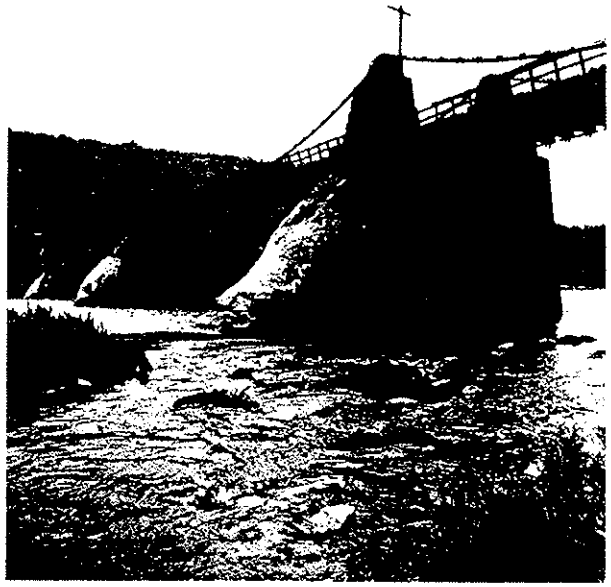

FIGURES 51 and 52.—The contrasting massiveness of masonry piers and lightness of wire cables, so much the measure of the suspension bridge and so often extolled by poet and painter in the Brooklyn Bridge, is as fully marked at the aqueduct.

FIGURES 53.—Essex-Merrimack Bridge near Newburyport, Massachusetts, before and after. In the 1909 "rebuilding" of the 1810 structure, the entire superstructure was replaced with a loose replica, leaving of the original fabric only the pier masonry below deck level. (From Engineering News (25 September 1913), volume 70, page 585.)

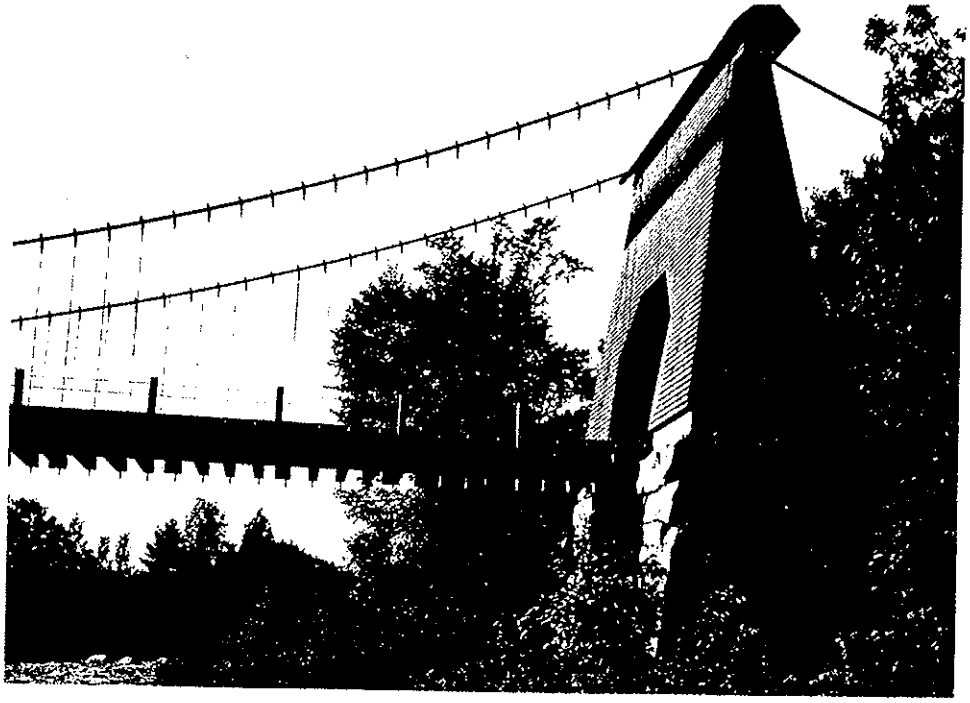

FIGURE 54.—The "Wire Bridge," New Portland, Maine. While having undergone some rebuilding, the bridge is original in its principal elements and is a rare survival of an early suspension structure. (Photograph by David Plowden.)

LUMBER

WANTED, on THE DEL. & HUDSON CANAL.

