TYPES AND DETAILS OF BRIDGE CONSTRUCTION

PART I, ARCH SPANS.

EXAMPLES OF CONSTRUCTED WOODEN, COMBINATION, WROUGHT IRON AND STEEL ARCHES FOR HIGHWAY AND RAILROAD BRIDGES.

A collection of essential features of special and important work, illustrating variety of design, development of standard practice and methods of erection.

Recorded and Classified for Students, Instructors. Designers, Engineers, Architects and Contractors.

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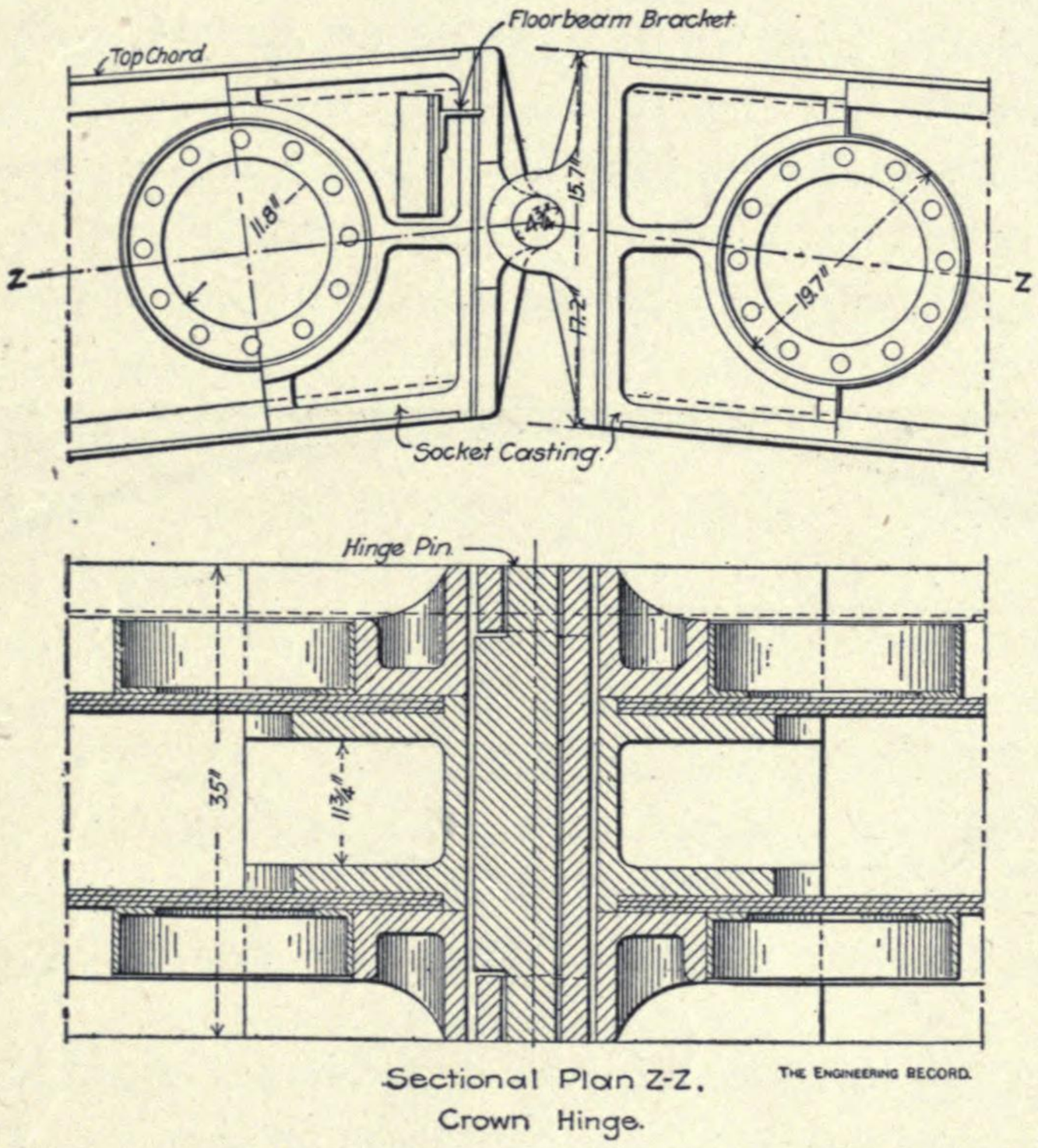
The seats on the trusses are vertical transverse flanges, each made of three steel castings bolted to the webs and flanges of the arch rib, and having additional bearing on a circular angle iron riveted to the outside of each web around a 12-inch bored hole. The outside trusses are decorated with ornamental cast-iron work; the skewback hinges are concealed by large figures in bas relief, which crown the pier tops, and a large sculptured escutcheon masks each crown hinge. The superstructure weighs about 6,037,000 pounds, was assembled on pile falsework and erected by traveling gantries which spanned the full width of the bridge.

