FHR-8-300 (11-78)

United States Department of the Interior
Heritage Conservation and Recreation Service

National Register of Historic Places Inventory—Nomination Form

For HCRS use only
received APR 16 1981
date entered MAY 5 1981

See instructions in *How to Complete National Register Forms*
Type all entries—complete applicable sections

1. Name

historic HANCOCK - GREENFIELD BRIDGE

and/or common COUNTY BRIDGE

2. Location

street & number Forest Road ("Old County Road") at Hancock - Greenfield town line, one mile east of US 202 ___ not for publication

city, town Hancock & Greenfield Hancock ___ vicinity of congressional district Second

state New Hampshire code 33 county Hillsborough code 011

3. Classification

Category	Ownership	Status	Present Use	
___ district	X public	X occupied	___ agriculture	___ museum
___ building(s)	___ private	___ unoccupied	___ commercial	___ park
X structure	___ both	___ work in progress	___ educational	___ private residence
___ site	**Public Acquisition**	**Accessible**	___ entertainment	___ religious
___ object	___ in process	___ yes: restricted	___ government	___ scientific
	___ being considered	X yes: unrestricted	___ industrial	X transportation
		___ no	___ military	___ other:

4. Owner of Property

name NH Department of Public Works & Highways

street & number 85 Loudon Road, John O. Morton Building

city, town Concord ___ vicinity of state New Hampshire 03301

5. Location of Legal Description

courthouse, registry of deeds, etc. Hillsborough County Registry of Deeds
Hillsborough County Courthouse

street & number PO Box #370

city, town Nashua state New Hampshire 03060

6. Representation in Existing Surveys

title NH Historic Preservation Plan has this property been determined elegible? ___ yes ___ no

date 1970 ___ federal X state ___ county ___ local

depository for survey records Department of Resources & Economic Development

city, town Concord state New Hampshire 03301

-continued-

7. Description

Condition
___ excellent
X good
___ fair

___ deteriorated
___ ruins
___ unexposed

Check one
X unaltered
___ altered

Check one
X original site
___ moved date ___________

Describe the present and original (if known) physical appearance

Present physical appearance: The Hancock-Greenfield Bridge carries the Forest Road ("Old County Road") over the Contoocook River approximately one mile east of US 202, joining Hancock, New Hampshire, on the west and Greenfield, New Hampshire, on the east.

The bridge has one span, supported by a Teco[1] - Pratt[2] timber truss designed by John W. Childs and Harold E. Langley. Because the wall-truss uprights are secured at top and bottom with crosswise ceiling and floor trusses, one might consider the entire bridge a box truss, with the roadway passing through its middle. The wall trusses consist of six panels formed by seven solid timber uprights with single-diagonal double-member timber braces in each panel. Continuous top and bottom chords are doubled timbers with spacer blocks between. The wall trusses are conected by Pratt-type ceiling and floor cross-trusses with parallel top and botton chords; the ceiling trusses are connected to longitudinal roof beams by doubled members forming a simple Fink truss. In addition to bearing on the top chord, the ceiling trusses are tied to the uprights with knee-braces whose curves, echoing the curved portal openings, are formed of plywood, although their vertical faces are sheathed in flush boards. The structure is stiffened by heavy timber beams extending between the abutments parrallel the wall trusses and resting on the floor trusses.

All connections are by means of steel bolts, with steel gusset plates at the intersections of diagonals and uprights at the top chord, between the first and second, and fifth and sixth panels. In all the structure contains three tons of steel.[3]

Two sets of lateral cross-bracing extend between the wall trusses: one set above the top chord and bolted to it. At the intersection of the ceiling cross-bracing, a vertical steel tie rod extends to the ridge beam above.

The abutments and angled wing walls, flared back toward the shore to prevent undermining by ice and flood, are of poured concrete; extreme ends of the wing walls are of granite blocks set in mortar. The bridge is about ten feet above average water level.

The Hancock-Greenfield Bridge is 88' long,[4] 27'2" wide, with a portal opening 14' high by 21' wide, providing for a two-lane roadway 20' wide within. The floor consists of 6" x 6" timbers laid flush, side by side, at right angles to the walls, and covered with asphalt pavement so that there is no interruption in the surface of the paved roadway. The posted legal load limit is eight tons (reduced from the original twenty tons).

The lower parts of the wall trusses are protected by a continuous bench sheathed in horizontal tongue-and-grove flush decking with crosswise tongue-and-grove board top, the whole painted white for greater visibility, and additionally protected at the base with a continuous solid timber curb of railroad crossties.

The exterior side walls are sheathed with vertical flush boards laid on horizontal strapping. The siding is stained brown; the stain has vanished on the northeast side, leaving it a weathered grey. The lower edge of the siding is extended to protect the cross-truss ends below, forming an interesting toothed pattern along the bottom of the bridge. The siding extends across the portals and for one bay's width into the bridge at both ends. The main part of the bridge is slightly narrower than the portal width; the portals are "boxed out" about six inches beyond each sidewall, apparently to sheathe heavier posts at the truss ends.

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NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

CONTINUATION SHEET REPRESENTATION IN EXISTING #1-SURVEYS **ITEM NUMBER** 6 **PAGE** 2

Historic American Engineering Record	-title
1974	-date
Library of Congress	-depository for survey records
Washington, DC	-city & state

The gable ends, sheathed with the same stained vertical flush boards as the sidewalls, are completely plain; the portal openings are likewise plain, except for the rounded corners of their flat arches. These arches, formed by the end sets of knee-braces and cross-trusses, are extended inward about two feet to create a lintel effect which is emphasized by a sheathing of horizontal flush boards at the corners. There are no windows or side openings.

The asphalt-shingled roof is laid on boards supported by light rafters which meet over the ridge beam, forming a gable of medium pitch. The roof covers the entire bridge, but overhangs the sides and ends only enough to form a protective drip edge. The eaves are open, with projecting exposed rafter ends "resting" on an applied frieze board.

The bridge is in excellent condition except for a very few pieces of damaged siding, and several boards missing from the tops of the interior benches. (These may have been removed by visitors, curious about the structure--and the fishing--below.)

Despite its simplicity, its careful proportions make the Hancock-Greenfield Bridge attractive, particularly when one realized that it could have been more easily built as a steel or concrete structure.

The National Society for the Preservation of Covered Bridges World Guide to Covered Bridges number for the Hancock-Greenfield Bridge is 29-06-02; the New Hampshire Department of Public Works and Highways' number for the bridge is 158/068; the New Hampshire Department of Resources and Economic Development number is 8.

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[1]Richard Sanders Allen, Covered Bridges of the Northeast (Brattleboro, Vermont: The Stephen Greene Press, 1957), 108.

[2]New Hampshire Division of Economic Development, The Covered Bridges of New Hampshire (Concord, New Hampshire: 1973).

