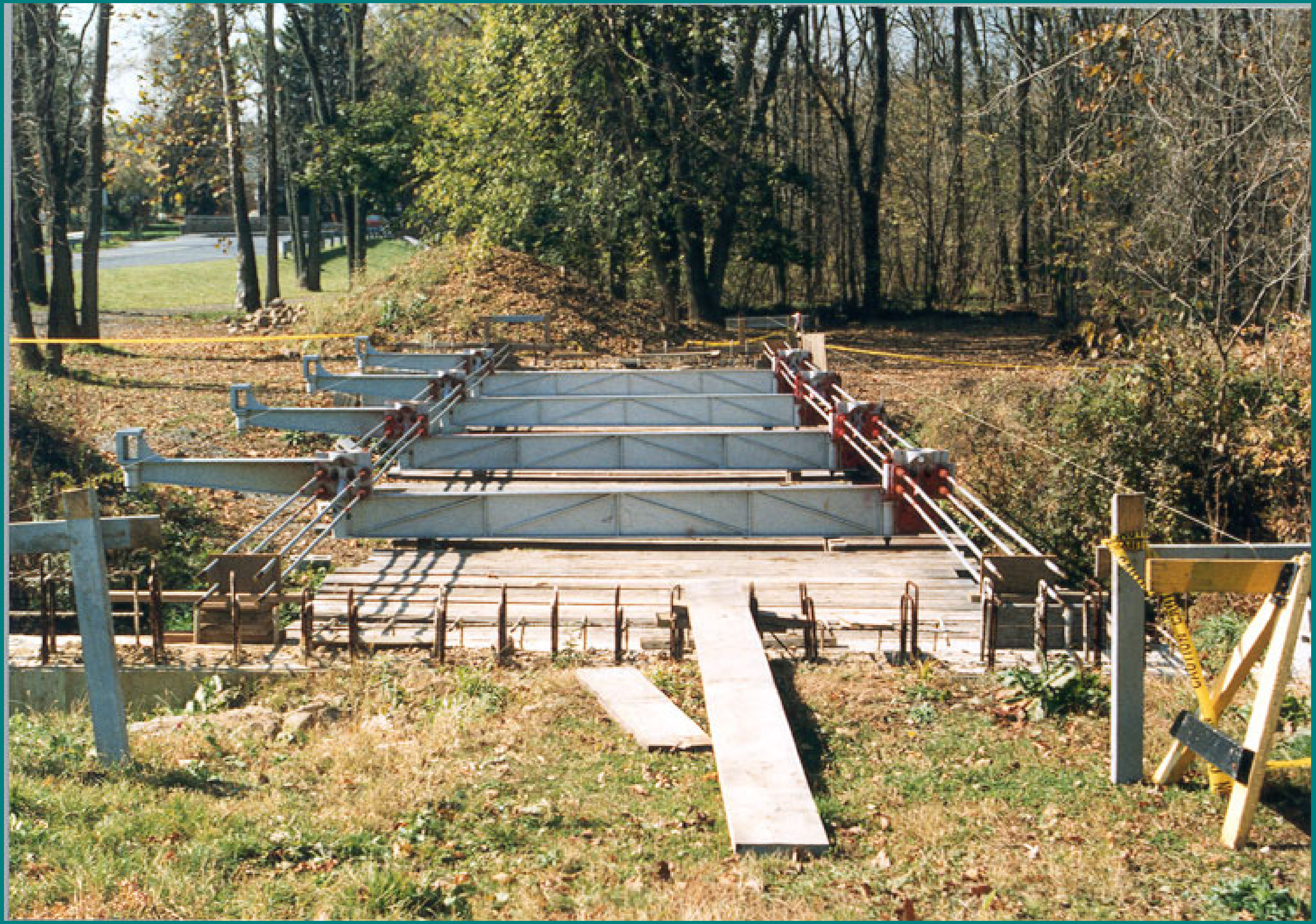


SETTING FALSEWORK, FLOORBEAMS AND TENSION CHORDS

SETTING FALSEWORK, FLOORBEAMS AND TENSION CHORDS



MAJOR PROJECT MILESTONES

- Spring-Summer 1998
  - Fabricated Four Tension Chord End Restraint Plates; Two Bearing Plates; Pieces for Lateral Strut Repairs
  - Completed Nonstructural Weld Repairs on Cast Iron Lateral Struts
  - Completed Collar Repairs on Cast Iron Verticals and Upper Chord Members
  - Completed Connection Detail Repairs for Cast Iron Lateral Struts

MEMBER REPAIR

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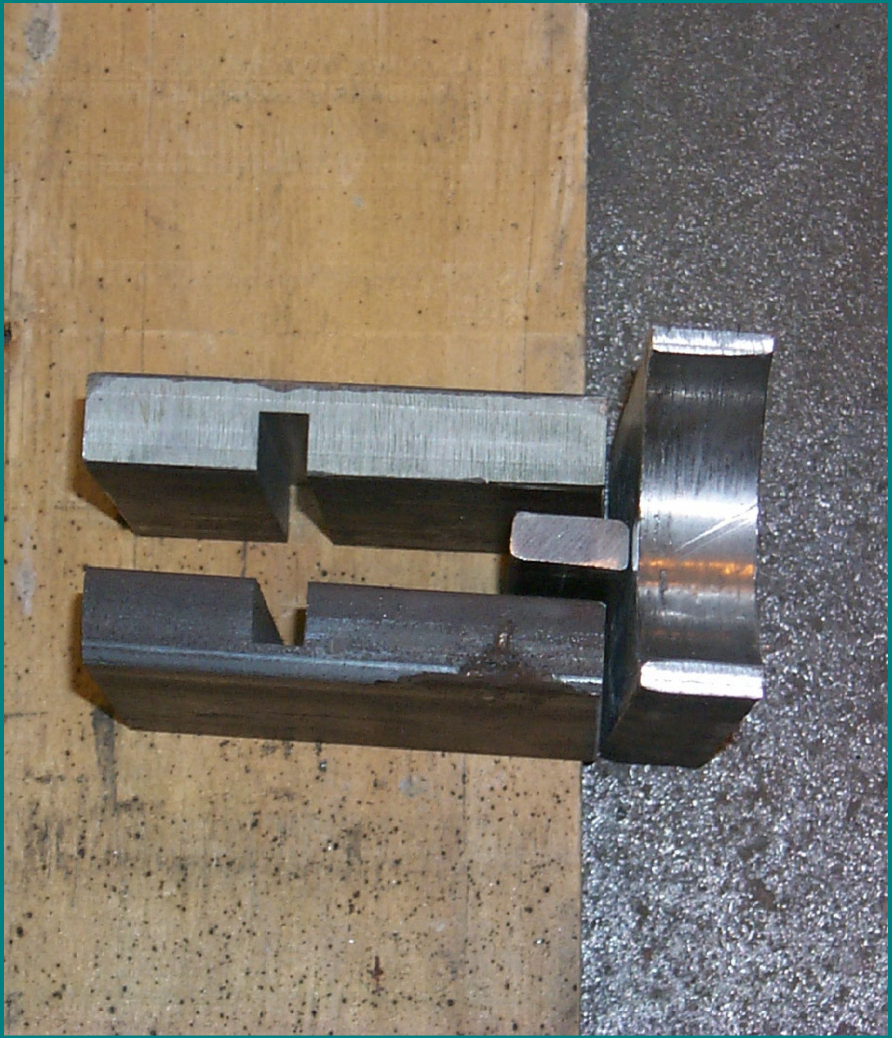
MEMBER REPAIR



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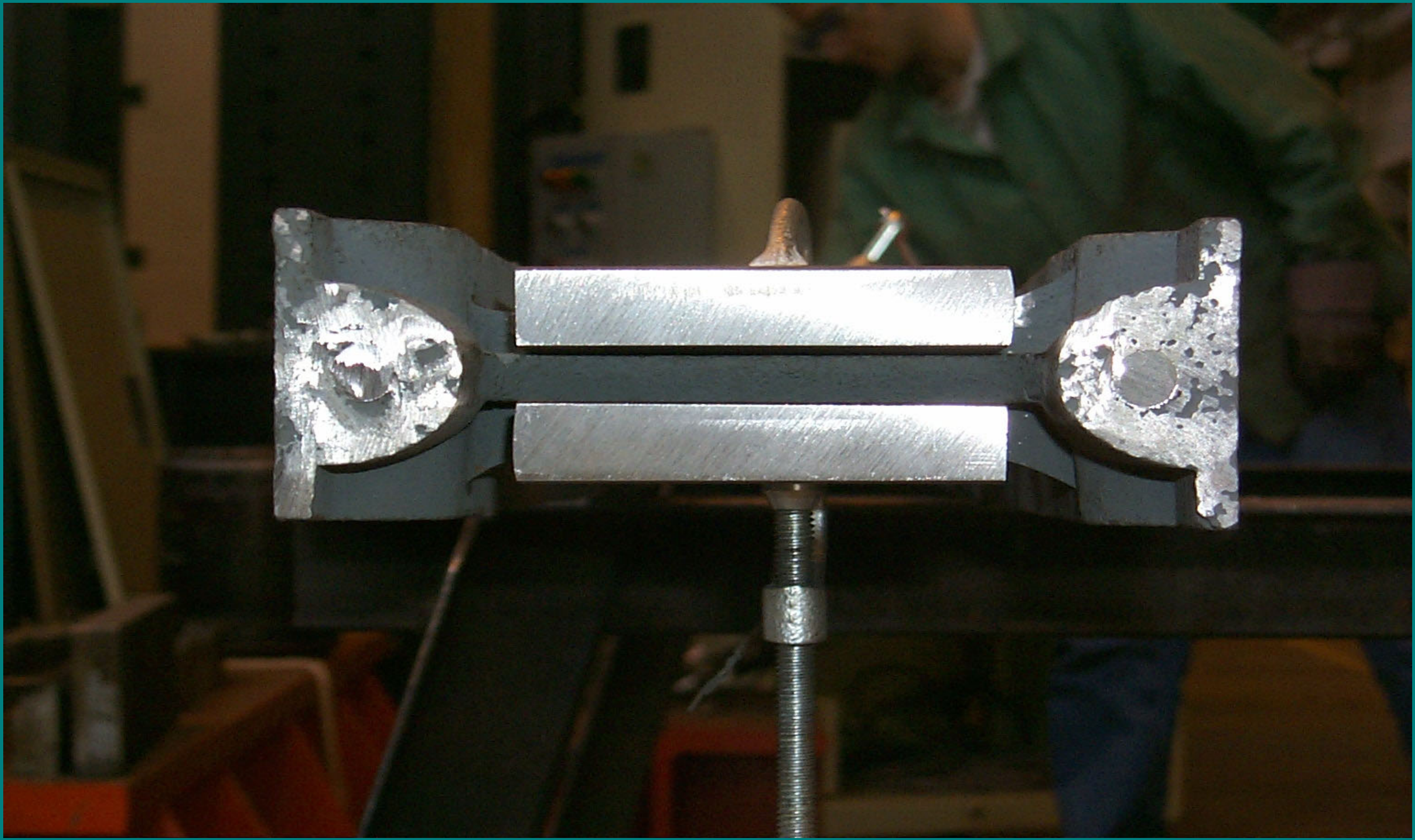