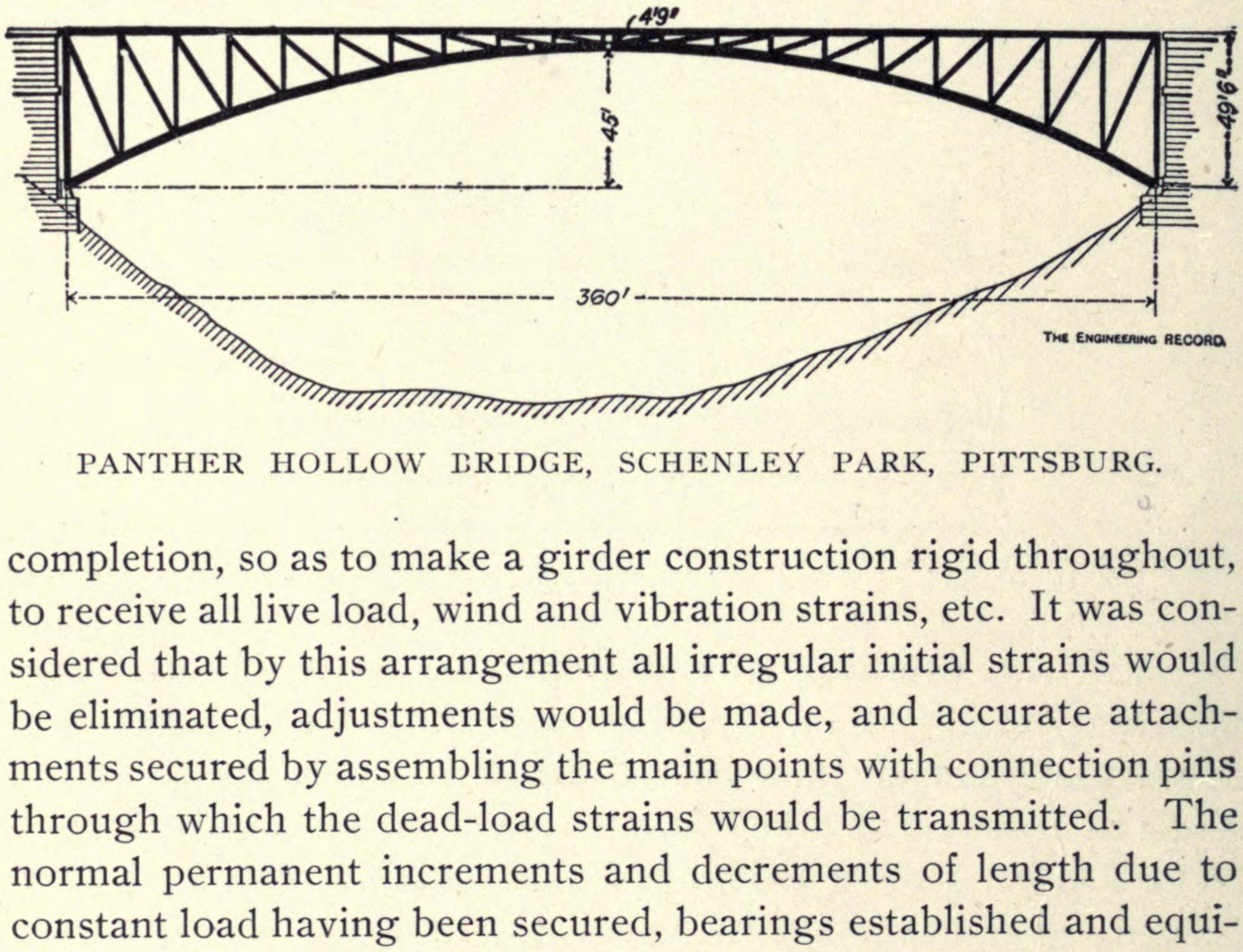


They had two overhead trusses, transverse to the bridge axis, supporting carriages on which trolleys with hand windlasses moved longitudinally and commanded the whole structure to handle its members and the hydraulic riveting machines.