[3]Thedia Cox Kenyon, New Hampshire's Covered Bridges (Sanbornville, New Hampshire: Wake-Brook House, 1957), 39.

[4]New Hampshire Division of Economic Development, op. cit.

8. Significance

Period	Areas of Significance—Check and justify below			
___ prehistoric	___ archeology-prehistoric	___ community planning	___ landscape architecture	___ religion
___ 1400–1499	___ archeology-historic	___ conservation	___ law	___ science
___ 1500–1599	___ agriculture	___ economics	___ literature	___ sculpture
___ 1600–1699	___ architecture	___ education	___ military	___ social/ humanitarian
___ 1700–1799	___ art	X engineering	___ music	___ theater
___ 1800–1899	___ commerce	___ exploration/settlement	___ philosophy	X transportation
X 1900–	___ communications	___ industry	___ politics/government	___ other (specify)
		___ invention		

Specific dates 1937 **Builder/Architect** John W. Childs & Harold E. Langley engineers; Hagen-Thibideau Construction Co., Wolfeboro, NH, builder.

Statement of Significance (in one paragraph)

Engineering: County Bridge was built in 1937 as the first permenent highway span in the northeastern United States which utilized modern timber connectors in an attempt to adapt the wooden truss to the needs of twentieth-century secondary road bridge construction. Designed as a Federal Emergency Relief Administration project by New Hampshire State Highway Department bridge engineer John W. Childs and assistant bridge engineer Harold E. Langley, the County Bridge utilized two 84-foot Douglas fir Pratt trusses designed to assure axial stressing of all members and to render the bridge completely susceptible to structural analysis. The longevity of the trusses was assured by the provision of a roof and siding for the span, as well as by the treatment of the truss and flooring members with zinc chloride and creosote. All joints used 2½ inch split-ring steel TECO timber connectors for maximun strength. These devices had been developed and tested by the Timber Engineering Company of Washington, DC, which had published technical literature on their use prior to the design of the advantages of a pin-connected joint without the deformation that often accompanied the use of bolts alone, thus multiplying the strength of timber joints three to four times over that attained by simple bolting.[1] The innovative use of timber connectors permitted the County Bridge to receive an H-10 (20 ton) load rating upon its completion.

The Timber Engineering Company had published a limited amount of literature on their products, the TECO timber connectors, prior to the design of the design of the County Bridge. Strong interest in the subject had begun in 1933 with the publication of popular articles on timber connectors in Scientific American and Popular Science. In the same year, the U.S. National Committee on Wood Utilization and the Forest Products Laboratory had published Modern Connectors for Timber Construction.[2] In 1935, the year before Childs and Langley designed the County Bridge, the Timber Engineering Company published their Manual of Timber Connector Construction.[3] Even so, the design of the County Bridge preceded the publication of booklets like Modern Timber Highway Bridges Designed with TECO Joint Connectors (1940) and the flood of some forty publications by the Timber Engineering Company which appeared during and after World War II.[4] The County Bridge may thus be seen as the prototype for a new class of light highway spans utilizing economical engineer-designed timber trusses and the latest developments in pre-war wood technology. This combination of advanced design and inexpensive materials permitted the span to be constructed for only about $30,000 and the entire project, including concrete abutments and wing walls, to be completed for $77,000.[5] Although increasing prosperity and declining relative costs of steel and concrete rendered this economical approach to highway bridge construction generally unnecessary after World War II, a few other bridges of similar design were later built using TECO timber connectors.[6] Four examples in nearby Massachusetts span Mill Brook north of Charlemont (1951), the Housatonic River at Sheffield (1953), the Nashua River at East Pepperell (1963), and the Green River north of Greenfield (1972).[7] The significance of the County Bridge as a pioneering experiment was recognized by its inclusion in the 1974 Historic American Engineering Record inventory of New England industrial and engineering sites.[8]

-continued-

FHR-8-300A
(11/78)

UNITED STATES DEPARTMENT OF THE INTERIOR
HERITAGE CONSERVATION AND RECREATION SERVICE

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

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CONTINUATION SHEET #3-SIGNIFICANCE **ITEM NUMBER** 8 **PAGE** 2

Transportation: The existing Hancock-Greenfield Bridge replaces an earlier covered bridge, "The Old County Bridge", on the same site. Erected jointly by the towns of Hancock and Greenfield in 1852, it was built by Charles Gray of Hancock according to Long's 1830 patent; after extensive flood damage in 1936, it was dismantled and replaced with the present structure.[9]

According to Floyd Avery of the New Hampshire Department of Public Works and Highways, the highway department chose to construct the TECO timber truss bridge because it was replacing a covered bridge; there was low existing and potential traffic volume on the road; and there was considerable local support for the continuation of a covered bridge at the site.[10]

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[1]Timber Engineering Company, Timber Design and Construction Handbook (New York: F.W. Dodge Corp., 1956), pp. 62-63.

[2]Washington, D.C.: U.S. Government Printing Office, 1933.

[3]Washington, D.C., 1935.

[4]The National Union Catalogue, Pre-1956 Imprints, Vol. 594 (London: Mansell Information/Publishing Ltd., 1978), pp. 440-442.

[5]New Hampshire Highway Department, Timber Spans report for bridge no. 158/068, dated August 25, 1941; C. Ernest Walker, "The Covered Bridges of Hillsborough and Strafford Counties, New Hampshire," Covered Bridge Topics, 19:1 (April, 1961), p.3.

[6]Ray E. Wilson, "Designs in Covered Bridge Trusses Through the Years," Covered Bridge Topics, 29:2 (Fall, 1971), p. 11.

[7]Richard Sanders Allen, Covered Bridges of the Northeast, revised edition (Brattleboro, Vermont: Stephen Greene Press, 1974), p. 111.

[8]T. Allan Comp, New England: An Inventory of Historic Engineering and Industrial Sites (Washington, D.C.: National Park Service, 1974), p. 69.

[9]Frank F. Fowle, Papers on the Covered Bridges Across the Contoocook River at Hancock, NH, and Early American Timber Bridges (Concord, NH: collection of NH Historical Society, 1936), 13-14.

[10]Conservation between Floyd L. Avery, Secondary Roads Engineer, NH Department of Public Works and Highways, and Linda Wilson, June 17, 1974.

9. Major Bibliographical References

-see continuation sheet #4, item #9, page #1-

10. Geographical Data

UTM NOT VERIFIED

ACREAGE NOT VERIFIED

Acreage of nominated property less than one

Quadrangle name Peterborough, NH

Quadrangle scale 15'

UMT References

	Zone	Easting	Northing		Zone	Easting	Northing
A	18	260550	4760000	B			
C				D			
E				F			
G				H			

Verbal boundary description and justification : The nominated area consists of a rectangular parcel approximately 128' in length running East and West, and 50' in width running North and South, centered on the bridge and with sides parallel to the bridge.