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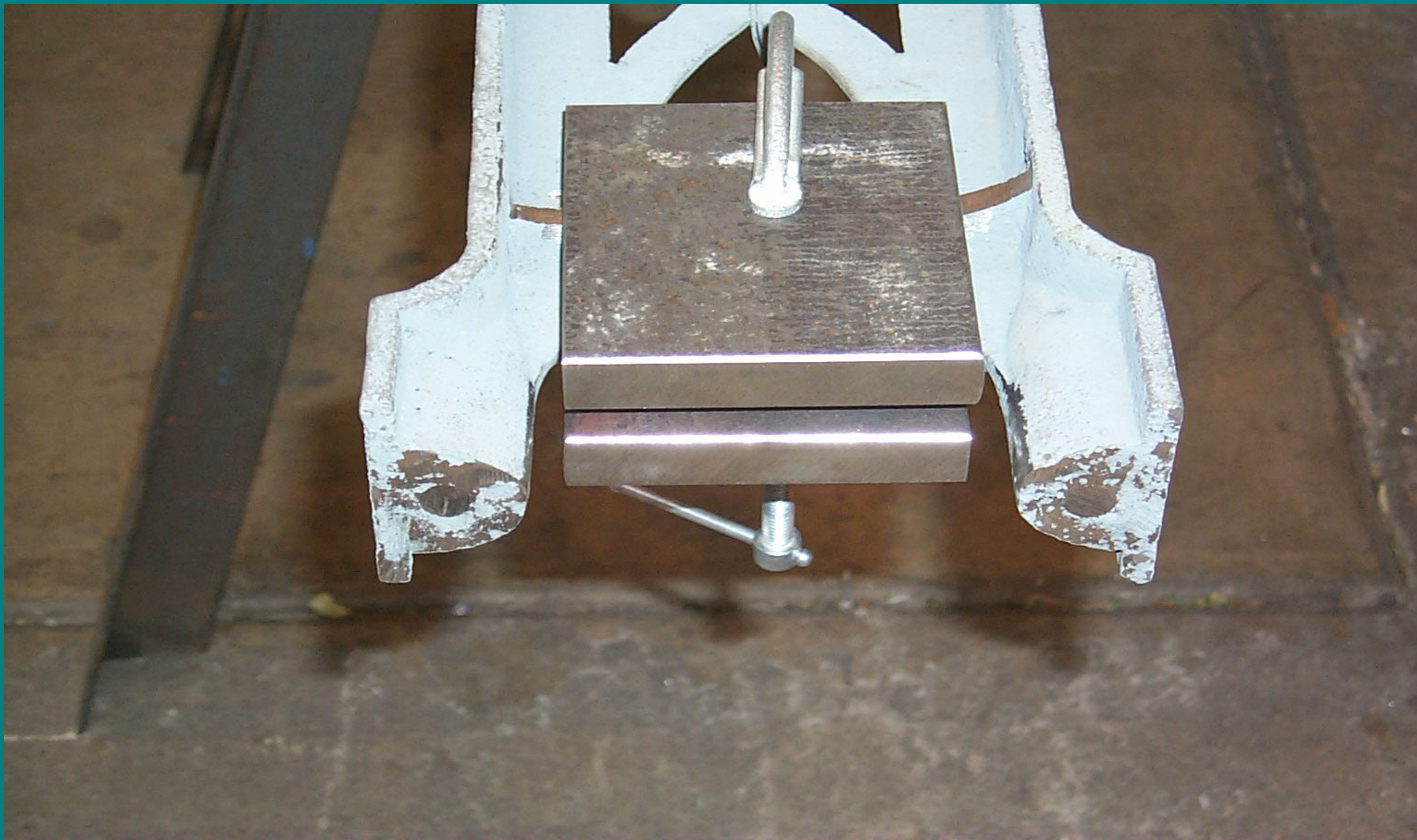

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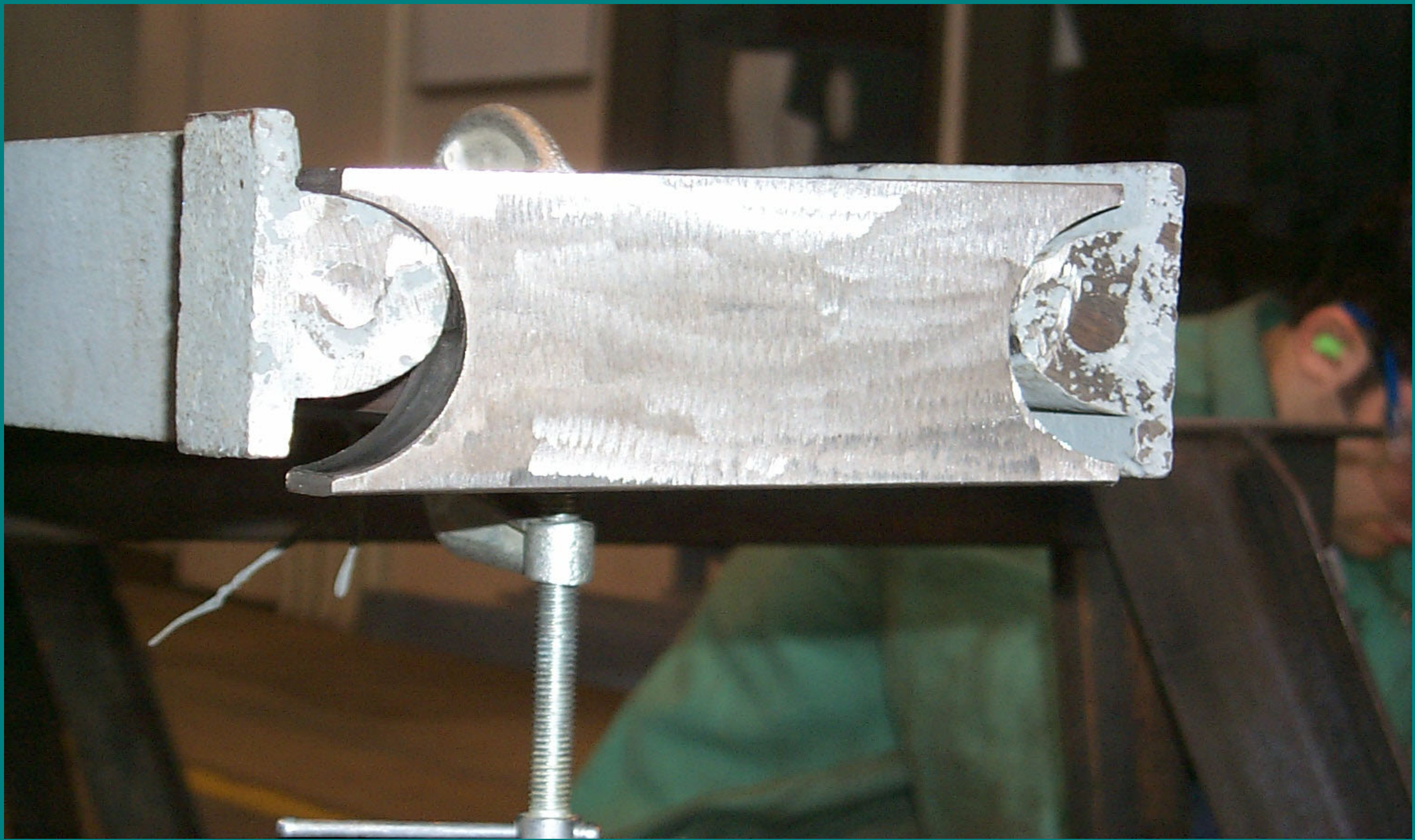

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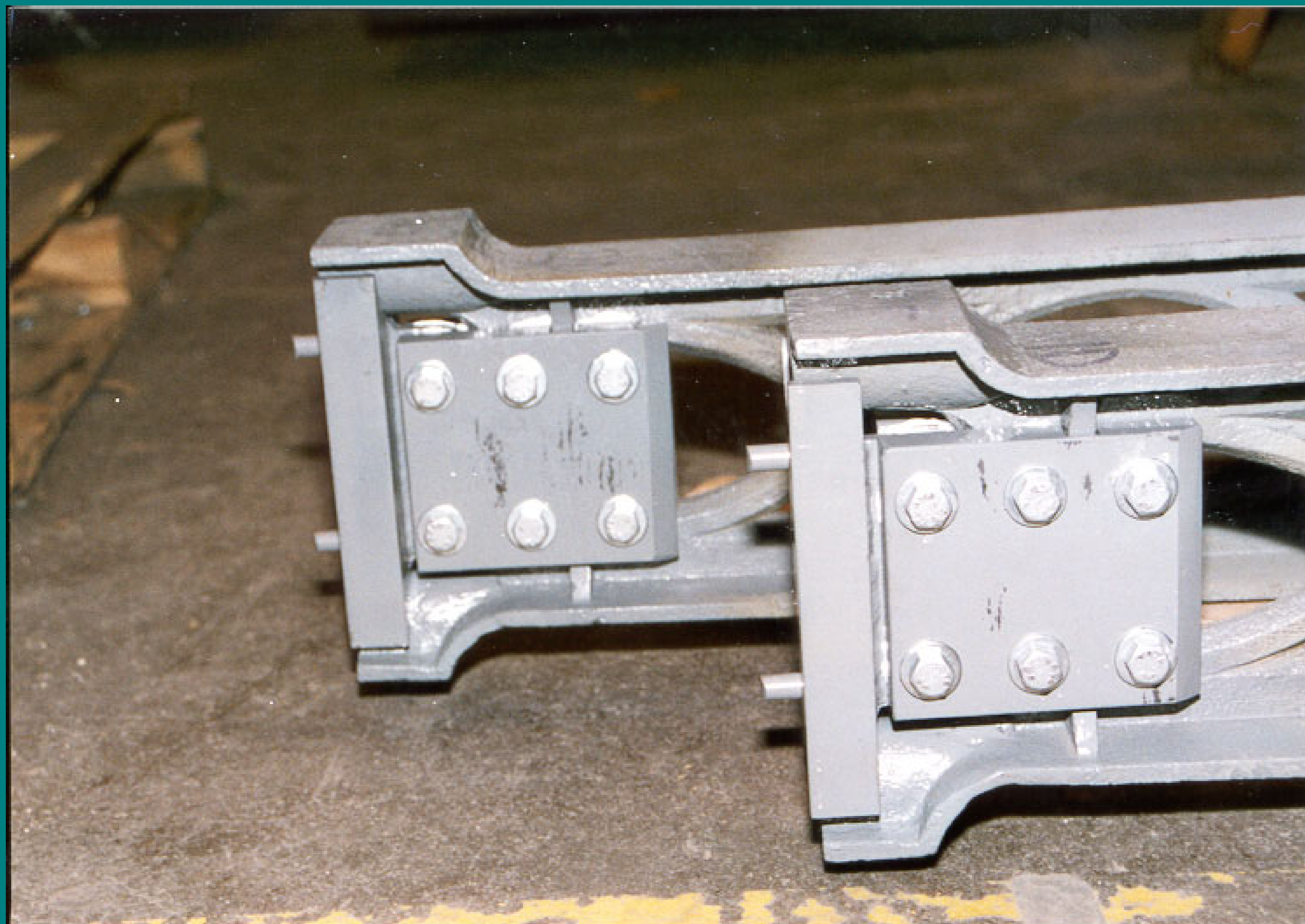
MEMBER REPAIR