PROPOSITIONS

Will be received until the 10th day of March next, for furnishing and delivering the following bill of Lumber, viz:

890	Pieces, 16 by 6 1-2 inches,—24 feet long,	104,910	feet Board Measure,	1,600	feet Linial Measure, 6 by 6 inches, for Railing,	1,600	feet Board Measure.
400	do. 14 by 7 inches at one end, 7 by 7 at the other,—16 ft. long.	89,300	do.	1,400	do. 6 by 7, any length over 20 feet,	1,900	do.
200	do. 7 by 18,—20 feet long,	80,400	do.	1,400	do. 5 by 5, do.	1,450	do.
800	do. 2 1-2 by 10,—10 feet long,	16,800	do.	Plank, 25 or 26 feet long, 2 1-2 inches *uniformly* thick,		76,680	do.
800	do. 2 by 10,—7 feet 8 inches long,	10,200	do.	Plank, 14 feet 4 inches long, 2 1-2 inches *uniformly* thick,		76,680	do.
400	do. 7 by 7,—12 feet long,	19,600	do.	Joice, 2 in. by 10, or 2 inches by 12, either 16, 20, or 24 ft. long,		22,400	do.
400	do. 6 by 7,—6 feet 8 inches long,	6,800	do.	Joice, 1 1-2 by 10 inches, 16 or 24 feet long,		19,200	do.
	1,600 feet Linial Measure, 7 by 7 inches, for Railing,	6,533	do.		Total Board Measure of Pine,	442,553	feet.

All the above bill to be of good sound White Pine, and work full size, free of shakes, rents or black knots, when counter-hewed, and delivered on the Pennsylvania side of the Delaware river above high water mark, between the mouth of the Lackawaxen and Delaware Dam (for Del. and Hud. Canal) by or before the first day of July next. Payment will be made when the Lumber is delivered on the bank as above stated, and approved and accepted to the satisfaction of the Engineer on Delaware and Hudson Canal for the time being. Proposals are desired to be in writing, stating the price per one thousand feet board measure, and directed to the subscriber, at the office of the Delaware and Hudson Canal Company, in Honesdale, Wayne county, Pa. For any information relating to the above bill of Lumber, apply to the Engineers or Superintendents on Delaware and Hudson Canal.

JOHN A. ROEBLING, *Engineer.*

February 23d, 1847.

FIGURE 55.—Invitation to supply lumber for the Delaware and Lackawaxen aqueducts. (Courtesy of Rensselaer Polytechnic Institute.)

Appendixes

I

Summary of Delaware & Hudson Canal Improvements

(From Whitford, Volume 1, page 1467)

Year of Completion	*Width at top (feet)*	*Width at bottom (feet)*	*Depth (feet)*
1829 (as first built)	28	20	4
1844	44	26	5
1852	48	30	6
1875	48	32	6

II

Comparative Data on the Four Delaware & Hudson Aqueducts*

	Delaware	*Lackawaxen*	*High Falls*	*Neversink*
Number of spans	4	2	1	1
Center-to-center span length (feet)	(see page 17)	114.37	145	170
Number of cables	2	2	2	2
Diameter of cables (inches)	8½	7+	8½+	9½
Total number of wires in each cable (see page 15)	2150	1624	2300	2880
Weight of cable per foot (pounds)	122.75	90	125.7	170
Weight of water in one span at 6′–6″ depth (tons)	489 (142-foot span)	424	538	632
Working tension on both cables (tons)	771	552	790	998
Ultimate tensile strength of both cables (tons)	3870	2900	4100	5200
Roebling's contract price	$41,750.	$18,650.	$20,400.	$24,900.
Cost per foot of suspended trunk (see page 10)	$78.00	$82.00	$141.00**	$146.00**

*Mostly from *Notes* (326), various pages.

**The per-foot cost of Neversink was greater because of the larger cables and anchorage ironwork, a function of the higher price normally paid for a longer than for a shorter span.

