A TEXT-BOOK

ON

ROOFS AND BRIDGES

PART I

STRESSES IN SIMPLE TRUSSES

BY

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The computation of stresses for given loads is readily effected by the application of the principles of the preceding chapters. When stresses are required for locomotive axle loads the equivalent uniform load may be found by Art. 47 or the computation may be directly made, the load being placed in proper position for a chord member by the aid of formula (1) in Art. 45, and for a web member by that of Art. 69. The following problem specifies live panel loads, which would be allowable for a highway bridge. The stresses for the lower chords in this case are +90.0, +130.1, +150.4, +159.4 kips, and those for the upper chords are −118.4, −152.2, −162.2, −159.4 kips; if the dead panel load be 18 kips, all on the lower chord, the dead load stresses are one-half of these values.

Prob. 70. In Fig. 70 *b* the panel length is 20 feet, the distance *AH* is 112 feet, the horizontal distances of the panel points *A*, *B*, *C* and *D* from *a* are 14.00, 29.66, 45.77 and 62.17 feet, while their heights above the lower chord are 16.80, 21.95, 25.39 and 27.10 feet. Compute the live load stresses in *BC*, *bc*, *Bb* and *Bc*, the panel load being 36 kips.

ART. 71. LONG SPAN SIMPLE BRIDGES.

The following table contains a list of all simple truss bridges in America having spans of 400 feet or more. It is the result of extensive correspondence and of search through engineering periodicals, especial care being taken to secure accuracy in the data herewith presented. The list is believed to be complete to 1904. The necessity for long span bridges arose primarily from the westward extension of transportation facilities over the Ohio River and its principal tributaries and later over the Mississippi and Missouri rivers. The length of span was at first determined mainly by considerations of economy, but afterwards the controlling condition was frequently imposed by the increased requirements of the United States government in the interests of navigation.

LONG SPAN SIMPLE BRIDGES.

Serial Number	Span, Center to Center of End Pins. ft.	in.	Kind of Truss.	Over what River.	Location.	Railroad. Single Track.	Railroad. Double Track.	Highway.	Date of Completion.
1	546	6	Pennsylvania	Ohio	Louisville and Jeffersonville	*			1894
2	542	6	Pennsylvania	Ohio	Cincinnati and Covington		*	*	1889
3	533	0	Pennsylvania	Delaware	Philadelphia		*		1896
4	523	0	Pennsylvania	Ohio	Pittsburgh (Brunot's Id.)	*			1890
5	522	0	Pennsylvania	Ohio	Wheeling	*			1890
6	521	$11\frac{3}{4}$	Warren, sub-verts.	Ohio	Henderson, Ky.	*			1885
7	519	$2\frac{1}{2}$	Pennsylvania	Ohio	Wheeling			*	1892
8	518	$1\frac{3}{4}$	Whipple	Ohio	Cairo	*			1889
9	518	0	Pennsylvania	Ohio	Kenova, W.Va.	*			1891
10	517	$8\frac{1}{2}$	Pennsylvania	Monongahela	Glenwood, Pa.			*	1895
11	517	6	Pennsylvania	Mississippi	St. Louis (Merchant's)		*		1890
12	517	6	Baltimore	Allegheny	Denny Station (Bessemer)	*			1897
13	515	0	Whipple	Ohio	Cincinnati	*			1877
14	515	0	Pennsylvania	Susquehanna	Havre de Grace, Md.	*			1886
15	515	0	Whipple	Susquehanna	Havre de Grace, Md.	*			1886
16	515	0	Pennsylvania	Monongahela	West Braddock, Pa.			*	1897
17	506	8	Pennsylvania	Ohio	Newport and Cincinnati	*		*	1896
18	500	0	Pennsylvania	Missouri	Sioux City	*		*	1895
19	498	0	Pennsylvania	Monongahela	Clairton, Pa.		*		1903
20	495	$8\frac{1}{8}$	Pennsylvania	Monongahela	Rankin, Pa.		*		1900
21	489	3	Pennsylvania	Monongahela	West Braddock, Pa.			*	1897
22	484	6	Pennsylvania	Ohio	Cincinnati and Covington		*	*	1889
23	475	0	Whipple	Susquehanna	Havre de Grace, Md.	*			1886
24	465	$0\frac{1}{4}$	Parker	Miami	New Baltimore, O.			*	1901
25	453	10	Pennsylvania	Monongahela	Pittsburgh (South 10th St.)			*	1904
26	450	0	Pennsylvania	Brazos	Waco, Tex.			*	1902
27	447	0	Pennsylvania	Allegheny	Mossgrove, Pa.	*			1899