MEMBER REPAIR

MAJOR PROJECT MILESTONES

- Summer 1998
  - Painted Tension Chord/Bracing Members
  - Delivered Tension Chord/Bracing Members to the Site
  - Finished Back Wall and Wing Wall Designs
  - Re-erected the Walnut Street Bridge

RE-ERECTING THE BRIDGE

- **September 8-10, 1998**
  - **Made Final Floorbeam Alignments**
  - **Installed Working Deck and Erected Scaffolding**
  - **Reviewed Final Construction Sequence**

RE-ERECTING THE BRIDGE

- September 14, 1998
  - Erected Downstream and Upstream Trusses in Stable Triangular Modules Starting from West Abutment
  - Connected First Trusses Together with Lateral Strut
  - Installed Second Verticals and First Upper Chord Members
  - Connected Trusses with next Lateral Strut and Installed Sway Bracing
  - Repeated Above Sequence Starting from East Abutment

RE-ERECTING THE BRIDGE

- September 15, 1998
  - Installed Remaining Two Upper Chord Members
  - Placed Upper Horizontal Sway Bracing Between Trusses
  - Placed Lower Horizontal Sway Bracing Between Trusses
  - Tensioned Fully All Bracing Members
  - Adjusted Bracing Lengths and Squared Truss Panels

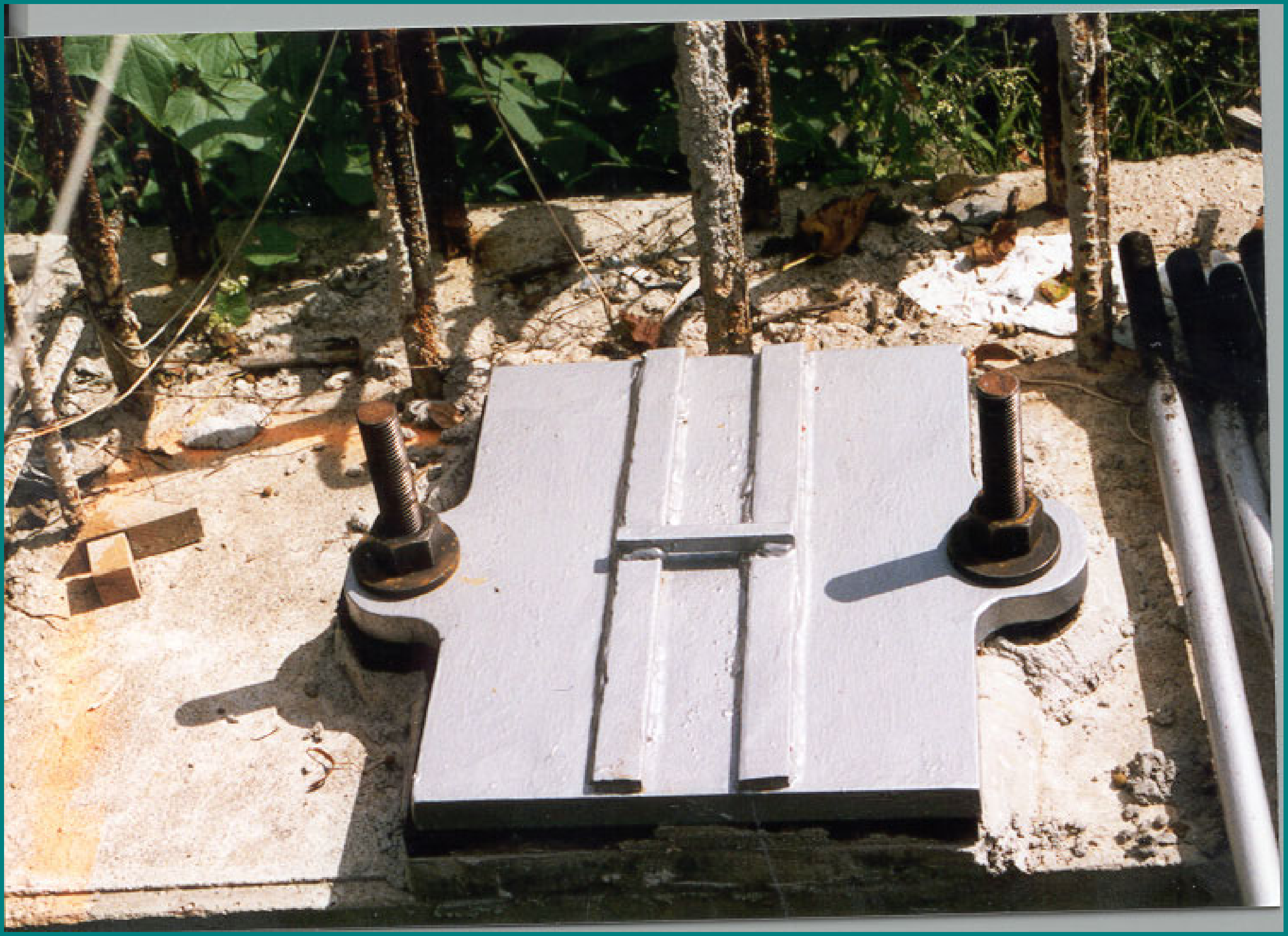
RE-ERECTING THE BRIDGE

- **September 22, 1998**
  - **Lowered Falsework Bridge Girders onto End Bearings**

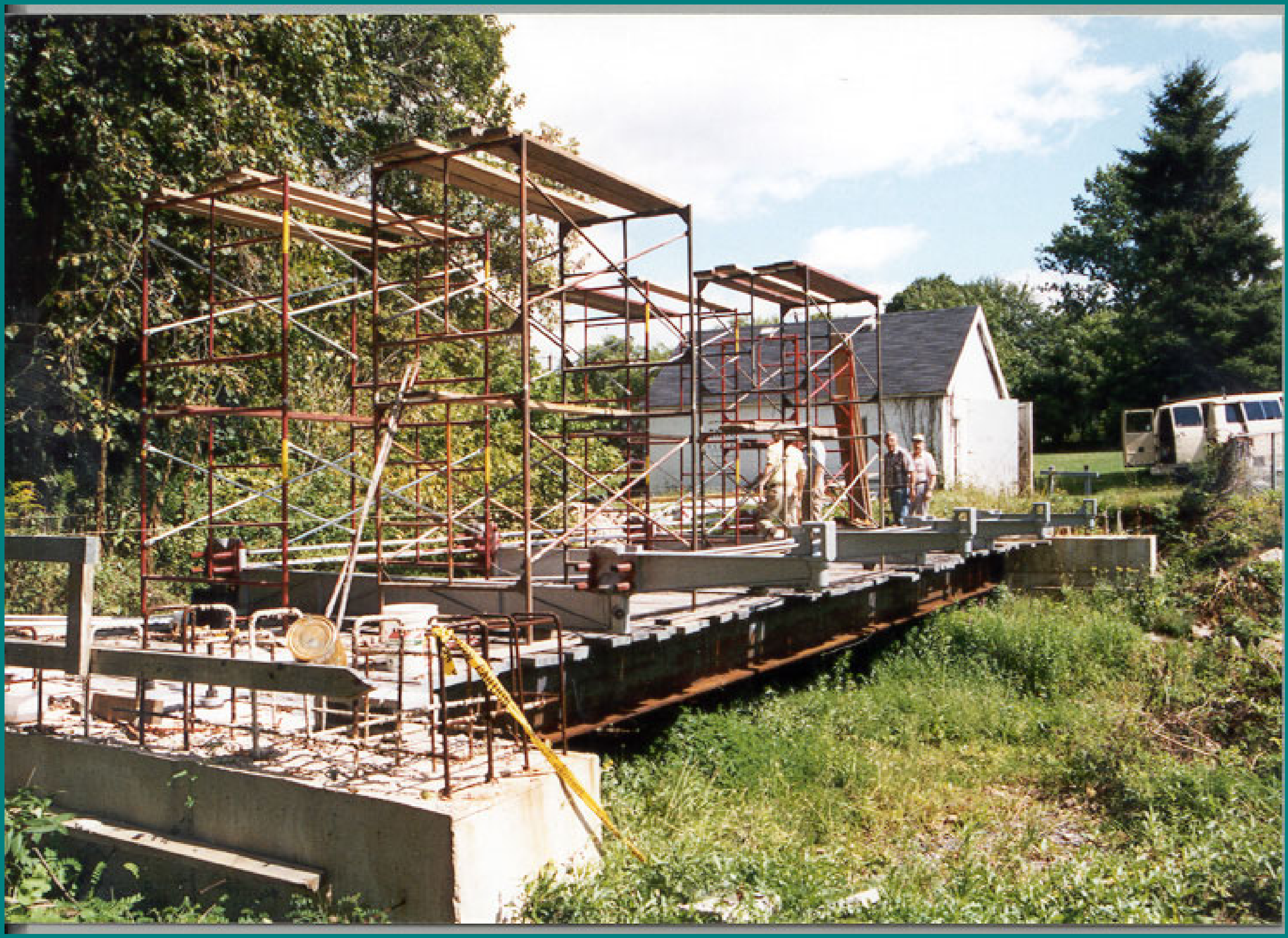
This Allowed Historic Walnut Street Bridge Trusses to Carry Full Dead Load of Structure