List all states and counties for properties overlapping state or county boundaries

state	code	county	code
state	code	county	code

11. Form Prepared By

name/title James L. Garvin* Linda Ray Wilson

organization New Hampshire Historical Society* ----

date June 19, 1974

street & number 30 Park Street* RFD #1, Box #288A

telephone (603) 225-3381* ---

city or town Concord,* Peterborough,

state New Hampshire* New Hampshire

12. State Historic Preservation Officer Certification

The evaluated significance of this property within the state is:

___ national X state ___ local

As the designated State Historic Preservation Officer for the National Historic Preservation Act of 1966 (Public Law 89–665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the Heritage Conservation and Recreation Service.

State Historic Preservation Officer signature

title Commissioner, Dept. of Resources & Eocnomic Development NH State Historic Preservation Officer

date February 23, 1981

For HCRS use only

I hereby certify that this property is included in the National Register

date 5/5/81

Keeper of the National Register

Attest: date

Chief of Registration

GPO 938 835

FHR-8-300A
(11/78)

UNITED STATES DEPARTMENT OF THE INTERIOR
HERITAGE CONSERVATION AND RECREATION SERVICE

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DATE ENTERED MAY 5 1981

NATIONAL REGISTER OF HISTORIC PLACES INVENTORY -- NOMINATION FORM

CONTINUATION SHEET MAJOR BIBLIOGRAPHICAL #4-REFERENCES **ITEM NUMBER** 9 **PAGE** 1

Allen, Richard Sanders. Covered Bridges of the Northeast. (Brattleboro, Vermont: The Stephen Greene Press, 1957.)

Fowle, Frank F. Papers on the Covered Bridges Across the Contoocook River at Hancock, New Hampshire, and Early American Timber Bridges. (Typescript, Concord, New Hampshire: collection of New Hampshire Historical Society, 1936).

Kenyon, Thedia Cox. New Hampshire's Covered Bridges. (Sanbornton, New Hampshire: Wake-Brook House, 1957).

New Hampshire Division of Economic Development. The Covered Bridges of New Hampshire. (Concord, New Hampshire: 1973).

Roy, Dick. List of New Hampshire Covered Bridges Past and Present, Revised November, 1966. (Typescript and scrapbook, including C. Ernest Walker, The Covered Bridges of Hillsborough and Strafford Counties, New Hampshire, et al, Concord, New Hampshire: collection of New Hampshire Historical Society, 1966).

Walker, C. Ernest. Covered Bridge Ramblings in New England. (Contoocook, New Hampshire: C. Ernest Walker, 1959.)

NPS Form 10-900
1024-0018
(Rev. 10-90)

OMB No.

RECEIVED 2280

APR 29 2003

NAT. REGISTER OF HISTORIC PLACES
NATIONAL PARK SERVICE

United States Department of the Interior
National Park Service

NATIONAL REGISTER OF HISTORIC PLACES REGISTRATION FORM

This form is for use in nominating or requesting determinations for individual properties and districts. See instructions in *How to Complete the National Register of Historic Places Registration Form* (National Register Bulletin 16A). Complete each item by marking "x" in the appropriate box or by entering the information requested. If any item does not apply to the property being documented, enter "N/A" for "not applicable." For functions, architectural classification, materials, and areas of significance, enter only categories and subcategories from the instructions. Place additional entries and narrative items on continuation sheets (NPS Form 10-900a). Use a typewriter, word processor, or computer, to complete all items.

1. Name of Property

historic name Hancock-Greenfield Bridge

other names/site number County Bridge

2. Location

street & number Forest Road ("Old County Road") at Hancock-Greenfield town line, one mile east of U.S. Route 202
N/A ☐ not for publication

city or town Hancock and Greenfield N/A ☐ vicinity

state New Hampshire code 33 county Hillsborough code 011 zip code 03047/03449

3. State/Federal Agency Certification

As the designated authority under the National Historic Preservation Act of 1966, as amended, I hereby certify that this X nomination ☐ request for determination of eligibility meets the documentation standards for registering properties in the National Register of Historic Places and meets the procedural and professional requirements set forth in 36 CFR Part 60. In my opinion, the property X meets ☐ does not meet the National Register Criteria. I recommend that this property be considered significant ☐ nationally X statewide ☐ locally. (☐ See continuation sheet for additional comments.)

Linda Ray Wilson April 28, 2003
Signature of certifying official Date

NEW HAMPSHIRE
State or Federal agency and bureau

In my opinion, the property ☐ meets ☐ does not meet the National Register criteria. (☐ See continuation sheet for additional comments.)

Signature of commenting or other official Date

State or Federal agency and bureau

4. National Park Service Certification

I, hereby certify that this property is: Signature of Keeper Date of Action

☐ entered in the National Register
☐ See continuation sheet.
☐ determined eligible for the National Register
☐ See continuation sheet.
☐ determined not eligible for the National Register
☐ removed from the National Register
☑ other (explain): Additional Documentation Accepted Edson H. Beall 6/9/03

5. Classification

Ownership of Property (Check as many boxes as apply)

☐ private
☐ public-local
X public-State
☐ public-Federal

Category of Property (Check only one box)

☐ building(s)
☐ district
☐ site
X structure
☐ object

Number of Resources within Property (Do not include previously listed resources in the count)

Contributing	Noncontributing	
		buildings
		sites
		structures
		objects
		Total

Number of contributing resources previously listed in the National Register One

Name of related multiple property listing (Enter "N/A" if property is not part of a multiple property listing.)
N/A

6. Function or Use

Historic Functions (Enter categories from instructions)

Cat: Transportation Sub: road-related (vehicular)

Current Functions (Enter categories from instructions)

Cat: Transportation Sub: road-related (vehicular)

7. Description

Architectural Classification (Enter categories from instructions)

Other: Pratt through truss

Materials (Enter categories from instructions)

foundation Concrete
roof Wood: shingles
walls Wood: vertical sheathing
other N/A

Narrative Description (Describe the historic and current condition of the property on one or more continuation sheets.)

8. Statement of Significance

Applicable National Register Criteria (Mark "x" in one or more boxes for the criteria qualifying the property for National Register listing)

☐ **A** Property is associated with events that have made a significant contribution to the broad patterns of our history.

☐ **B** Property is associated with the lives of persons significant in our past.

X C Property embodies the distinctive characteristics of a type, period, or method of construction or represents the work of a master, or possesses high artistic values, or represents significant and distinguishable entity whose components lack individual distinction.

☐ **D** Property has yielded, or is likely to yield information important in prehistory history.

Criteria Considerations
(Mark "X" in all the boxes that apply.)

☐ **A** owned by a religious institution or used for religious purposes.

☐ **B** removed from its original location.