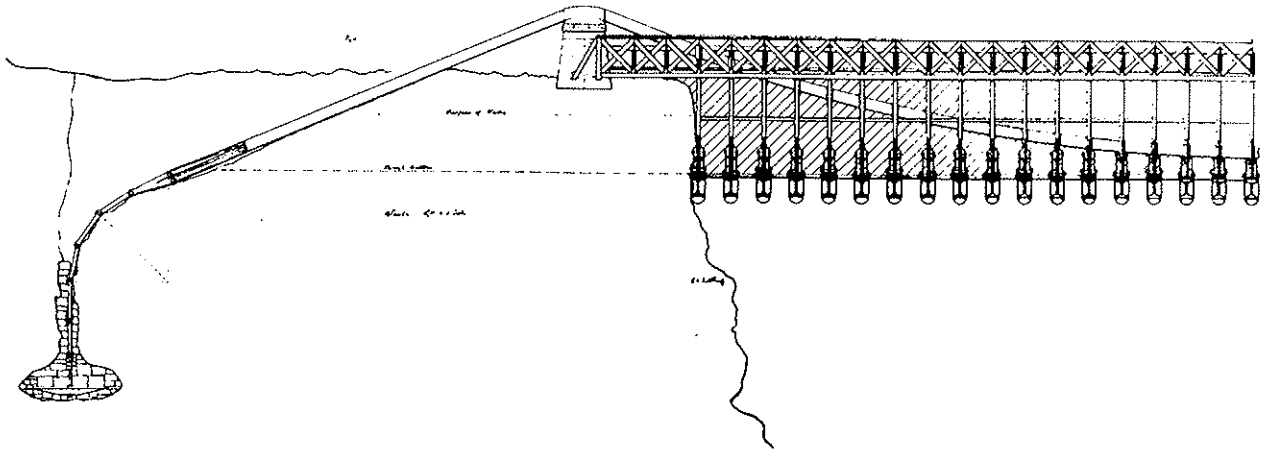

FIGURE 56.—Suspension aqueduct design by Washington A. Roebling. See Appendix III.

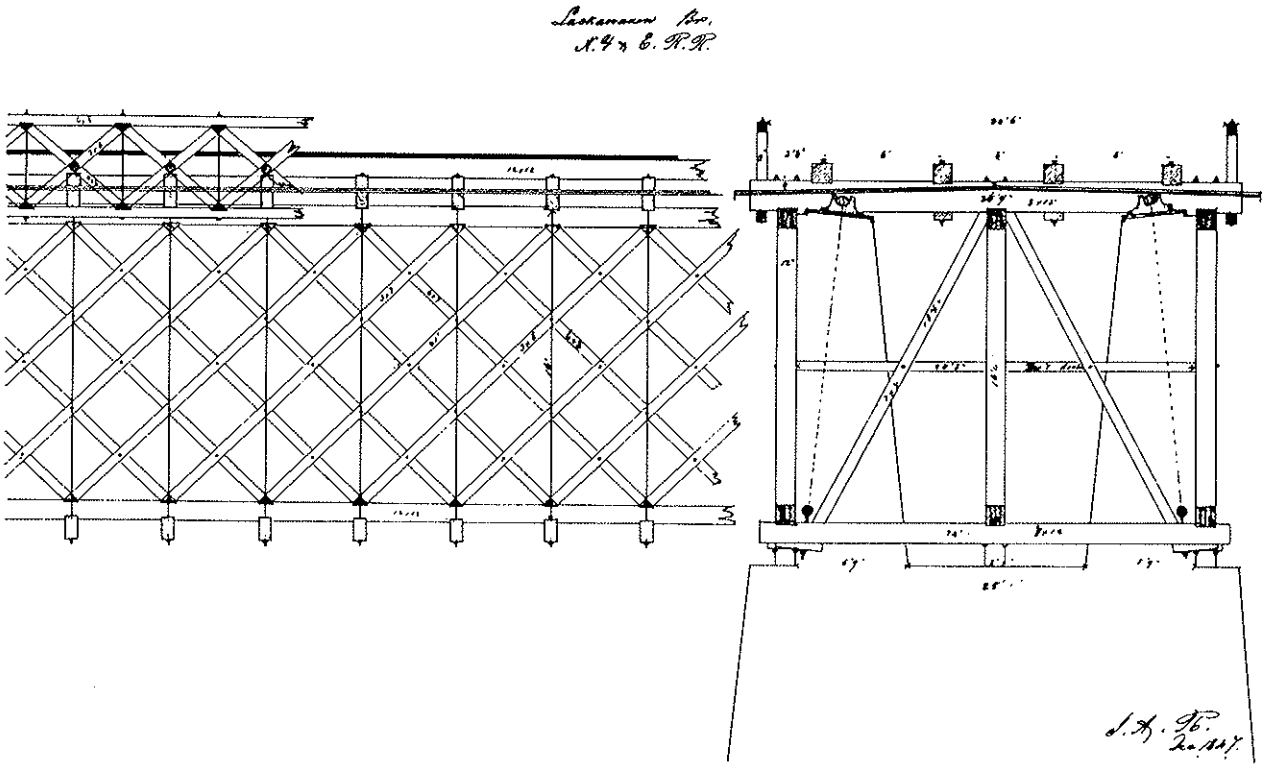

FIGURE 57.—Proposal for the New York and Erie Railroad suspension bridge at Lackawaxen. See Appendix IV.