RE-ERECTING THE BRIDGE

RE-ERECTING THE BRIDGE



RE-ERECTING THE BRIDGE



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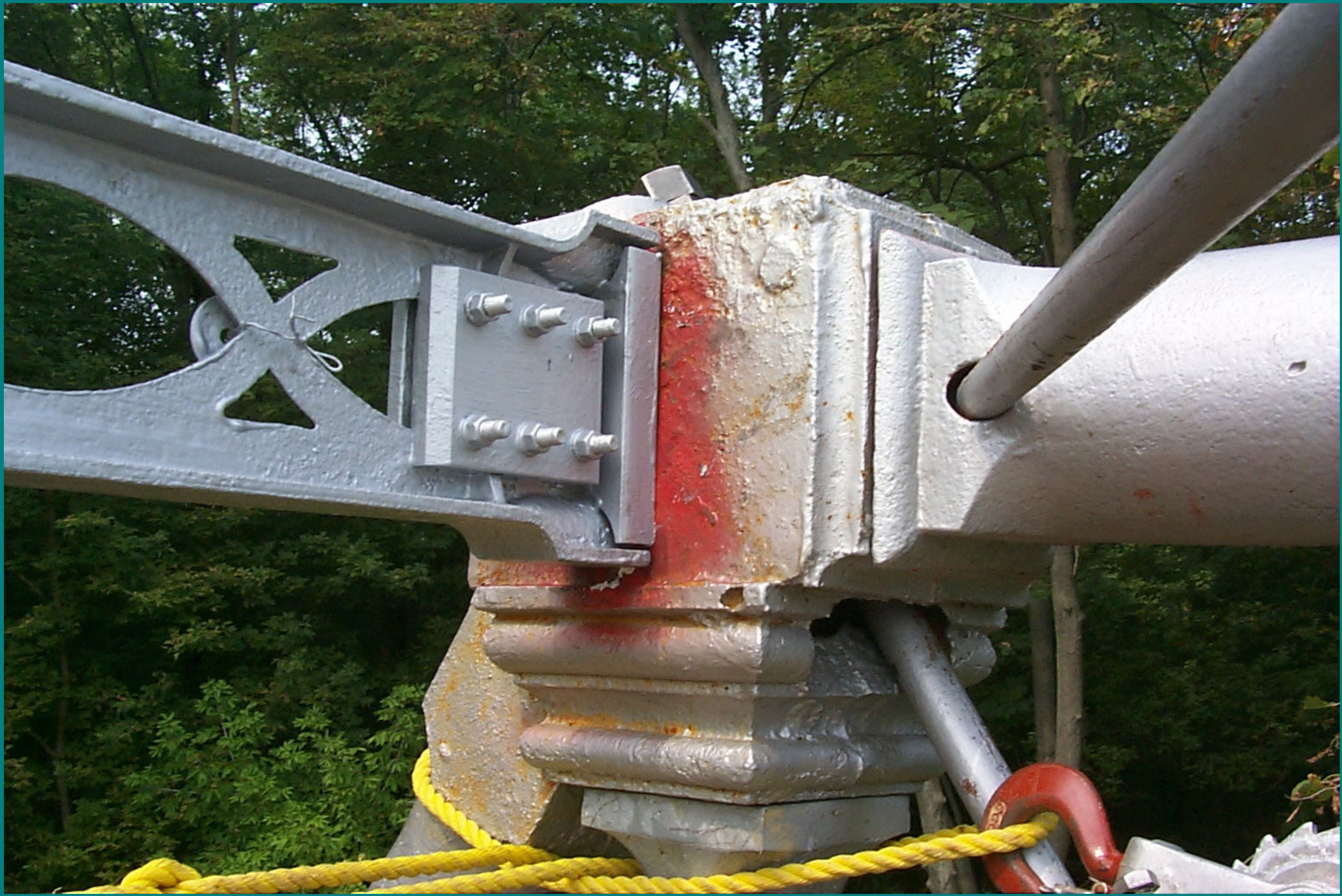

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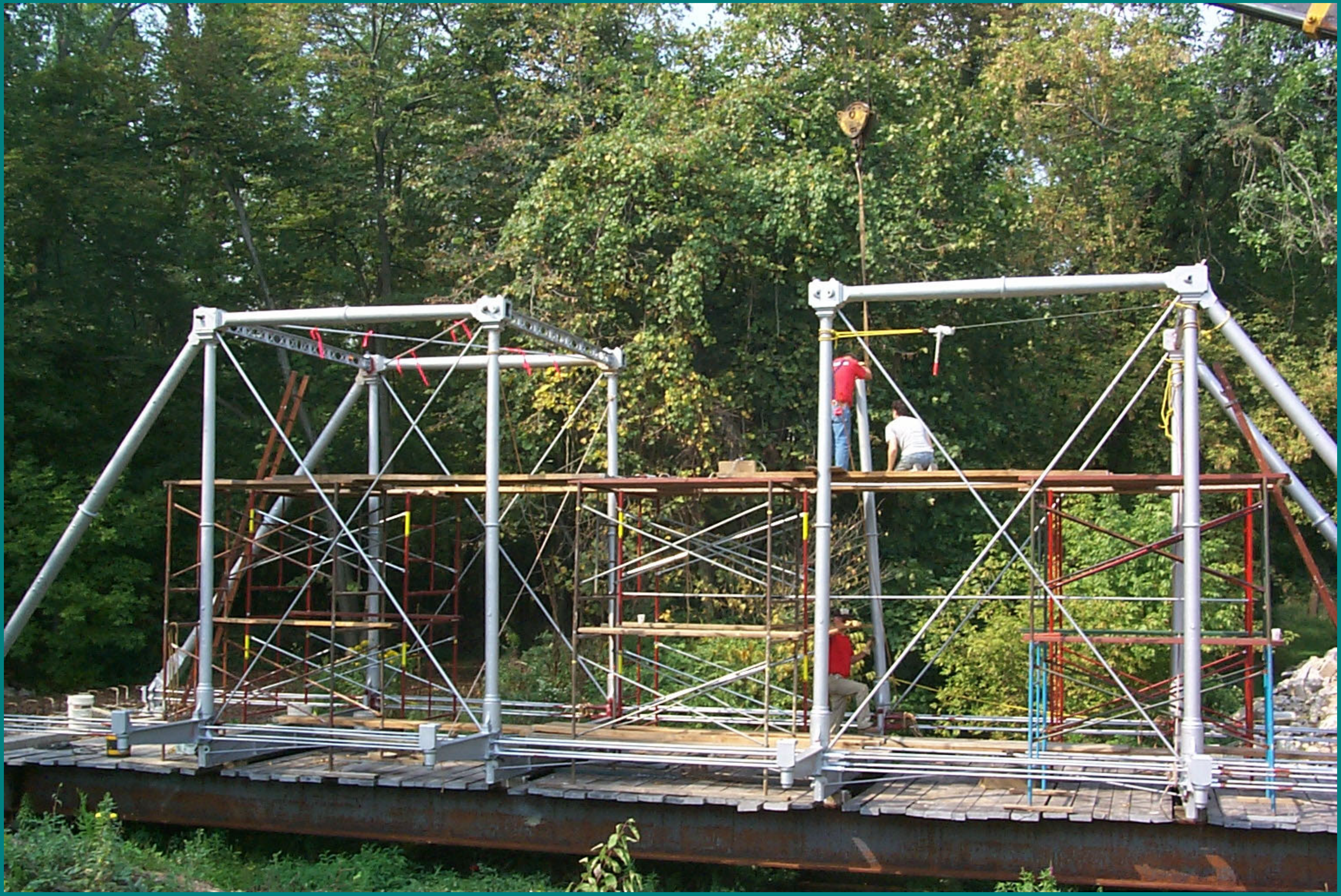

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RE-ERECTING THE BRIDGE

FINAL SITEWORK

- Fall 1998
  - Placed Wood Stringers and Decking on Bridge
  - Completed Concrete Backwalls

FINAL SITEWORK

FINAL SITEWORK

FINAL SITEWORK

FINAL SITEWORK

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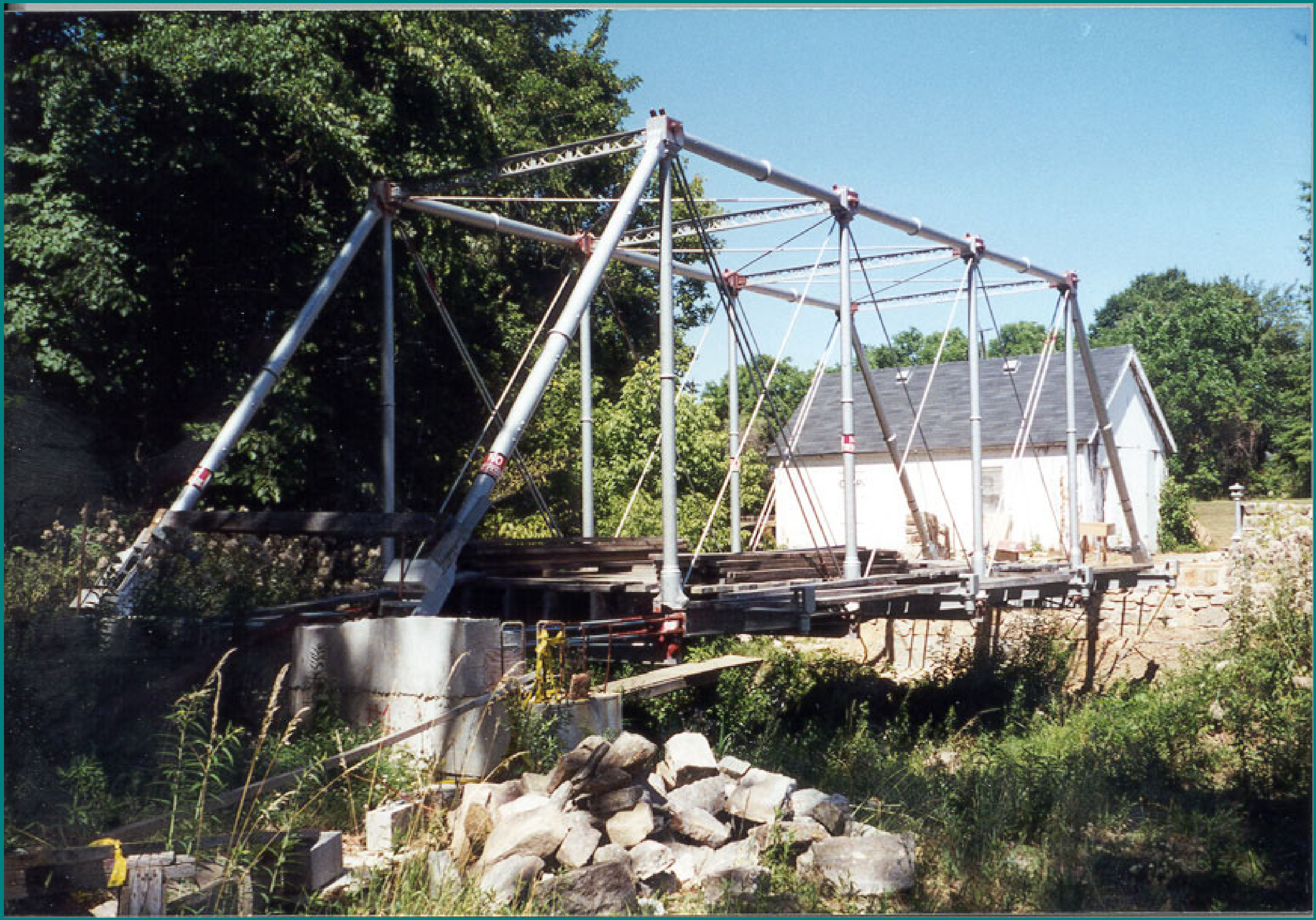
FINAL SITEWORK



CONTRIBUTORS

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HELLERTOWN HISTORICAL SOCIETY
REHABILATATION & RESTORATION PROJECT
Walnut Street "Pony" Bridge - 1860
The last remaining CAST & WROUGHT IRON BRIDGE in North America
HELLERTOWN'S HERITAGE - HELP US PRESERVE IT