☐ **C** a birthplace or a grave.

☐ **D** a cemetery.

☐ **E** a reconstructed building, object, or structure.

☐ **F** a commemorative property.

☐ **G** less than 50 years of age or achieved significance within the past 50 years.

Areas of Significance
(Enter categories from instructions)
Engineering

Period of Significance
1937

Significant Dates
1937

Significant Person
(Complete if Criterion B is marked above)
N/A

Cultural Affiliation
N/A

Architect/Builder
Pratt, Henry B., Jr. (1910-2001)

Narrative Statement of Significance (Explain the significance of the property on one or more continuation sheets.)

9. Major Bibliographical References

Bibliography (Cite the books, articles, and other sources used in preparing this form on one or more continuation sheets.)

Previous documentation on file (NPS)

☐ preliminary determination of individual listing (36 CFR 67) has been requested.
X previously listed in the National Register
☐ previously determined eligible by the National Register
☐ designated a National Historic Landmark
☐ recorded by Historic American Buildings Survey # ______
Name of repository: ______
☐ recorded by Historic American Engineering Record # ______

Primary Location of Additional Data

X State Historic Preservation Office
☐ Other State agency
☐ Federal agency
☐ Local government
☐ University
☐ Other

10. Geographical Data

Acreage of Property less than one

UTM References (Place additional UTM references on a continuation sheet)

	Zone	Easting	Northing		Zone	Easting	Northing
1	19	260578	4759980	3			
2				4			

☐ See continuation sheet.

Verbal Boundary Description
(Describe the boundaries of the property on a continuation sheet.)

Boundary Justification (Explain why the boundaries were selected on a continuation sheet.)

11. Form Prepared By

name/title James L. Garvin, State Architectural Historian

organization New Hampshire Division of Historical Resources date 2 January 2003

street & number 19 Pillsbury Street telephone (603) 271-3483

city or town Concord state NH zip code 03302-2043

Additional Documentation

Submit the following items with the completed form:

Continuation Sheets

Maps
A **USGS map** (7.5 or 15 minute series) indicating the property's location.
A **sketch map** for historic districts and properties having large acreage or numerous resources.

Photographs
Representative **black and white photographs** of the property.

Additional items
(Check with the SHPO or FPO for any additional items)

Property Owner

(Complete this item at the request of the SHPO or FPO.)

name New Hampshire Department of Transportation

street & number 1 Hazen Drive telephone (603) 271-3734

city or town Concord state NH zip code 03302-0483

The Hancock-Greenfield Bridge was entered in the National Register of Historic Places on May 5, 1981. The present National Register nomination reflects new information and replaces the nomination of 1981. The following description is based on a study of original engineering drawings that were unavailable in 1981 and on conversations with the engineer who designed the bridge. This description replaces the former description of 1981.

The Hancock-Greenfield Bridge (N.H. bridge number 158/068; *World Guide to Covered Bridges* number 29-06-02)) is a covered timber truss bridge on Forest or Old County Road, about one mile east of U.S. Route 202. The bridge spans the Contoocook River at the town line between the towns of Hancock, New Hampshire, on the west, and Greenfield, on the east.

The Hancock-Greenfield Bridge was constructed in 1937. The engineer who designed the span was Henry B. Pratt, Jr. (1910-2001). Engineer Pratt was then an employee of the New Hampshire Highway Department, working under the supervision of Harold E. Langley.

The bridge is a single span, standing on abutments of reinforced concrete. It has a span of 84'-0" between bearings. The stream channel between the faces of the abutments has a clear opening of 81'-8."

The bridge is a six-panel Pratt truss constructed of sawn members of dense select structural grade Douglas fir. The six panels in the main trusses are each 14'-0" long. The vertical distance between the centerlines of the top and bottom chords is 19'-4." The centerlines of the main trusses are 24'-0" apart, and the bridge has a clear roadway width of 20'-0" between timber wheel guards. The total height of the portal openings above the road surface is 14'-0." The vertical clearances as posted at each end of the bridge are 13'-6" at the center and 12'-3" at the braced corners of the portals.

Depending upon the appropriate detail, truss members are connected at panel points by bolted Timber Engineering Company (TECO) split-ring timber connectors or by TECO flanged shear plates. The ends of members at the two panel points that receive maximum stresses (U^1 and U^5) are connected by steel gusset plates and bolted $2^5/_8$-inch shear plates to establish wood-to-steel connections. Other structural connections in the main trusses are made with bolted 2½-inch split-ring timber connectors that make wood-to-wood connections.

Vertical members of the main trusses are solid timbers ranging in cross-sectional dimensions from 8" by 10" to 10" by 12." Truss diagonals are composed of paired members, held apart and stiffened by wooden blocks or spacers placed at intervals along their lengths. Individual diagonal members range in dimensions from 3" by 12" to 6" by 18." Upper chords are composed of paired 6" by 12" members which, like the truss diagonals, are stiffened at intervals by wooden blocks placed between them. Bottom chords are paired 4" by 12" members, similarly separated by wooden spacers placed at intervals. All connections in the webs of the main trusses, except for those at U^1 and U^5, described above, are made with groups of bolted 2½-inch split-ring timber connectors.

The trusses are laid out to give the bridge a four-inch positive camber, measured at mid-span.

The main trusses of the bridge are rigidly connected together both below the bridge floor and at the upper ends of the vertical members by lateral trusses. The trusses below the bridge floor serve as floor supports. The trusses that connect the upper ends of vertical members serve as sway bracing at the tops of the main trusses.

The floor trusses connect the bottoms of the main trusses, running across the width of the bridge between each vertical member in the main bridge trusses, and connected solidly to these verticals by split-ring connectors. Each floor truss is a shallow Pratt truss, 3'-6" in total height, composed of paired 3" by 8" diagonals and 8" by 8" verticals, with upper and lower chords fashioned from paired 3" by 12" members. All joints of the floor trusses are fastened with 2½-inch split-ring timber connectors.

Resting on the top chords of the floor trusses, some 3'-6" apart, are a series of solid 6" by 16" stringers that run longitudinally along the length of the bridge, stiffened at intervals by diagonal bridging. These longitudinal stringers support the floor of the span. The floor is composed of a solid membrane of laminated 6" by 6" timbers that run across the width of the bridge, at right angles to the stringers, and are connected to one another by TECO toothed rings. This laminated flooring is protected against decay by a treatment of chromated zinc chloride. On top of the laminated floor membrane is a wearing surface that was originally composed of one-inch-thick asphaltic planking, running longitudinally through the bridge. As defined by the 1935 edition of the *New Hampshire Highway Department Standard Specifications for Road and Bridge Construction*, asphaltic planking was a rigid, extruded paving material composed of organic or vegetable fiber, mineral filler (usually crushed slate or limestone), and up to 50% asphalt cement. When laid over a wooden floor, as in this bridge, asphaltic planking was laid in a bed of mopped hot asphalt cement, tamped or rolled to establish a bond, and nailed to the underlying wood. The bridge floor has since been covered with a pavement of asphalt-bound macadam.