The Panther Hollow Bridge is a steel and mansonry structure situated in the beautiful Schenley Park, Pittsburg, Pa. It was illustrated in "The Engineering Record" of June 4, 1898, from which the following description is reprinted: It is of a class to which an increasing amount of attention is directed, as cities turn to the embellishment of their park spaces, and by reason of the nature of their surroundings and their intended use, architectural merit has to be considered in the design of such bridges, as well as structural excellence. This bridge crosses from the

Phipps Conservatory to the Speedway, and has a total length of about 620 feet. In the ravine which it spans are a railway and a small water course. The bridge has a main steel deck span constructed of four three-hinged arch trusses. Two symmetrical masonry approaches are formed by the abutment of the steel arch, which is carried up to the roadway as a pier 20 feet wide, followed by two 30-foot arches and an end abutment which terminates with two circular segmental wing walls curved outward. The end pedestals are surmounted by large bronze panthers. The principal dimensions of the main span are, length 360 feet, center to center of end pins, rise 45 feet, center height of bottom chord above ground 115 feet, width of roadway 40 feet, width of sidewalks 10 feet each.

The trusses are three-hinged arches, with one-seventh rise, designed to have their members act temporarily as pin-connected during erection, and afterward be solidly riveted together before



PANTHER HOLLOW BRIDGE, SCHENLEY PARK, PITTSBURG.

completion, so as to make a girder construction rigid throughout, to receive all live load, wind and vibration strains, etc. It was considered that by this arrangement all irregular initial strains would be eliminated, adjustments would be made, and accurate attachments secured by assembling the main points with connection pins through which the dead-load strains would be transmitted. The normal permanent increments and decrements of length due to constant load having been secured, bearings established and equilibriums attained, the splice plates of the joints were matched, their holes drilled or reamed in place to exact correspondence, and the rivets driven freely without any shearing or bearing strain, so as to provide rigid connections ready to develop action only when additional stress or live load was imposed, and then to receive it directly, while dead-load strains or their equivalent were still carried through the pins.

In the designer's analysis of the calculations of the arch trusses he states that "The parabola of the bottom chord corresponds to the form of a chain covered with an equally distributed load, consequently neither diagonal nor horizontal construction members are required for equilibrium for this condition, only the members are necessary that transfer the loads of the top chord to the chain. According to the assumption, the dead load is equally distributed over the span, and has consequently no influence on the diagonal and horizontal members; neither has the equally distributed live load. By special loading a maximum stress can be produced in each member, by contrary load a minimum stress, and as both together have to be equal to zero, maximum values will be equal to minimum values—only with different signs, either plus or minus—consequently only one of both needs to be calculated.

"In finding the limit between loaded and unloaded panels, the fact is considered that the resultant of one-half of the span will always pass through the two hinges, its direction is consequently known; the other resultant passes through the third hinge, and the respective panel point of that member, for which the condition of loading is to be established. Afterward the vertical and horizontal component of the pressure in the vertex (the middle hinge), is ascertained, and then the stress in the members is found in the usual manner. In figuring the maximum and minimum stresses for the verticals, it is considered that each vertical has beside the share for dead load also a panel of equally distributed live load to carry, but if the live load is so placed that it produces a maximum live-load strain, it will in reversed position produce a minimum stress. Both maximum and minimum stresses added will make a regular panel live load. For the calculation of bottom chord stresses the effect of dead and live load is to be considered. By corresponding location of the live load, the minimum stress will be found a small fraction greater than for equally distributed live load. It is not necessary to figure the maximum live-load stress, as it will always remain inside the compression line."

For the proportioning of the truss members the following formulas for unit stresses S are used:

For the bottom chord (all in compression)

$$S = 12{,}500 - 500\frac{l}{v}$$

Where l = length of members in feet center to center of connection,

v = least radius of gyration in inches.

For the web members and top chord (alternate tension and compression) $S = 10{,}800$

$$S = \left(1 - \frac{\text{Max. lesser strains}}{2 \times \text{max. greater strains}}\right)$$

For the floor system: Unit compression stress for rolled beams

$$S = \frac{11{,}500}{1 + .0288\frac{l^2}{b^2}}$$

Unit compression stress for riveted girders

$$S = \frac{10\ 800}{1 \times .0288\frac{l^2}{b^2}}$$

Where l = supported length in feet, b = width of flange in inches.