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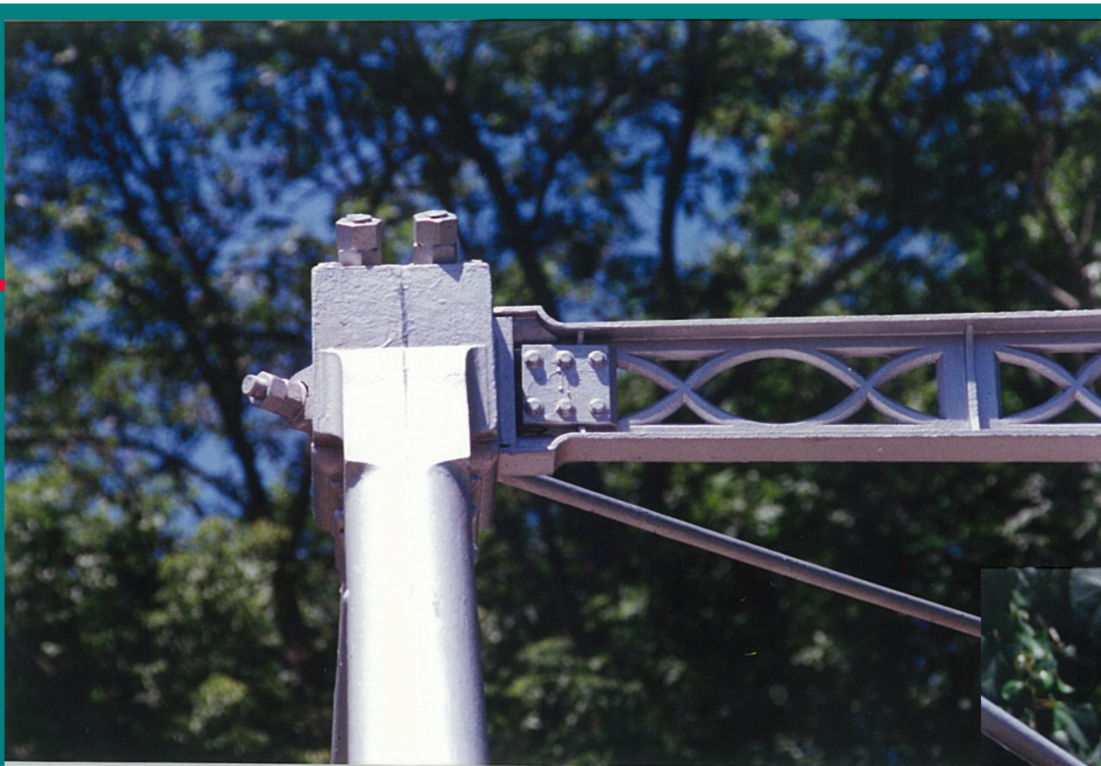
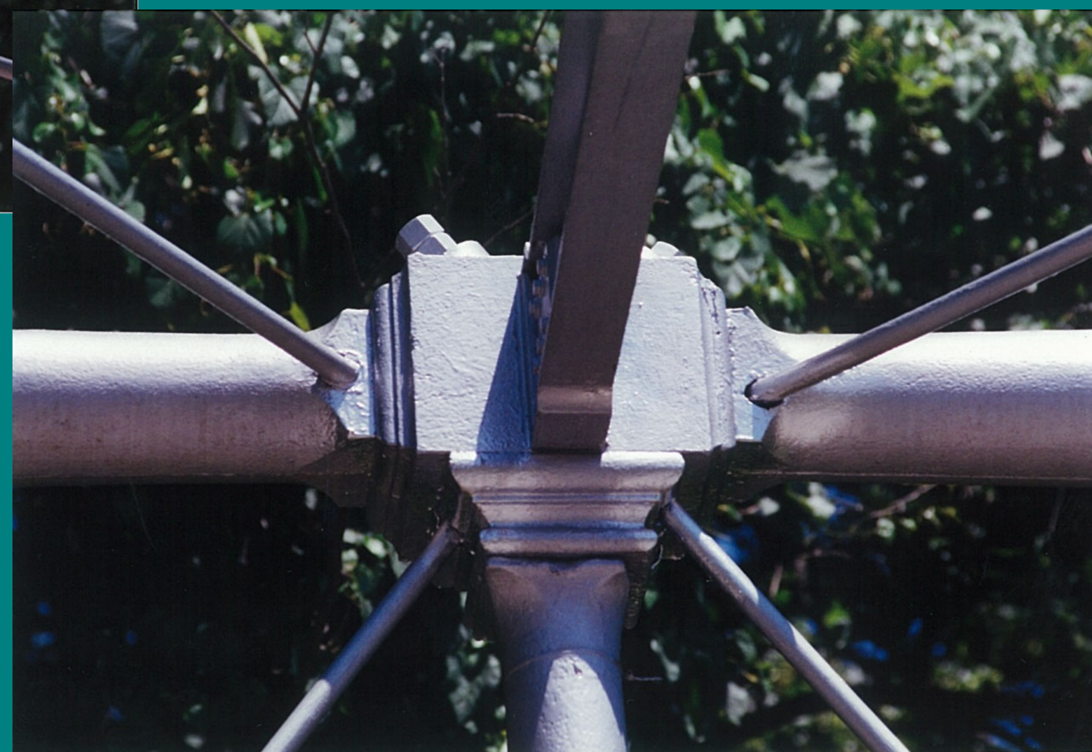




THE END

Any Questions?

Aesthetic and Structural Lessons Learned on the Walnut Street Bridge Rehabilitation Project

Perry S. Green, PhD, PE

The Bridge, Description, and Historic Attributes

- The Walnut Street Bridge is located in Hellertown, Northampton County, PA.
- It was rehabilitated between 1994 and 2000 through the joint efforts of a small volunteer group of Civil/Structural Engineering graduate students at Lehigh University, Bethlehem, PA and the Hellertown Historical Society.
- The bridge is part of the Historic American Engineering Record (HAER) Collection, being designated PA206.

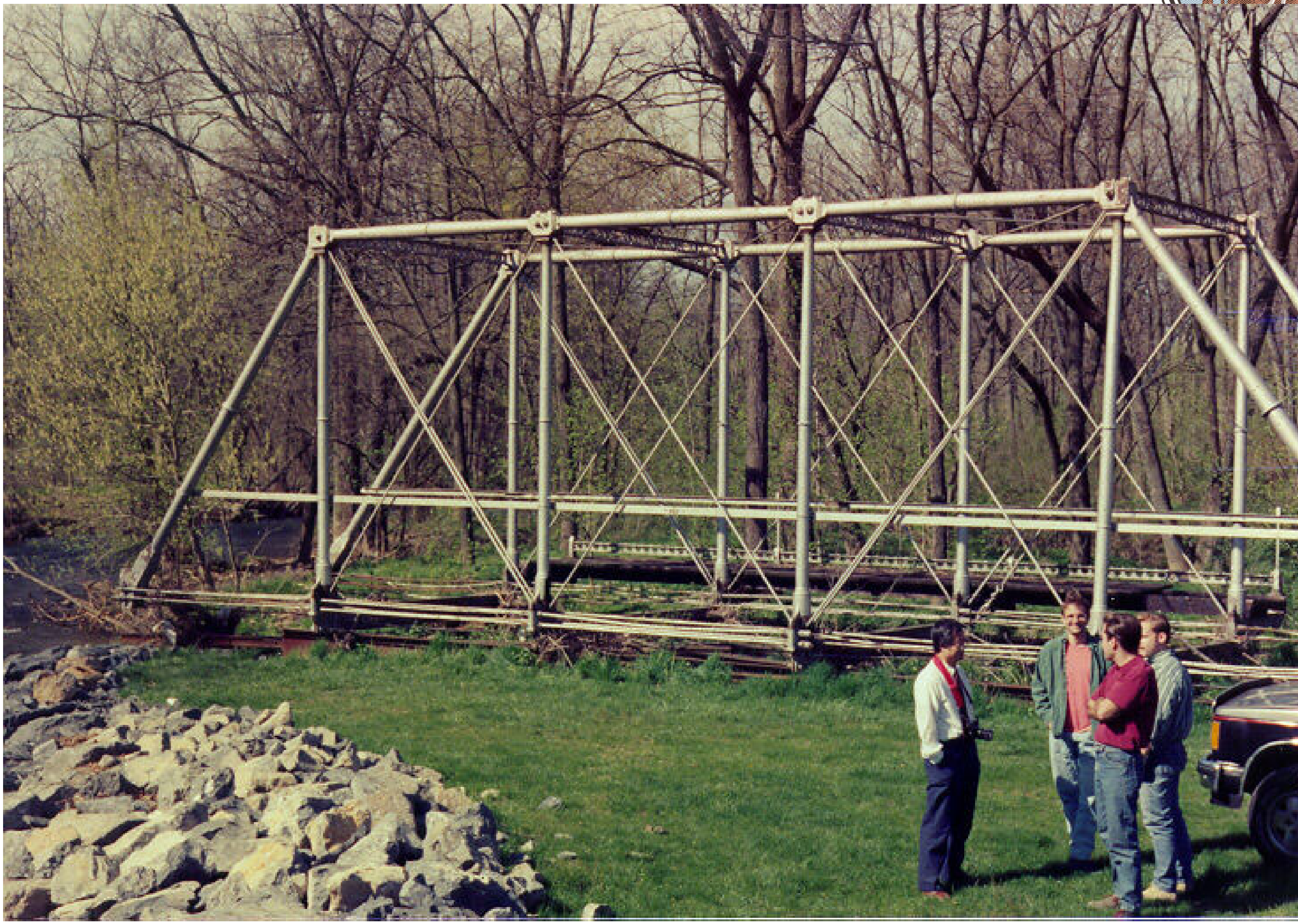
The Bridge, Description, and Historic Attributes

- The bridge structure is a single-span, single-lane through Pratt truss previously located on Walnut Street that spanned Saucon Creek in Hellertown. It was removed from service in the early 1970s due to structural and functional deficiencies and simply relocated to a temporary holding place nearby, i.e. along the creek bank where it rested for about 25 years.
- The original bridge, circa 1860, was constructed of cast and wrought iron members fabricated by the Beckel Iron Foundry and Machine Shop formerly located in Bethlehem, PA. It was designed by Francis Lowthorp and includes several patented details. It is approximately 15ft. high with a clear span of 55ft. and is the only through truss built by the Beckel Foundry still known to exist.

PART ONE

BACKGROUND AND OVERVIEW

A VISION, A PLAN, A GOAL - 1994



Project Narrative

In 1994 a group of CEE Graduate Students initiated plans to rehabilitate the Walnut Street Bridge as a pedestrian foot bridge across a nearby mill race adjacent to Saucon Creek. However, before any work was initiated, the bridge was evaluated to determine whether it could be "fixed". Subsequently, preliminary restoration and repair alternatives were developed at the same time a survey was conducted to accurately document member arrangement and global geometry. The truss was dismantled and immediately after each individual member was removed, an in-depth inspection was conducted and its condition documented. All severely damaged members were sent to the ATLSS Center at Lehigh Univ. for further assessment and structural repair or in-kind replacement.