LONG SPAN SIMPLE BRIDGES.—*Continued.*

Serial Number.	Span, Center to Center of End Pins.	Kind of Truss.	Over what River.	Location.	Railroad.		Highway.	Date of Completion.
					Single Track.	Double Track.		
	ft. in.							
28	442 10½	Pennsylvania	Ohio	Beaver, Pa.	*			1889
29	440 0	Baltimore	Missouri	Bellefontaine, Mo.		*		1893
30	439 3	Pennsylvania	Allegheny	Pittsburgh (Sixth Street)			*	1893
31	435 10	Baltimore	Miami	Hamilton, O.			*	1895
32	430 0	Pennsylvania	Mississippi	Red Wing, Minn.			*	1896
33	416 0¾	Pennsylvania	Missouri	St. Charles, Mo.			*	1904
34	416 0	Pennsylvania	Ohio	Pittsburgh (Brunot's Id.)	*			1890
35	415 6	Whipple	Ohio	Point Pleasant, W.Va.	*			1885
36	413 0	Pennsylvania	Allegheny	New Kensington, Pa.			*	1901
37	410 0	Pennsylvania	Kentucky	Frankfort, Ky.			*	1904
38	408 0	Pennsylvania	Massena Canal	Massena, N.Y.			*	1901
39	407 0	Parker	Monongahela	Port Perry, Pa.		*		1903
40	407 0	Parker	Allegheny	Brilliant, Pa.		*		1904
41	406 0	Pennsylvania	Miami	Hamilton, O.			*	1899
42	401 6	Pennsylvania	Missouri	Plattsmouth	*			1903
43	400 0	Whipple	Missouri	Bismarck	*			1883
44	400 0	Whipple	Missouri	Randolph	*			1887
45	400 0	Whipple	John Day	John Day, Ore.	*			1886
46	400 0	Whipple	Missouri	Sioux City	*			1888
47	400 0	Whipple	Missouri	Nebraska City	*			1888
48	400 0	Whipple	Missouri	Omaha and Council Bluffs	*			1888
49	400 0	Whipple	Ohio	Cairo	*			1889
50	400 0	Pennsylvania	Arkansas	Little Rock	*			1899

NOTE.—The following spans are in the same bridge: numbers 2 and 22; 4 and 34; 9 and 49; 14, 15 and 23; 16 and 21.

In the preceding table the majority of the bridges have Pennsylvania trusses. Those in which the upper chord is bent only at one panel point in each half span include numbers 1, 2, 4, 18, 22, 28 and 34. Those having a flat portion about 4 panels long at the middle, although the rest of the chord is fairly curved, are numbers 5, 10, 14, 17, 20, 37, 38 and 42. The sub-diagonals are all struts in numbers 1, 2, 5, 18, 22, 33, 42 (see Fig. 71 *a*) and 50; and all ties in numbers 3 (Fig. 70 *a*), 4, 8, 10, 11, 14, 16, 17, 21, 25, 26, 27, 28, 32, 34, 36, 37, 38 and 41; while the trusses in numbers 19, 20 and 30 have several sub-diagonal struts at the ends and ties near the middle of the span. For spans less than 400 feet about the same proportions will hold in regard to the arrangement of the sub-diagonals. Number 27 is a deck truss with a bent lower chord.

Riveted trusses of the Pennsylvania type have been used only in highway bridges, the shortest span being less than 160 feet. Pin trusses of the same kind, as short as 180 feet, have been used in railroad bridges, but should preferably not be employed for spans below 250 feet. A view of a combination truss bridge of 12 panels with a span of 298 feet and 1 inch may be found on Plate LIV of the Transactions of American Society of Civil Engineers, Vol. 27, page 466, October, 1892.