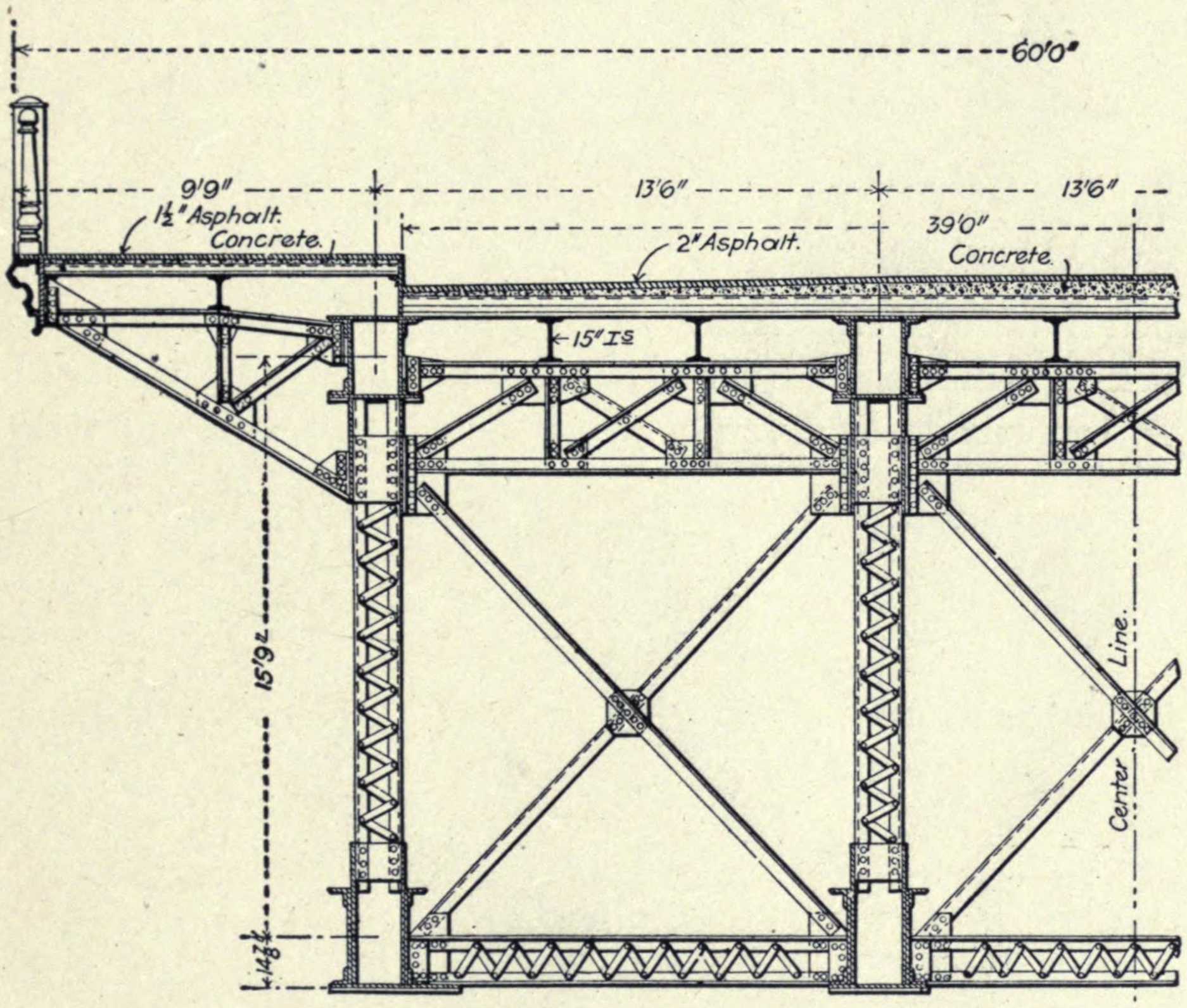
Assumed dead loads of floors in pounds per square foot: for roadway, Carnegie's trough section M10, 25, 3 inches of ashes 18; $2\frac{1}{2}$ inches of concrete 25; 2 inches of asphaltum 17, total 85 pounds. For sidewalks, Carnegie's trough section M30, 11, $1\frac{1}{2}$ inches of asphaltum 11, 2 inches hot binder 20, total 42 pounds.

Assumed live load per square foot: for floor system 150 pounds for roadway plus 100 pounds for sidewalk; for truss system 89 pounds for roadway plus 60 pounds for sidewalk. The estimated quantities included 2,016,465 pounds of steel, 8,000 cubic yards of masonry, 2434 square yards of asphalt pavement, and 1734 square yards of telford pavement, and the contract price was $167,500.