PROJECT NARRATIVE

While structural repairs were being designed and implemented, a comprehensive material's testing program was developed and executed in order to determine material properties to increase the limited database for such materials commonly being used in the mid 19th century. Test specimens were obtained from members that were not going to be reused or were taken from members where their structural integrity would not be compromised. The types of ASTM standard materials tests that were conducted included: Bending, Charpy V-notch, Compression, Hardness, and Tension. Information pertaining to the existing paint system was also obtained while a decision was made as to the appropriate coating type and color to be used on the rehabilitated bridge.

PROJECT NARRATIVE

A new site for the bridge was selected, land cleared, and new concrete foundations and abutment walls were designed and constructed. A viable reconstruction sequence and erection plan was submitted to and approved by the Hellertown Historical Society and the Walnut Street Bridge was re-erected. The bridge was formally reopened to pedestrian traffic in 2000 and over 20 years later still serves the local community as a pedestrian bridge in a restored historic area in Hellertown.

Project Timeline

- **1994 – Spring: Initial site visit, proposal development, presentation, decision**
- **1994 – September 24, 25: Bridge disassembly and removal**
- **1994 – Fall: Member condition assessment**
- **1995 – Summer: Cast iron member cleaning and sandblasting**
- **1995 – Summer: New site selection made; site cleared; east side footing and abutment wall constructed**
- **1995 – Fall: Cast iron material testing; west side footing and abutment wall constructed**
- **1996 – Spring/Summer/Fall: Cast iron members painted; wrought iron member replacements and tension member coupling nuts fabricated**
- **1997 – Spring/Summer: Falsework bridge designed, materials procured, and fabricated; contract issued for 3 new cast iron vertical members**
- **1997 – Fall: Erected falsework bridge; placed cast iron floorbeams, casting node blocks, and tension chord members**

Project Timeline

- **1998 – Spring/Summer: Cast iron member repairs; fabricated new bearing plates and tension chord end restraints**
- **1998 – Summer: Painted and delivered to site remaining tension chord and bracing members; finished back wall and wing wall designs**
- **1998 – September 8-10: Made final floorbeam alignments; installed working deck; erected scaffolding; reviewed final erection plans**
- **1998 – September 14, 15: Re-erected the Walnut Street Bridge on the falsework bridge**
- **1998 – September 22: Lowered falsework bridge allowing the Walnut Street Bridge to carry its own weight for the first time in ~25 years**
- **1998 – Fall: Placed wood stringers and decking; completed concrete backwalls**
- **1999 – Final sitework; overall painting and grading**
- **2000 – June: Official dedication ceremony and reopening the bridge to pedestrian traffic only**

DECISIONS AND LESSONS LEARNED

The pure aesthetic decisions and lessons learned ranged from where the bridge would be relocated so that it would still fit into its local environment to the proper paint color, stonework, and wood stringer and decking materials to be used as part of the rehabilitation.

Decisions and Lessons Learned

The pure structural decisions and lessons learned were initially focused on the repair or replacement of:

1) The vertical and horizontal wrought iron round bar bracing members; and
2) The round bar wrought iron tension chord members.

Various diameters of bars were used in the construction of the bridge, but their historic value was deemed insignificant relative to all the unique cast iron members that made up the primary load-carrying structural system of the bridge from the floorbeams and columns to the upper chords and lateral struts.

DECISIONS AND LESSONS LEARNED

The combined decisions and lessons learned were extensive and involved minor to major repairs of these primary cast iron members such that their structural functions would not be compromised and their designed fixes would not substantially detract from the overall appearance of the bridge once returned to service as a pedestrian bridge.

Decisions and Lessons Learned

The final structural lesson learned that will be discussed in some detail involves the cast iron columns.

When one of the eight (8) columns was routinely being moved at the ATLSS Center as it was undergoing repair it was broken at two locations. For this column, repair was no longer an option and it needed to be replaced if the project were to be finished successfully.

This incident might have been the silver lining to avoiding a member failure or the failure of the overall structure during re-erection. Once known, and a solution found, the project was put back on track.

Now, over twenty (20) years later, the rehabilitated Walnut Street Bridge still stands as a pedestrian bridge that Hellertown is proud to have and maintain.

PART TWO

INITIAL BRIDGE SURVEY

DEVELOPING LESSONS

An identification system for all the members was devised so that all documentation produced related to the bridge rehabilitation would be consistent. Primarily this system was used for the cast iron members and therefore excluded the wrought iron bracing members as well as the lower tension chord. The **DOWNSTREAM** truss is the one with the separate cast iron joint blocks. The **UPSTREAM** truss has an integrally cast joint block leading to the pedestrian sidewalk.

DEVELOPING LESSONS

- ENDPOST – EP
- VERTICAL – V
- FLOORBEAM – FB
- UPPER CHORD – UC
- LATERAL STRUT – LS
- JOINTS are numbered L0 through L5 along the lower chord and U1 through U4 along the upper chord
- A typical member of the truss might be designated UC-U2-U3-DN
- A typical member spanning between the trusses would be designated by its joint location, LS-4

PART THREE

DISASSEMBLING THE BRIDGE

Developing Lessons

For graduate students that are research assistants on projects at the ATLSS Center one ever present parameter with any structural system is that stability always needs to be maintained. This was put into good practice when the bridge was disassembled.

- **Erected Scaffolding**
- **Stabilized Trusses**
- **Secured Connections**
- **Blocked and Shored Up Endposts**
- **Marked Members with Temporary Identification Tags**
- **Removed First Cast Iron Member by Hand**
- **Cut and Removed First Two Wrought Iron Diagonals**
- **Broke Trusses Down into Triangular Modules**
- **Cut and Removed Remaining Wrought Iron Members**
- **Removed Remaining Cast Iron Members**
- **Placed all Cast Iron Members in Secured Storage**

SEPTEMBER 23 – 25, 1994

SEPTEMBER 23 – 25, 1994

PART FOUR

MEMBER ASSESSMENT

Developing Lessons

Shortly after the bridge was disassembled and all the cast iron pieces moved to a secure area within the Historical Society's property a member by member condition assessment was undertaken. One can clearly see the amount of corrosion that has taken place at the vertical member-floorbeam connections, the amount of organic debris from bird's nests to wasp's nests found in the vertical column members, and the deterioration of the cast iron members especially at the joint interfaces where cast alignment collars have been slightly damaged to completely broken or sheared off.

FALL 1994


FLOOR BEAM
FB - 4


UPSTREAM
UPPER CHORD
UC - U1-U2


DOWNSTREAM
UPPER CHORD
UC - U2-U3


DOWNSTREAM
VERTICAL
V - L1-U1

PART FIVE

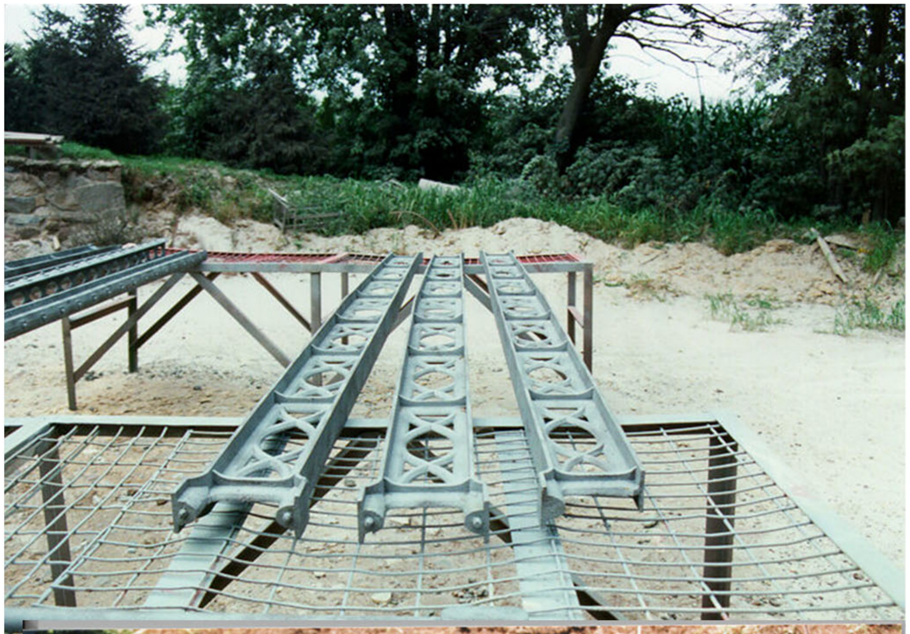
MEMBER DETAILS

DEVELOPING LESSONS

What is unique, what needs to be preserved? What can be replaced and what needs to be repaired? Those repairs might only need to be cosmetic for aesthetic reasons or structural to assure that the bridge will once again function as a bridge carrying load, albeit just pedestrians walking across the roadway deck. Numerous examples are provided showing the conditions of the cast iron End Posts, Lateral Sway Struts, and Upper Chords immediately after sandblasting prior to a prime coat being applied or just after the members were coated with primer.

How many differences can you observe between just the tops of the Downstream End Posts?

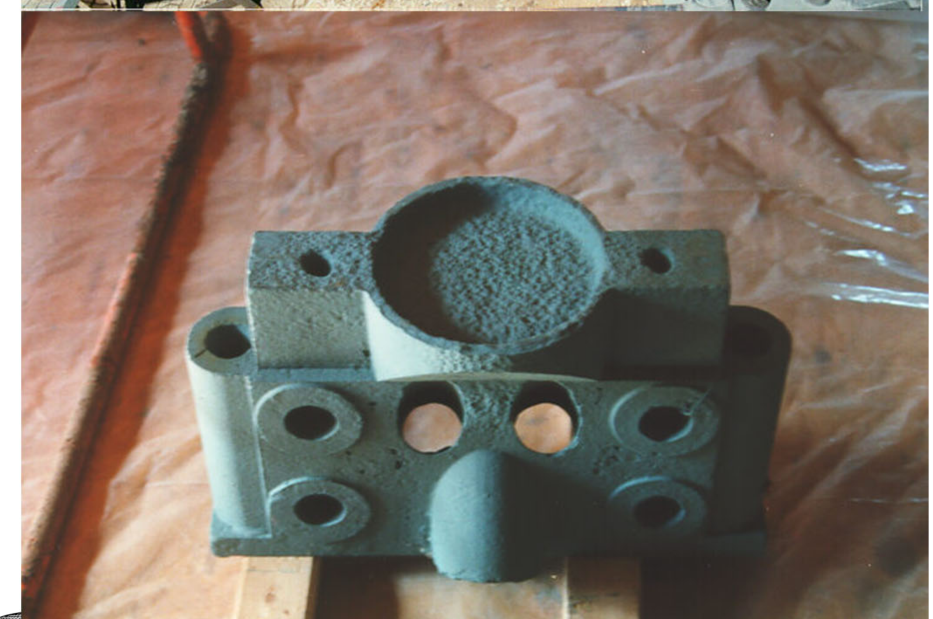
SUMMER 1995



Developing Lessons

It's prudent here to take an in-depth look at the bridge's floorbeams. One's first observation might be that they have integrally cast vertical dogboned shaped stiffeners and bowstring shaped diagonal stiffeners. Upon further examination one might notice the member's nonprismatic shape, both in regards to the flanges and web depth. It's easy to see there is an offset cantilever at one end of the floorbeam for the sidewalk with a cast joint block included as part of the member. At the other end is a "placeholder" for a separate cast joint node block that will be secured to the floorbeams. This is the patented detail attributed to Francis Lowthorp which is used to carry the tension chord rods at the lower panel points of the truss where the verticals are connected to the floorbeams.