The bottom of the bridge is strengthened against wind loads by 4" by 8" lateral cross braces that are attached to the tops of the lower chords and run diagonally across the bridge under the floor. Design of the bridge took into consideration the very considerable wind loads from the solidly sheathed walls and the expansive roof surfaces.

The main trusses of the bridge are also connected solidly to one another at their tops. At each panel point is a timber Warren upper lateral truss, fabricated with 2½-inch split-ring connectors and having a total height of about three feet. The bottom chords of these upper lateral trusses are connected to the vertical members of the main bridge trusses by welded steel knee braces. The braces are fabricated with curved profiles and are covered with a casing of wooden sheathing. The portals of the bridge are given added rigidity by the merger of the Warren upper lateral trusses with diagonal wooden lacing that continues down each side of each portal, again braced at the upper corners by welded steel knee braces.

Together, the upper lateral trusses and the knee braces impart extreme rigidity to the bridge. The upper portion of the bridge is further braced against wind loads by 3" by 8" upper lateral cross braces that run diagonally across the bridge from the tops of the upper chords. A steel rod attached to the ridgepole supports the midpoints of these diagonal members where they intersect at the center of the bridge.

The gable roof of the bridge is supported by simple triangular trusses that rise from the top chord of each upper lateral Warren truss. Diagonal struts rise from points four feet on each side of the centerline of the bridge to support a heavy timber ridgepole, while other diagonals support a purlin that runs longitudinally at the midpoint of each roof slope. The ridgepole and purlins, in turn, support a series of common rafters, placed about 1'-10" on centers. The rafters are covered with spruce sheathing. Long covered with asphalt shingles, the bridge was roofed with wooden shingles in September 1981.

The side walls and portals of the bridge are covered solidly with vertical sheathing boards of matched Douglas fir, attached to horizontal nailers that are affixed to the outer faces of the main trusses. Inside the bridge, vertical sheathing extends back about five feet from each portal opening to protect the ends of the trusses. A band of matched boarding, applied horizontally and painted white for nighttime visibility, extends three feet above the floor of the bridge to protect the lower zone of the main trusses from dirt and moisture.

The Hancock-Greenfield Bridge was entered in the National Register of Historic Places on May 5, 1981. The present National Register nomination reflects new information and replaces the nomination of 1981. The following statement of significance is based on a study of original engineering drawings that were unavailable in 1981, on conversations with the engineer who designed the bridge, and on further research on the introduction of timber connector technology during the 1930s. This Statement of Significance replaces the former statement of 1981.

The Hancock-Greenfield Bridge is significant under National Register Criterion C, in the category of engineering, as the first permanent highway span in the northeastern United States to utilize modern timber connectors as a means of adapting the wooden truss to the needs of twentieth-century secondary road transportation. The bridge was designed in 1936 in response to the request of local residents who asked for a new covered bridge to replace a predecessor that had been lost in catastrophic floods. This pioneering example of bridge construction preceded three similar highway spans that were built in the neighboring state of Massachusetts between the early 1950s and the early 1960s, and another constructed by the National Park Service in Ohio in 1986. The Hancock-Greenfield Bridge retains integrity of location, design, setting, materials, workmanship, feeling, and association for 1937, the date of construction. The only visible change to the bridge since 1937 has been the replacement of original asphalt roofing shingles with wooden shingles in 1981.

Engineering: On March 12, 1936, four days of rain and warm weather freed a heavy blanket of snow and ice that covered northern New England. First to flood were smaller streams that served as tributaries to the region's major rivers. Over the following six days, the rising waters of these tributaries caused great damage. The devastation along their banks was followed by the rapid rise of the region's bigger rivers, including the Connecticut, Androscoggin, and Merrimack. In New Hampshire, the floods of 1936 were the worst ever recorded, filling valleys not only with unprecedented volumes of water but also with thick ice floes that destroyed everything they hit.[1] Among the wooden bridges damaged beyond repair by the floods of 1936 was the "County Bridge" of 1852, spanning the Contoocook River between the towns of Hancock and Greenfield, New Hampshire.

Heavily hurt by the flooding, the State of New Hampshire authorized a $2 million state bond issue to supplement federal funding. New Hampshire's response to the floods was, however, heavily conditioned by several New Deal programs that provided unprecedented amounts of federal funding for highway and bridge improvements. Among these was the National Industrial Recovery Act of 1933, which provided funding for secondary and feeder roads without a requirement for matching funds. The Hayden-Cartwright Act of 1934 provided further funding for highway projects, with the requirement that at least 25% of its funds be expended on secondary roads. Collectively, these laws provided for greatly increased federal and state oversight of road and bridge construction. Title II of the National Industrial Recovery Act, for example, required that "all plans must be submitted to and approved by the [federal] Bureau of Public Roads before construction can commence and all work [shall be] carried out under State and [federal] Government supervision." Contract drawings for WPA-funded bridge replacements bear the project symbol "WPFR," meaning "Works Progress Flood Replacement." The Hancock-Greenfield bridge project number was WPFR No. 15.[2]

The New Hampshire Highway Department initially proposed to replace the "County Bridge," between Hancock and Greenfield, with a concrete span. Sentimental attachment to the old bridge of 1852, however, impelled local residents to petition the state agency for a timber replacement bridge that would resemble the lost span. The highway department acquiesced after gaining approval for the novel idea from the federal Bureau of Public Roads, which had authority over all flood replacement designs. In the summer of 1937, Waldo G. Bowman, associate editor of *Engineering News-Record*, gave national notice to the project when he announced that

> Plans are under way to replace an old covered timber bridge, using steel dowel connectors instead of wooden pegs or iron bolts at the joints, and a truss type whose stresses are determinable in contrast to those in the multiple-intersection [Town lattice] trusses of our forefathers. The bridge will cost as much as a steel or concrete bridge, but it is worth even more to the New Hampshire people who live near it.[3]

In responding to local sentiment, the New Hampshire Highway Department assigned twenty-six-year-old engineer Henry B. Pratt, Jr. (1910-2001), of Antrim to design the bridge under the supervision of Harold E. Langley. Langley then bore the title of Assistant Bridge Engineer in the department, but was a highly experienced designer who, in fact, superintended virtually all bridge design in the agency.

To achieve a timber design that met Bureau of Public Roads approval, engineer Henry B. Pratt, Jr., employed a Pratt truss design that that lent itself to the kind of structural analysis that would have been applied to a steel truss of similar design. He utilized a new technology that permitted the panel points of the truss to resist stresses comparable to those in a riveted metal truss.