One of the most interesting recent developments in bridge construction in America is the extension of the Parker truss to the longer spans for which it was formerly supposed that only trusses with subdivided panels could properly be employed. In this type of truss the greatest span is 465 feet and $\frac{1}{4}$ inch, being that of number 24 in the table. The trusses have 17 panels and are $66\frac{1}{2}$ feet deep at the middle. The channel span of the Pennsylvania Railroad bridge over the Monongahela River at Port Perry, completed in 1903, represents the highest development of this type of truss (see Fig. 71 *b*). There are 11 panels each 37 feet long, the depth at the middle being 67 feet, and the bridge is a heavy double-track structure. The panels are several feet longer than any previously used in simple truss bridges, and are only exceeded by the 40-foot panels near the towers in the cantilever bridge of the Wabash Railroad across the Monon-

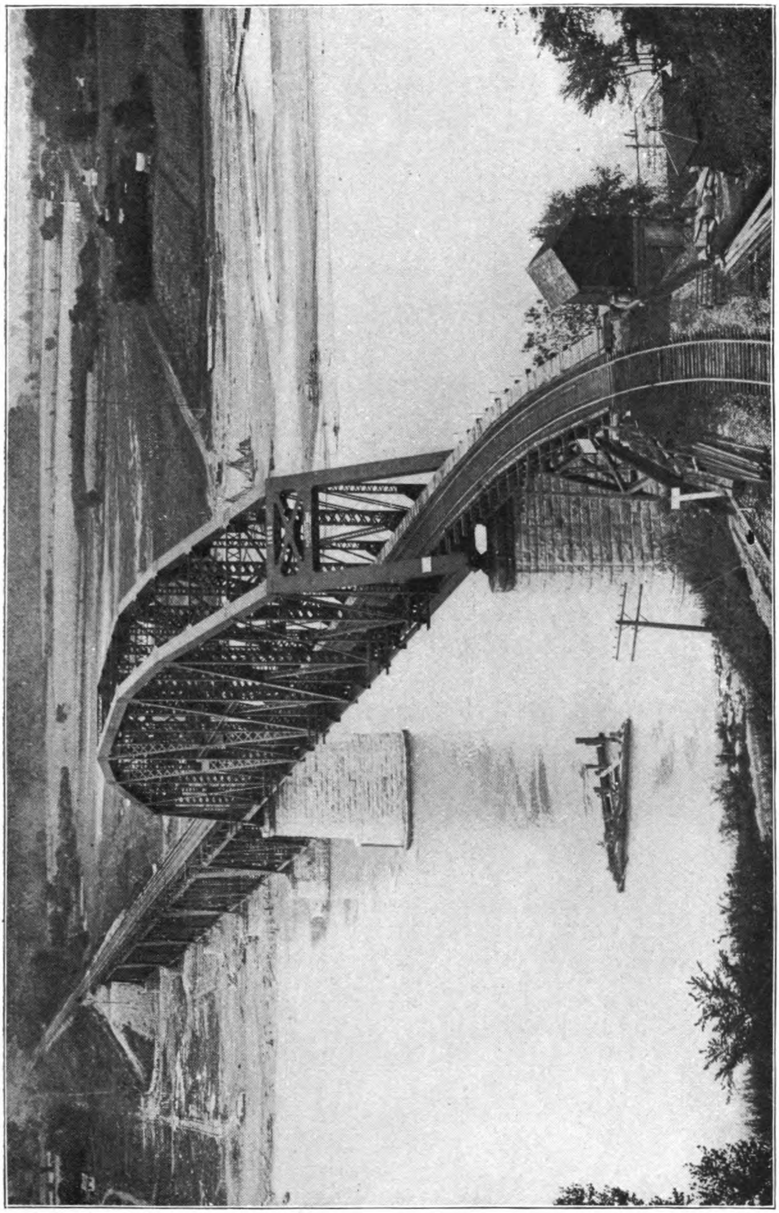

Fig. 71 *a*. Chicago, Burlington and Quincy Railroad Bridge over the Missouri River at Plattsmouth, Neb. Rebuilt in 1903.