SUMMER 1995



UNITED STATES PATENT OFFICE.

FRANCIS C. LOWTHORP, OF TRENTON, NEW JERSEY.

IRON TRUSS-FRAME FOR BRIDGES.

Specification of Letters Patent No. 17,684, dated June 30, 1857.

To all whom it may concern:

Be it known that I, FRANCIS C. LOWTHORP, of the city of Trenton, county of Mercer, and State of New Jersey, have invented certain new and useful Improvements in the Construction of Iron Truss-Frames for Bridges; and I do hereby declare the following to be a full, clear, and exact description of the same, reference being had to the accompanying drawing and to the letters of reference marked thereon.

My invention relates to the construction of iron truss frames for bridges, and consists in so connecting lower chord rods, verticals, diagonals, and counter diagonals to a straining plate peculiarly formed and constructed for their reception, that the said lower chord rods may be simple, light, and straight, easily connected, adjusted, and detached, free from eyes and slots for receiving keys and other expensive forged work, and that the straining plate at the same time may not be submitted to any tensile strain and may admit of being connected simply and readily to the verticals and diagonals.

The whole is designed and constructed for the purpose of forming the lower chords of truss-frame bridges in the lightest possible manner compatible with appropriate strength, and of parts more simple and portable and less expensive than have been hitherto used for a like purpose.

In order to enable others skilled in the art to make and use my invention, I will now proceed to describe its construction and operation.

On reference to the drawing which forms a part of this specification: Figure 1, is a front elevation of sufficient of an iron truss-frame bridge to show my improvements. Fig. 2, a transverse section of a portion of the bridge, being a side view of Fig. 1, looking in the direction of the arrow. Fig. 3, a sectional elevation on the line 1—2, Fig. 2. Fig. 4, also a sectional elevation on the line 3—4, Fig. 2.

Similar letters refer to similar parts throughout the several views.

A is the lower portion of one of the vertical posts of the bridge and in the bottom of this post is a recess for the reception of the projection *a* on the straining plate B. Through the latter passes a pin C, to which are jointed the end of the main diagonals D, D, and D′, D′, and the counter diagonals E, E, the ends of the two main diagonals D′, D′, passing into the opening *b* of the straining plate. Through orifices in the latter also pass the screwed ends of the lower chord rods H, onto the points of which are screwed the lengthened nuts J, J, which also serve to receive the ends of the lower chord rods G′, G′.

The rods H are furnished with ordinary nuts I, I, which, together with the lengthened nuts J, J, serve to connect the opposite rods securely to the plate B.

Instead of the lengthened nuts J, J, I propose in some instances to use the ordinary well-known swivel nuts.

By the above-described mode of connecting the lower chord rods to the straining plate B, the said rods may be readily adjusted, detached and replaced, may (with the exception of their screwed ends), be perfectly plain, free from eyes, or slots for receiving keys, and other heavy and expensive forged work, thus enabling me to construct the lower chords of truss-frame bridges in a much superior manner (both as regards simplicity of workmanship, lightness of material, strength and portability of parts and ready connection of the same together) to those constructed in the usual manner.

It will be further seen that the straining plate for receiving the lower chord rods affords a simple and direct mode of attachment for the diagonals and verticals, and also that the straining plate is not submitted to that tensile strain which is unavoidable when the lower chords are attached in the usual manner.

I do not desire to confine myself to the precise form of straining plate described and illustrated, as the same may be adapted to receive a greater or lesser number of lower chord rods, or to any description or number of diagonals and verticals. But

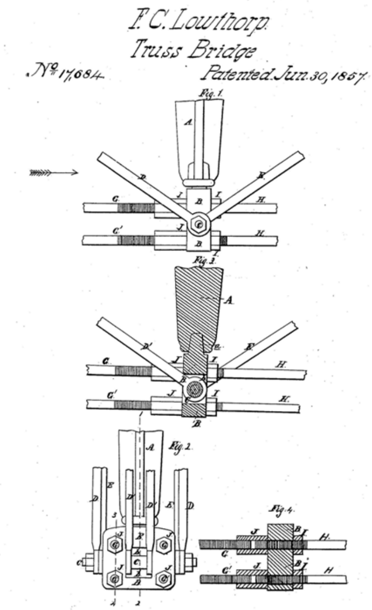
What I claim, and desire to secure by Letters Patent, is—

The straining plate B in combination with the rods G and H when the latter are connected to the plate, substantially in the manner herein set forth, and when the said plate is arranged to receive the vertical or verticals and diagonals of iron truss-frame bridges.

In testimony whereof, I have signed my name to this specification before two subscribing witnesses.

F. C. LOWTHORP.

Witnesses:
HENRY HOWSON,
WILLIAM E. WALTON.



PART SIX

NEW CONSTRUCTION

Developing Lessons

The first major efforts in reassembling the bridge took place during the Summer and into the Fall of 1995. In early June 1995 a new site was chosen for the bridge not more than 200 yards away from its original location. It was decided that a bridge of this stature had to be spanning some body of water otherwise it would look out of place in the setting chosen. Therefore, the bridge was to be placed at the trail head of a nature walk, crossing the mill race coming from Wagner's Grist Mill located almost directly adjacent to the bridge on the South side of Walnut Street. After the site location was approved by the governing board of the Hellertown Historical Society, the site was surveyed, trees cleared, and rough grading completed.

DEVELOPING LESSONS

Foundation and abutment wall design was completed during the Summer 1995 and in the Fall of that year two new bridge support structures were constructed.

All the labor utilized for this effort was volunteer, which included layout and bending of all the reinforcing bars, surveying the site for general location and detailed placement of the foundations and walls, constructing the formwork, tying the rebar cages, and placing the concrete.

During excavation of the west foundation and abutment wall the local water table was breached so a dewatering system had to be put in place. This minor complication was overcome with a little more effort and plenty of stone.

Fall 1995

PART SEVEN

MEMBER REPLACEMENT

DEVELOPING LESSONS

Early in the project it was decided that there was no value in trying to reuse the wrought iron bars as they would be replaced in-kind with the same size carbon steel bars. The bars were donated, came in 20 ft. lengths, but came unthreaded. The thread length needed was substantial especially when used as part of the tension chord that was connected together with coupling nuts that would be made from a solid hex bar.

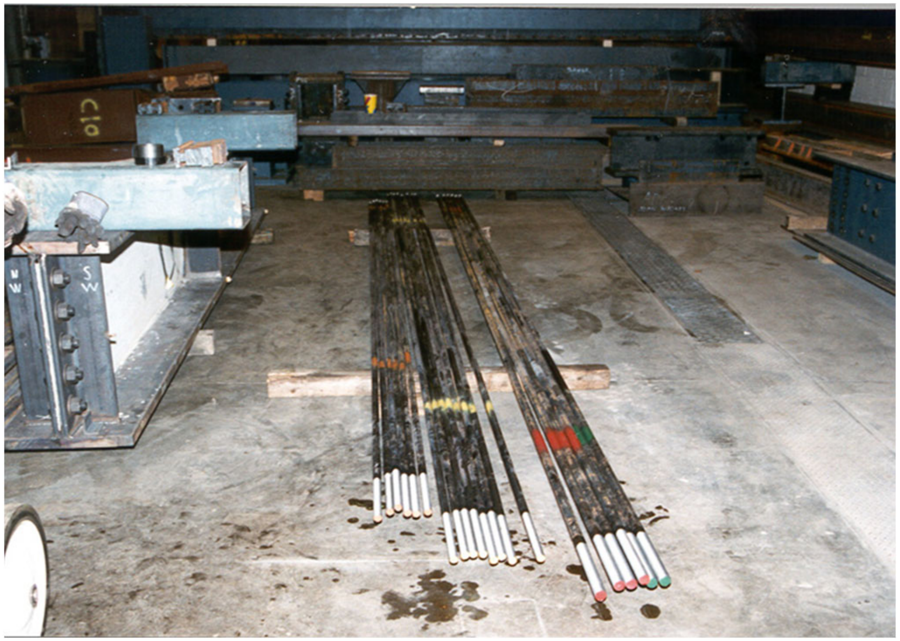
A pipe threader was used by multiple volunteers to help thread 72 bars – 144 threaded ends. Bar sizes were 3/4", 1", and 1-1/4" diameter. Have you ever used one?

Only two (2) end post bearing plates were ever located by the Historical Society and therefore, two new bearing plates were fabricated out of donated plate material.

DEVELOPING LESSONS

All eight (8) cast iron verticals had been transported to the ATLSS Center where decisions were being made how to repair the cracks and missing pieces in a few of the members. One day while one of these pieces was being relocated using a forklift, it hit a bump in the lab floor and the column broke at two distinct locations. After examining the surfaces where the member broke it was clear that it could not be repaired and needed to be replaced. That was a hard decision, but in the end three new grey cast iron verticals were made from a sand casting mold utilizing one of the undamaged members. This new material is actually not brittle and is weldable. Shims were provided to go on the top collars so when the upper chords were placed everything would fit together.

Spring/Summer/Fall 1996-1998



SPRING/SUMMER/FALL 1996-1998

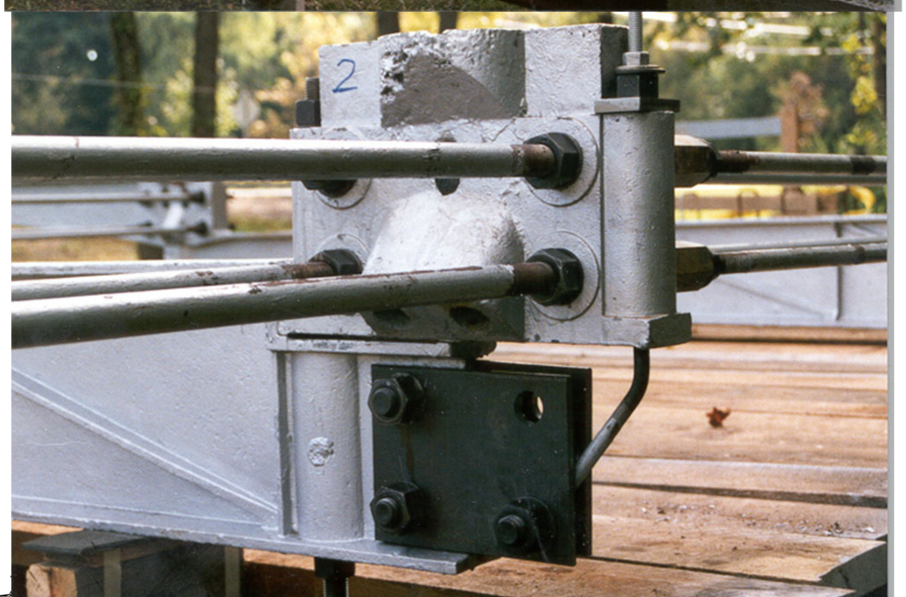
PART EIGHT

SETTING FALSEWORK BRIDGE, FLOORBEAMS, TENSION CHORDS

DEVELOPING LESSONS

It's almost time! The decisions that needed to be made would determine whether the project could be safely and successfully completed. The falsework bridge concept was developed and became a reality when Bethlehem Steel decided to donate two (2) 70ft. long ASTM A572 wide flange beams. Essentially a two-girder bridge that spanned between the abutment walls was designed and erected. This bridge acted in two capacities: 1) It provided a safe working platform to re-erect the Walnut Street Bridge over the mill race, and 2) It was designed to be lowered out of the way once the historic bridge was re-erected and deemed able to carry load as originally designed.