The Hancock-Greenfield Bridge was designed in accordance with federal Bureau of Public Roads (BPR) standard specifications of May 1, 1935, and with American Association of State Highway Officials (AASHO) and New Hampshire Highway Department standard specifications of 1935.[4] Engineer Pratt utilized design stresses for live and dead loads in the truss members of the bridge that were comparable to stresses that would have been computed for a steel Pratt truss of the same span, allowing for the difference in the dead weight of the wooden structure. The bridge was designed for H-10 loading, which calls for each of the two travel lanes of the bridge to support a total load of a uniform weight of 300 pounds per linear foot, and a single concentrated load of 14,000 pounds.[5]

One major difference between the design of the enclosed Hancock-Greenfield Bridge and an open steel Pratt truss is the need to accommodate the considerable wind loading that affects a covered bridge. Pratt's calculations considered wind pressures on the tightly-boarded side walls of the bridge, and on its roof planes.[6] Less than a year after it was completed, the bridge passed unscathed through the hurricane of 1938, the most powerful tropical storm yet recorded in New England.

The Hancock-Greenfield Bridge was enabled to accommodate standard H-10 design loading through the use of steel timber connectors. These devices distributed the considerable shear stresses at the panel points of the bridge over much wider surfaces of the wooden truss members than would have been the case with doweled or bolted joints. This distribution of stresses over wide areas of wood permitted the joints to resist the same stresses that would have been encountered in a steel bridge of similar span and design.

Central European and Scandinavian scientists had developed some sixty types of timber connectors before the 1930s. The American forest products industry began to study a number of these devices for introduction into the United States during the early 1930s. The U.S. Forest Products Laboratory at Madison, Wisconsin, undertook an extensive series of tests on these many devices, eventually selecting seven or eight as particularly promising for use in the United States.[7] In 1933, the U.S. National Committee on Wood Utilization issued an influential report on timber connectors, *Modern Connectors for Timber Construction*, written by its own engineers and by an engineer employed by the Forest Products Laboratory of the U.S. Department of Agriculture.[8] Attaining widespread popular attention, this report stimulated new interest among American engineers in the potential of wood as a structural material. Several standard models of timber connectors first became commercially available in the United States in 1933.[9]

An article in *Scientific American* in 1933 described the advantages of timber connectors over traditional bolted connections for wooden members:

> With their larger circumferences, the connectors take an increased load and distribute it over a larger area of the timbers, thus avoiding the undistributed high unit "edge stresses" frequently experienced under bolted connections where the small diameter bolt plays against a localized area of the timber face, crushing the timber at this point, and, together with bent bolts, accounting for slip and consequent sag in structures. On the most conservative laboratory data, the load-

> bearing capacity of the new joint is increased from four to eight times—and in certain cases as high as twelve times—that of the ordinary bolted joint.[10]

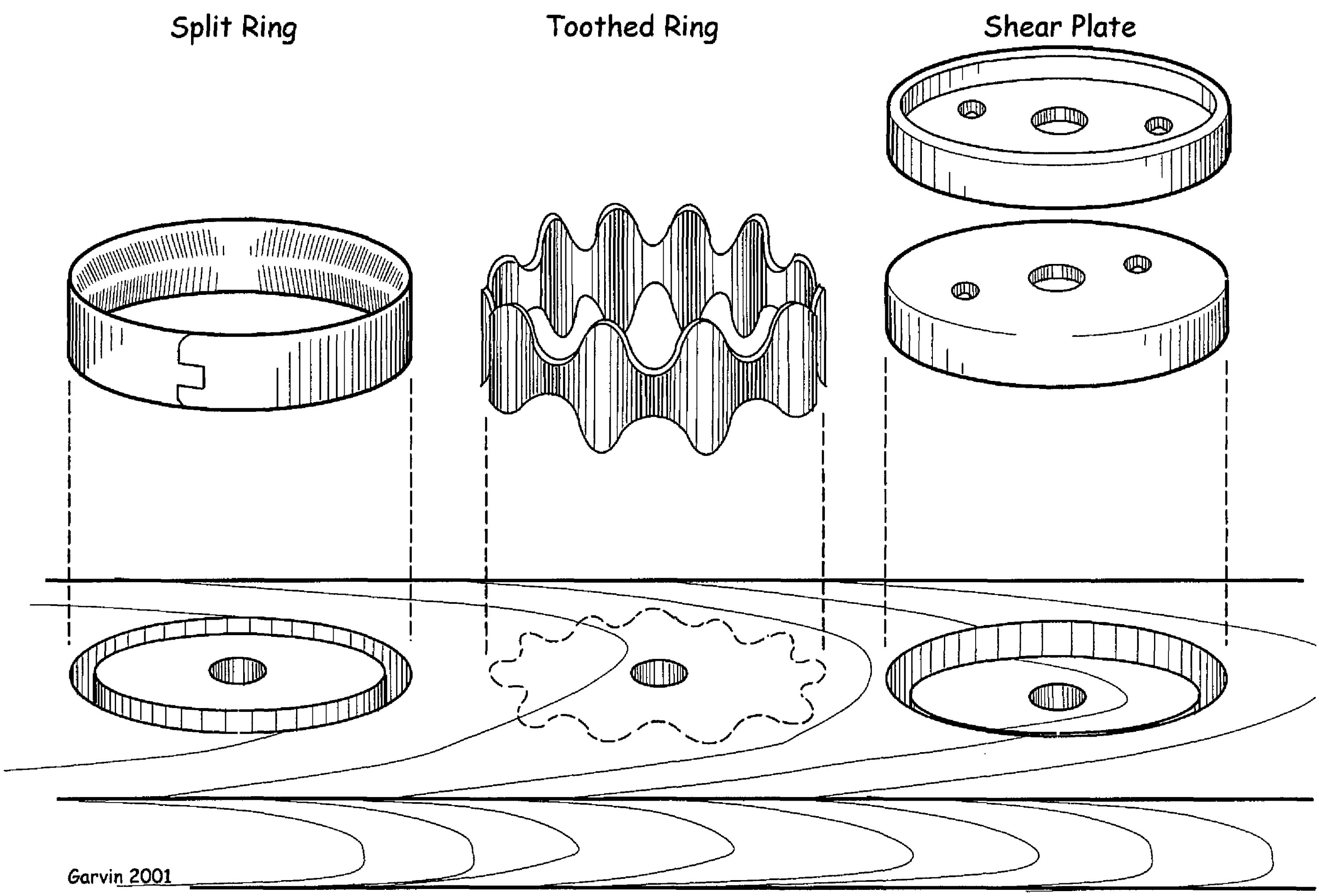
The Hancock-Greenfield Bridge was the first permanent highway span in the northeastern United States to use timber connectors to permit wooden trusses to achieve a performance comparable to that of the steel truss.[11] The bridge employs the three types of timber connectors that had become the most commonly used by the mid-1930s. All three types were manufactured by the Timber Engineering Company (TECO) of Washington, D.C., a subsidiary of the National Lumber Manufacturers' Association. In 1934, TECO acquired the patent rights to a number of timber connectors for the purpose of distributing them on a commercial basis.[12] In 1935, TECO issued its own *Manual of Timber Connector Construction* to provide engineers and contractors with authoritative data on the use and performance of connectors. This manual stated that