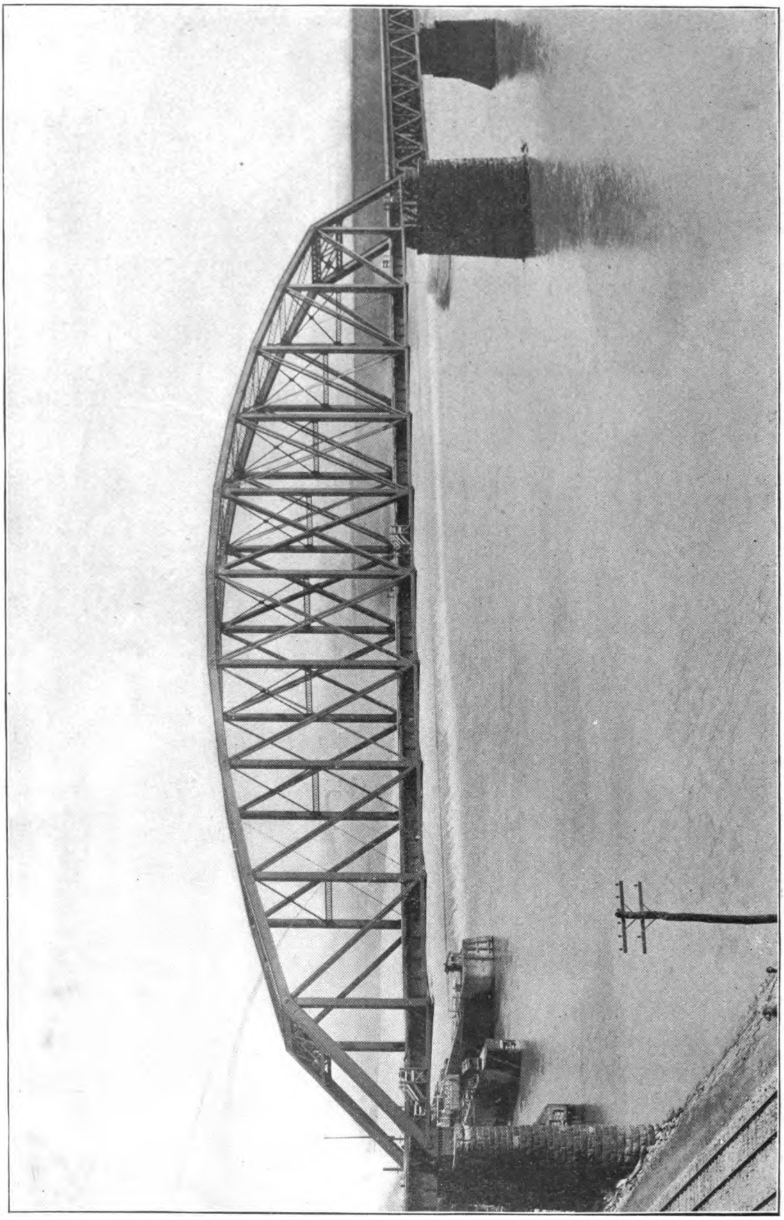

Fig. 71 *b*. Pennsylvania Railroad Bridge over the Monongahela River at Port Perry, Pa. Built in 1903.

gahela River at Pittsburgh. A duplicate of this span was erected in 1904 as the channel span of a bridge over the Allegheny River at Brilliant, Pa., on the line of the same railroad.

The longest Parker trusses without counters have 12 panels each 25 feet long, and are in the Missouri Pacific Railway bridge over the Arkansas River (second crossing), built in 1904. The longest riveted span is 225 feet long, was erected in 1903 on the same railroad system at the crossing of the north fork of the White River. The four-truss Market Street Elevated Railway bridge over the Schuylkill River at Philadelphia has a span of 212 feet, the trusses being 40 feet deep.

Prob. 71. Consult Engineering News, Vol. 22, page 578; Vol. 48, page 40; Engineering Record, Vol. 37, page 448; Vol. 38, page 225; Vol. 46, page 338; and prepare skeleton diagrams showing various modifications of the ends of Pennsylvania trusses and compare them with that shown in Fig. 70 *a*.

ART. 72. ECONOMIC DEPTH.

A bridge usually has two trusses which support a floor and its load, and the chords are connected by lateral bracing. The economic depth for a truss of given span is that depth which renders the entire weight of the bridge a minimum. Since, however, the weight of the floor and lateral bracing is independent of the depth of the truss, these may be left out of consideration, if the panel length be assumed. The theoretic discussion of this problem is an approximate one only, for the numerous practical points to be considered render exact algebraic formulation almost impossible. At the outset, however, it must be noted that an economic depth exists, for the greater the depth the less are the chord stresses and hence also the weights of the chord members, while the weights of the web members increase with the depth because of their increase in