The lateral braces and sway braces are all made of angles riveted at their connections, and there are no adjustable members or connections in the bridge. In the main truss the pins were calculated for a double dead load only, and after the bridge was swung the field holes for the rivets were reamed before riveting. These rivets were figured for a double live load only with the usual excess of 30 per cent., the main object being to have a rigid bridge, and all rivets in the lines of stress. The four trusses forming one-half of the bridge were completely assembled together on timber centering. The upper surface of the centering consisted of a platform conforming to and supporting the lower chords of the set of semi-arches, which were allowed to overhang one panel

at the crown. Then the other trusses were similarly erected to join them at the center.

The sidewalks are carried outside the main trusses by cantilever brackets, each of which has an end connection plate to receive the exterior horizontal longitudinal hand rail and cornice girder. The entire weight and thrust of the bridge is carried by the eight end shoes or skewback connections for the trusses. Each shoe is a riveted steel pedestal, receiving the end pin and distributing the reaction on the rigid horizontal and vertical bearing

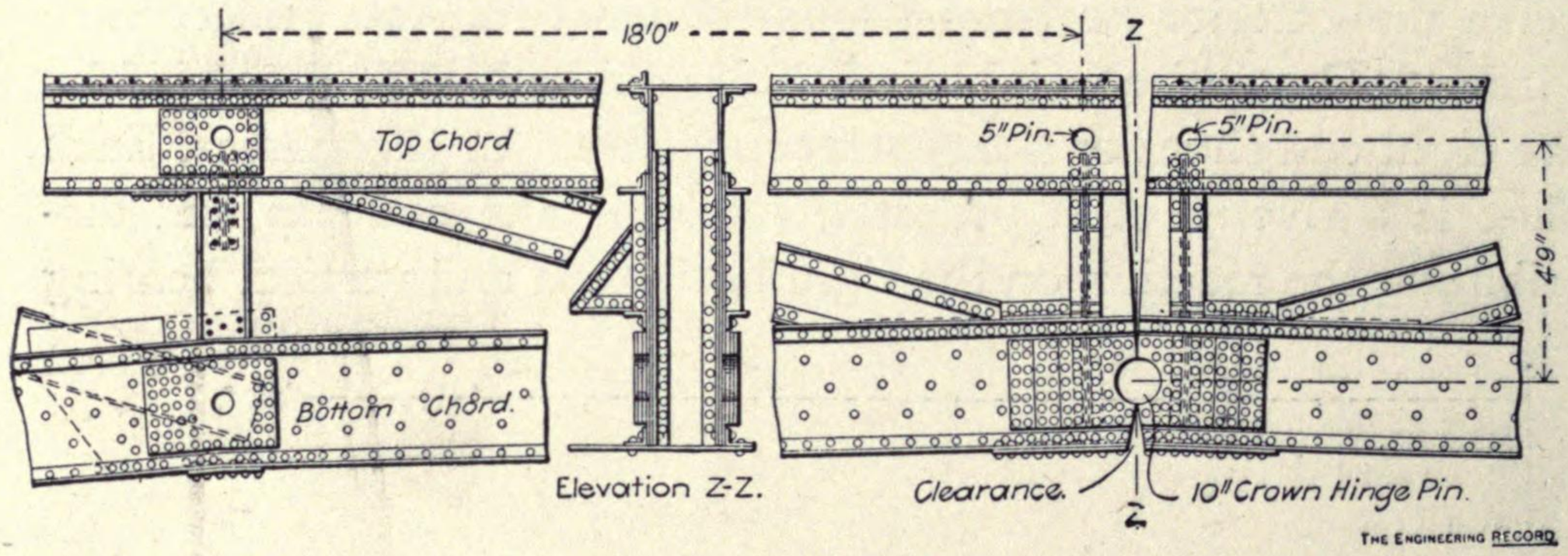


Half Intermediate Cross-Section.

surfaces, which are bedded with lead plates on cut-stone seats in the masonry.