> Timber connectors now make it possible in most cases to develop the full allowable loads of the members connected; in fact, it is possible under some circumstances to make the joints stronger than the members themselves. These improved connections enable a pound of good structural timber to do in general the same work that is to be expected from a pound of steel. The greatly increased strength secured at crucial points is of such prime engineering importance as frequently to change both the methods of design and [the] cost aspects of many structural types. Timber can now be used economically for types of structures for which it has not formerly been considered, and timber structures can now be designed for wider spans and heavier loads than before.[13]

The most commonly used timber connector in the Hancock-Greenfield Bridge is the 2½-inch split-ring connector. Used for wood-to-wood connections, the split-ring is a steel ring that is placed in annular grooves or daps cut into the faces of adjoining timbers through the use of a power-driven grooving tool that simultaneously bores a central bolt hole and cuts the annular groove for the ring. The ring is broken by a tongue-and-groove "split" in its circumference. The break in the ring permits the steel to adjust itself slightly as its central bolt is tightened and to develop a full bearing against the core left by the grooving tool and the outer wall of the groove. To ensure full bearing, the grooving tool is designed to cut a core of wood inside the ring that is a bit larger than the diameter of the ring, so that the split in the ring opens slightly when the joint is bolted. Its capacity to adjust itself to a full bearing under the pressure of the bolt allows the split-ring connector developed a higher efficiency than any other type of fastening.[14] A total of 5,020 split-ring connectors were employed in the main truss connections of the Hancock-Greenfield bridge.[15]

The second most commonly-used connector in the bridge is the 2⁵⁄₈-inch toothed ring. Toothed rings are unbroken circles of thin steel having undulating sharpened edges that bite into the faces

Timber Engineering Company (TECO) Timber Connectors



of adjoining timbers under the pressure of tightening or impact. Requiring no pre-cut daps, toothed rings are usually embedded in the faces of the timbers by the careful tightening of nuts on a threaded rod of high-strength steel. After the adjoining timbers are pulled together and the rings are seated, the threaded rods are withdrawn and ordinary bolts are inserted in the bolt holes. In cases where toothed rings cannot be pressed into adjoining members by tightening nuts on rods or bolts, the TECO *Manual of Timber Connector Construction* of 1935 recommended driving the rings unto the wood, protecting them against damage with a special recessed "follower."[16] Toothed rings were used to fasten the laminated 6" by 6" floor timbers in the Hancock-Greenfield Bridge. Because adjoining timbers are not bolted together, the rings between them could not be seated by the usual method of tightening nuts on a threaded rod or bolt. These toothed connectors were therefore embedded in the floor timbers by blows from a maul. A total of 3060 toothed ring connectors were used in the span.[17]

The third type of connector employed in the bridge is the $2^5/_8$-inch steel shear plate, a fastener that is used for wood-to-steel connections. Shear plates are steel or malleable cast iron disks with central bolt holes and flanged edges on one side of the disk. The flanges of the shear plates fit into pre-cut annular rings or daps in the wooden member, as with split-ring connectors. The annular rings lie at the circumference of shallow circular recesses that are cut into the face of the timber, allowing the flat faces of the plates to lie flush with the surface of the wood. Bolts inserted through the central holes in the shear plates clamp the plates tightly against steel gusset plates. The bolts transfer shear stresses from the timbers to the steel gusset plates. As noted under "Description," steel gusset plates were employed in the Hancock-Greenfield trusses at panel points U^1 and U^5, which receive the maximum stresses in the trusses. A total of 584 shear plates were used to connect wooden truss members to the steel gusset plates at the four key panel points in the two trusses.[18]

Completion of the new Hancock-Greenfield Bridge in the autumn of 1937 caused much interest and gratified local residents who had wanted a new covered bridge to replace the old span. A newspaper article datelined October 3, 1937, shortly before the official opening of the bridge, called the span "the first covered bridge that has been built in New Hampshire in about eighty years." The article noted "difficulties in getting the federal government to give its approval to a project of this kind," which had delayed the completion of the project.

Among the delays in completing the design of the span were changes ordered by the federal Bureau of Public Roads. After engineer Henry B. Pratt, Jr., completed the initial drawings under the supervision of Assistant Bridge Engineer Harold Langley, Bureau of Public Roads plan checkers required certain changes to the bridge's design. Although the bridge had been designed according to the best judgment of the New Hampshire Highway Department, BPR authorities insisted that the design be brought into complete conformity with TECO's *Manual of Timber*

Connector Construction. They required changes to the design of compression members and to the bolt sizes used with the split-ring timber connectors.[19]

The Hancock-Greenfield Bridge was a pioneering structure. It was designed only three years after the commercial introduction of the timber connector in the United States, three years after publication of *Modern Connectors for Timber Construction* (the first significant American publication on timber connectors), and just one year after publication of Timber Engineering Company's *Manual of Timber Connector Construction.* The bridge attained national recognition when a photograph of the new span was published in the *Engineering News-Record* on January 13, 1938.[20] A number of other highway spans of varying types were built with TECO connectors prior to American involvement in World War II, and many others during the war.[21]

The idea of using timber connectors to build covered wooden bridges capable of sustaining normal highway loads, first employed by the New Hampshire Highway Department in 1936, was revived in Massachusetts after the war. In 1950, the board of selectmen of Charlemont, Massachusetts, petitioned the Massachusetts Department of Public Works and Highways for a new covered bridge to replace the old Bissell Bridge, which was in dangerous condition. The result was the new Bissell Bridge, a ninety-two-foot span built with timber connectors[22]. The new Bissell Bridge was followed in 1952 by the Lower Sheffield Bridge, a massive 135-foot covered bridge (demolished in the 1980s) that also used timber connectors.[23] A third Massachusetts covered bridge employing timber connectors was built in Pepperell in 1964.[24] Another covered highway bridge using TECO timber connectors was built by the National Park Service in Cuyahoga Valley, Ohio, in 1986.[25]

At least two private covered bridges have been built using TECO timber connectors: a 150-foot pedestrian bridge at the Sheraton Wayfarer Inn in Bedford, New Hampshire (1963); and the 140-foot Lake of the Woods Bridge in Mahomet, Illinois (1965).[26]

The Hancock-Greenfield Bridge represents a pioneering use of a new timber technology. Although the bridge was designed to resemble a nineteenth-century span, the structure introduced an advanced technology that greatly enhanced the usefulness of wood as a structural material in an age otherwise dominated by concrete and steel structures. The bridge represents the earliest known use of timber connectors for a highway span in the northeastern United States.