FALL 1997



PART NINE

MEMBER REPAIR

DEVELOPING LESSONS

At the ATLSS Center the following was accomplished:

Four tension chord end restraint plates were fabricated (these are new and not part of the original design)

Two endpost bearing plates were fabricated, previously shown

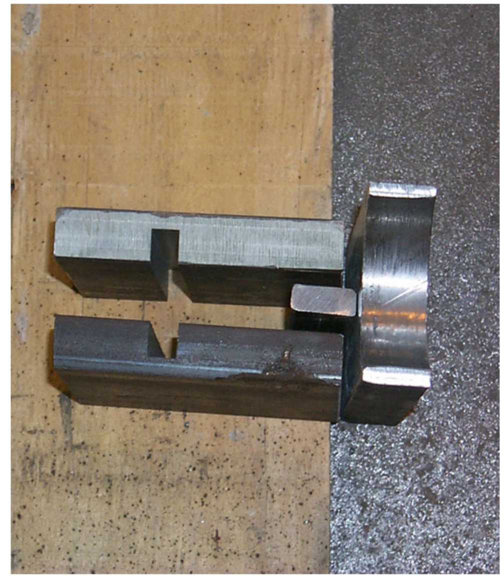
Collar repairs were completed on the cast iron verticals and upper chord members

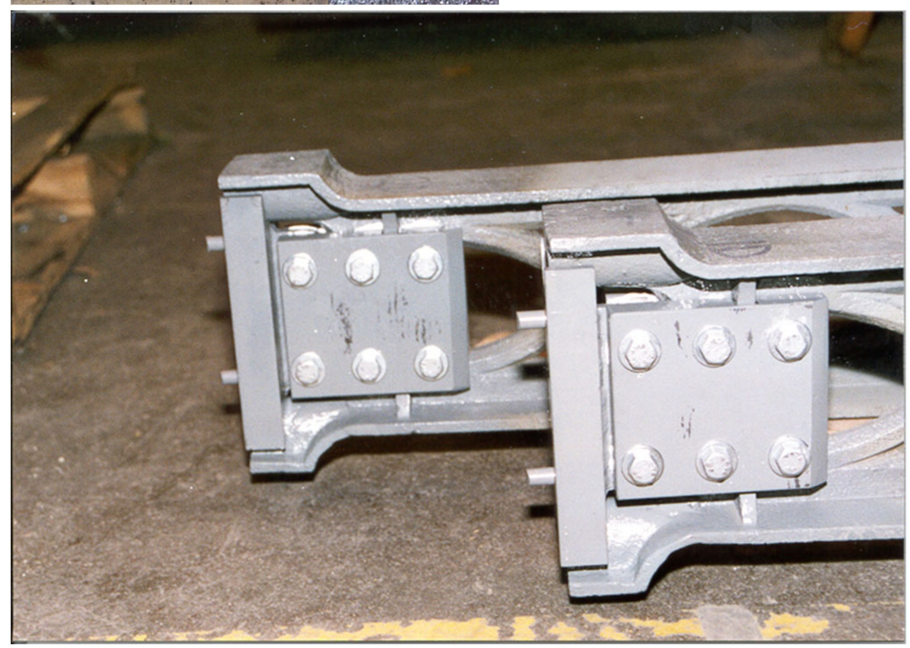
Supplemental pieces were fabricated for the cast iron lateral strut repairs

Connection detail repairs were completed for the lateral struts

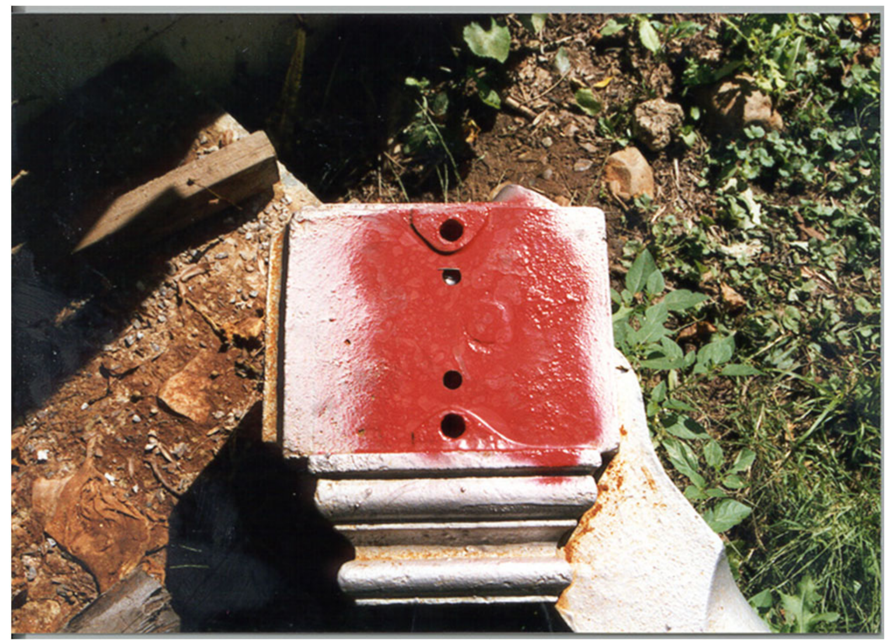
Other nonstructural weld repairs were completed on the lateral struts

SPRING/SUMMER 1998





Spring/Summer 1998



PART TEN

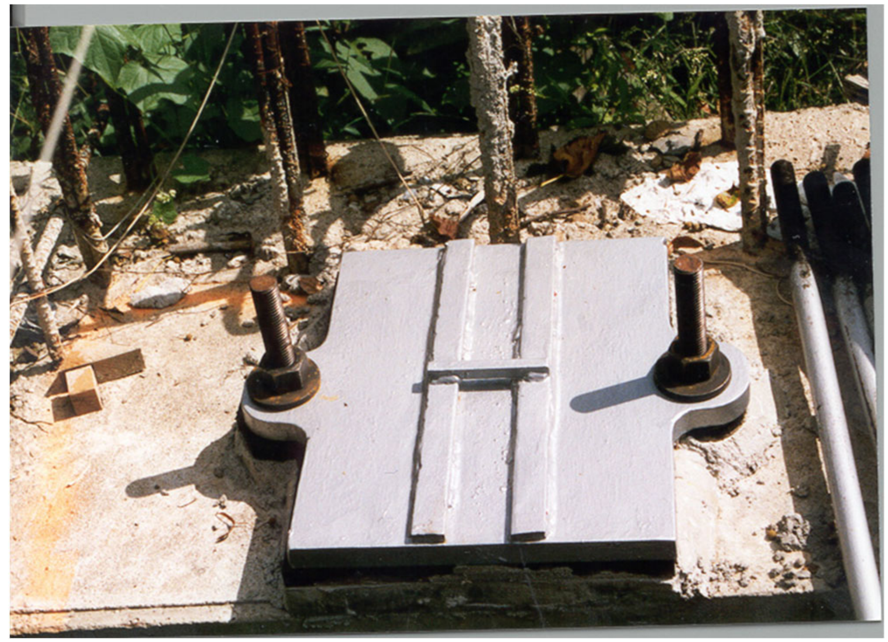
RE-ERECTING THE BRIDGE

DEVELOPING LESSONS

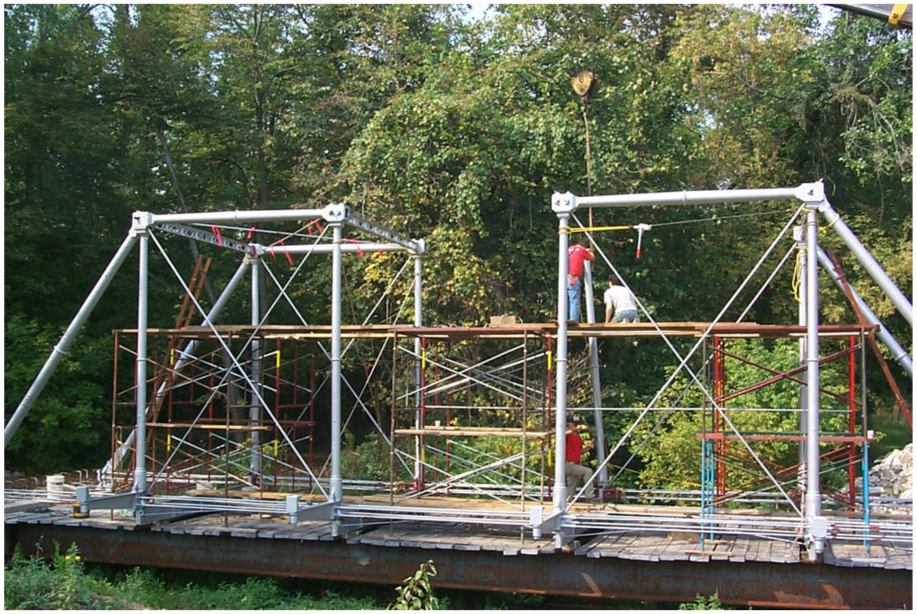
At the new Walnut Street Bridge site the following was done in preparation for re-erecting the bridge:

- Final floorbeam alignments were made
- A working deck platform was installed on top of the floorbeams
- Scaffolding was erected on the working deck
- Everyone reviewed the final construction sequence to make sure nothing was overlooked

SEPTEMBER 8-10, 1998



SEPTEMBER 14-15, 1998



SEPTEMBER 14-15, 1998

SEPTEMBER 22 1998

PART ELEVEN

FINAL SITE WORK

Fall 1998

FINAL LESSONS LEARNED

1. Not everything goes as planned.
2. Know your limitations and do not take on a project that you don't have the time, experience, and/or knowledge to complete.
3. Volunteers are free, but don't take advantage of them.
4. Donations are free, but make sure every one that is given is appreciated, recognized, and properly thanked; without them maybe the project doesn't even get started.
5. Make sure you have contingencies in place to overcome unanticipated issues or problems – know that they will happen.

ANY QUESTIONS?

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