III

Design for a Suspension Aqueduct

This design for a suspension aqueduct is from the senior thesis of Washington A. Roebling (1837-1926), class of 1857, Rensselaer Polytechnic Institute. While his design admittedly follows closely those of his father's Delaware & Hudson aqueducts, Washington Roebling proposed a number of modifications, necessitated principally by the greater loads imposed by a 164-foot span, 40-foot trunk width, and 7-foot water depth. The width, the same as that of the aqueducts on the enlarged Erie Canal, would pass two large boats abreast. The changes were mainly quantitative—use of two 14½-inch cables on each side of the trunk with other elements proportionately heavy—but the design also specified built-up wrought-iron plate girders for the floor beams and wire-rope suspenders, both significant departures from the Delaware & Hudson aqueducts. (Courtesy Rensselaer Polytechnic Institute.)

IV

Proposed Railway Suspension Bridge

This proposed suspension bridge was designed to carry the New York and Erie Railroad over the Lackawaxen River near the aqueduct site. Designed by Roebling while building the two aqueducts at Lackawaxen, it had many characteristics in common, particularly in the cable and anchorage systems. The deep, lattice-truss-stiffened deck closely forecast that used in his Niagara railroad bridge begun four years later. The estimated cost for the bridge, with two spans of 195 feet each, was $11,040 for a single-track structure and $22,080 for a double. (*Suspension Bridges Dec 1847 John A. Roebling*, page 27.) (Courtesy Rensselaer Polytechnic Institute.)

V

Neversink Aqueduct

Comparison of Roebling's Proposals for a 1- and a 2-span Structure*

	1 span	*2 span*	*1 span as built***
Clear span length (feet)	170	2 @90	160
Cable diameter (inches)	9½	6¾	9½
Cable length (feet)	261***	266***	203
Cable weight, both, with wrapping (tons)	46.5	23	36
Cable cost @ 10 cents per pound	$9,200	$4,600	$7,490
Anchor chain weight, total (tons)	13	4.5	22
Total cost	$24,900	$18,000	24,900

**Suspension Aquaducts . . . Febr. 1847.* Data, about November 1847.
***Never Sink Aquaduct . . . Oct. 1848.*
***The early plans proposed running the cables on the west shore through chases in solid rock directly to the anchor plates, as had been proposed for the High Falls Aqueduct, without intervening anchor chains. Distance, saddle to plate, 62 feet.

VI

The Delaware Aqueduct Saddles

(See Figure 47)

Not all of the modifications to the Pittsburgh Aqueduct design made at Lackawaxen were for the better. In *Wire Cables & Machinery . . . August 1848,* Roebling observes that the saddle pattern employed in the first two Delaware & Hudson aqueducts is unsatisfactory in having the seat for the cables too wide. At Pittsburgh, the space was just about as wide as the cable diameter so that the cable's circular section was preserved as it passed through the saddles. At Lackawaxen, he used a width of 11 inches causing the 8½-inch cables to flatten considerably at that point, destroying the roundness of the strands and cables near the saddles and causing unequal tension in the individual wires (see also Figure 22). Despite these misgivings, the saddles of the two later aqueducts apparently were cast from the same patterns for the same widening and flattening is evident at High Falls (Figures 35 and 36).

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Two bodies of Roebling manuscript papers exist: The Roebling Collections in the Library of Rensselaer Polytechnic Institute, Troy, New York, and in the Special Collections of the Library of Rutgers University, New Brunswick, New Jersey. The former is a collection of vast scope and immense value, covering all of John A. and much of Washington A. Roebling's professional careers. There are many notebooks, letters, and reports, but the collection's crowning glory is a large number of drawings and sketches—design, presentation, study, and working. The entire collection was recently classified and cataloged by the author with a grant from the American Society of Civil Engineers. A published version is anticipated. The Rutgers Collection, while smaller, contains some material of great technical interest as well as personal items in the form of letters, diaries, and other documents. There is little graphic material. The collection is readily accessible and well cataloged. Oddly, the technical material in both collections overlaps to a considerable extent, the result apparently of haphazard handling and storage while the material was passing through various family hands.

The first nine references below are all manuscript notebooks. The first four are from the Rensselaer Polytechnic Institute Collection; the next five from the Rutgers. Various other Rensselaer Polytechnic Institute letters, notes and drawings are cited individually, for which the Library catalog number is given.

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