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[1] Lew A. Cummings, *Flood Waters, New Hampshire, 1936: A Permanent Photographic History of New Hampshire's Greatest Disaster.* (Manchester, N.H.: John W. Cummings, 1976).
[2] Waldo G. Bowman, "Bridge Building Follows Flood," *Engineering News-Record,* July 8, 1937: 53-58.
[3] Waldo G. Bowman, "Bridgebuilding Down East," *Engineering News-Record,* July 22, 1937: 149.
[4] Construction drawings, Hancock-Greenfield Bridge (WPFR No. 15; WPA No. 6-1-10058), 15 sheets, 1936-7 (New Hampshire Department of Transportation), sheets 1 and 10.

[5] Wilson G. Harger and Edmund A. Bonney, *Handbook for Highway Engineers* (New York: McGraw-Hill Book Company, 1927), pp. 200-201.
[6] Interview with Henry B. Pratt, Jr., April 23, 2000.
[7] "Connectors Cut Woodbuilding Cost," *Popular Science Monthly*, October 1933, p. 44; comments by Peter T. Landsem on Robert Fletcher and J. P. Snow, "A History of the Development of Wooden Bridges," *Proceedings* of the American Society of Civil Engineers, November 1932.
[8] U.S. National Committee on Wood Utilization, *Modern Connectors for Timber Construction*. Report #24, prepared jointly by Nelson S. Perkins, construction engineer, and Peter Landsem, assistant construction engineer, National Committee on Wood Utilization, U.S. Department of Commerce, and by George W. Trayer, senior engineer, Forest Products Laboratory, Forest Service, U.S. Department of Agriculture. Washington, D.C.: U.S. Government Printing Office, 1933.
[9] Timber Engineering Company, Manual of Timber Connector Construction (Washington, D.C., 1935), p. 19.
[10] "Modern Connectors for Timber Joints," *Scientific American* 149 (1933):36.
[11] The New Hampshire Highway Department built a temporary pedestrian suspension bridge in Manchester, N.H., at the same time, using timber connectors in the construction of the bridge's two wooden towers. This temporary bridge utilized 1½-inch steel cables salvaged from a highway suspension bridge over the Connecticut River between Chesterfield, N.H., and Brattleboro, Vermont. The temporary span was dismantled upon completion of the Notre Dame Bridge in December 1937. Waldo G. Bowman, "Bridge Engineer's Odyssey," *Engineering News-Record*, July 15, 1937: 106; Bowman, "Bridgebuilding Down East," *Engineering News-Record*, July 22, 1937: 149-50.
[12] Howard J. Hansen, *Modern Timber Design* (New York: John Wiley and Sons, 1943), pp. 36-37.
[13] Timber Engineering Company, *Manual of Timber Connector Construction* (Washington, D.C., 1935), p. 1; this publication was later reissued as *Design Manual for TECO Timber Connector Construction*, 1943, 1950, 1955, 1956, etc.
[14] Timber Engineering Company, *Timber Design and Construction Handbook* (New York: F. W. Dodge Corporation, 1956), p. 63.
[15] Construction drawings, Hancock-Greenfield Bridge (WPFR No. 15; WPA No. 6-1-10058), 15 sheets, 1936-7 (New Hampshire Department of Transportation), sheet 10.
[16] Timber Engineering Company, *Manual of Timber Connector Construction* (Washington, D.C., 1935), p. 7.
[17] Construction drawings, Hancock-Greenfield Bridge (WPFR No. 15; WPA No. 6-1-10058), 15 sheets, 1936-7 (New Hampshire Department of Transportation), sheet 10.
[18] Ibid.
[19] Interview with Henry B. Pratt, Jr., April 23, 2000.
[20] "Bridges of Today," *Engineering News-Record*, January 18, 1938, p. 62.
[21] *Civil Engineering* 2, no. 9 (September 1932): 549; *Modern Timber Highway Bridges Designed with TECO Joint Connections* (Washington, D.C.: Timber Engineering Company, 1940); *The Forest Fights* (Washington, D.C.: Timber Engineering Company, 1942); *Fabricating TECO Timber Connector Structures* (Washington, D.C.: Timber Engineering Company, 1943).
[22] National Society for the Preservation of Covered Bridges, Inc., *Covered Bridge Topics*, September 1950; September 1951; July 1972; Cara T. Welch, National Register nomination for the Bissell Bridge, Charlemont, Massachusetts, June 22, 2001.
[23] Richard Sanders Allen, *Covered Bridges of the Northeast*, rev. ed. (Brattleboro, Vt.: Stephen Greene Press, 1974), pp. 69-72; National Society for the Preservation of Covered Bridges, Inc., *Covered Bridge Topics*, Fall 1952.
[24] National Society for the Preservation of Covered Bridges, Inc., *Covered Bridge Topics* 21 (January 1964):1.
[25] National Park Service, *CRM Bulletin* 10 (June 1987):1-3.
[26] Ray Wilson, "The TECO Truss," National Society for the Preservation of Covered Bridges, Inc., *Covered Bridge Topics* 29 (January 1972):8. The Lake of the Woods Bridge employs TECO split-ring connectors, but depends on steel girders to support its traffic loads, walls, and roof (*Covered Bridge Topics* 30 [July 1972]:3).

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-----. *The Forest Fights*. Washington, D.C., Timber Engineering Company, 1942.

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Wilson, Ray. "The TECO Truss," *Covered Bridge Topics* 29 (January 1972): 8.

Verbal Boundary Description:

The boundaries of the nominated property extend to the full width of the state-owned right-of-way of Forest or Old County Road at the Contoocook River, and to the length of the Hancock-Greenfield Bridge and its abutments on both sides of the Contoocook River in the towns of Hancock and Greenfield, New Hampshire.

Boundary Justification:

These boundaries encompass the wooden span and the concrete abutments and wing walls of the Hancock-Greenfield Bridge. The boundaries include the entire structure built by the State of New Hampshire in 1936-7.

PHOTOGRAPH LABELS

The following pertains to all 4 views:

1.) Hancock-Greenfield Bridge
2.) Hancock & Greenfield (Hillsborough County) NH
3.) Photographer: James L. Garvin
4.) Photographs taken November 2002
5.) Negatives at: NH Div. of Historical Resources, Concord NH

Photo #1:
south elevation, looking northeast

Photo #2:
south elevation and west portal, looking northeast

Photo #3:
north elevation and west portal, looking southeast

Photo #4:
interior view, looking northeast

SKETCH MAP — HANCOCK-GREENFIELD BRIDGE
(NOT TO SCALE)