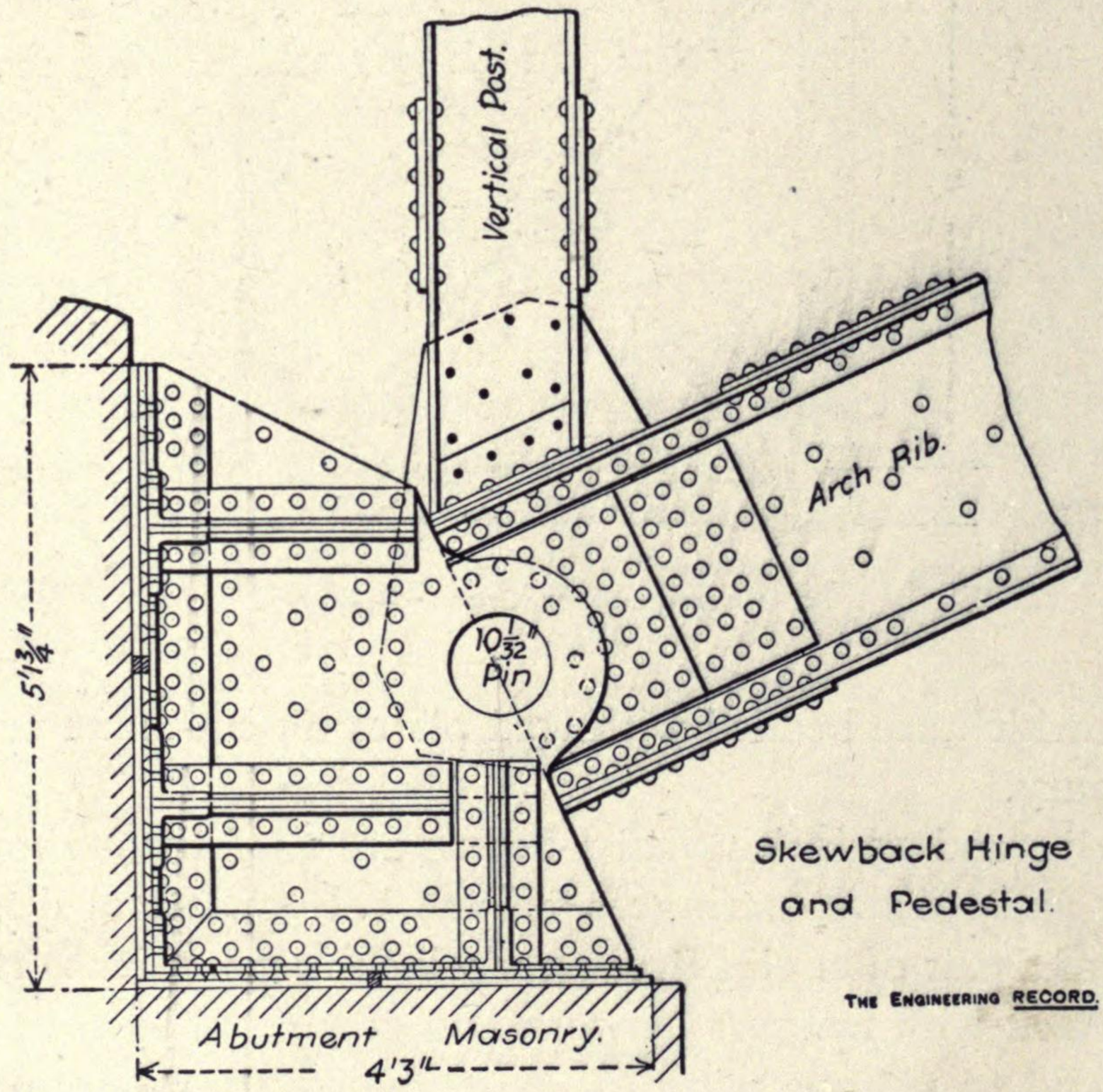
Twelve and 15-inch rolled I-beams are used throughout for sidewalk and roadway stringers. Each bottom lateral diagonal consists of a pair of angles (from 3 x 3-inch to 3 x 5-inch) riveted back to back with washers between and connected by four rivets at each end to oblique wing plates engaging the bottom chord pins. The bottom transverse lateral struts, $2\frac{1}{2}$ feet deep, are I-shaped, made of two pairs of $3\frac{1}{2}$ x $3\frac{1}{2}$-inch angles latticed. The sway bracing in transverse vertical planes at panel points consists of pairs of 3 x 3-inch diagonal angles connected by bottom

plates, field riveted at the intersections, and attached to angle clips at the ends. The roadway troughs are riveted up into two sections, each bolted into slotted holes in the opposite edges of an



Crown Hinge.

11-inch transverse expansion plate 40½ feet long, which allows for temperature variations. The sidewalk paving is laid up to end curbs, each made of a vertical 15 x ¼-inch plate with its edges



Skewback Hinge and Pedestal.

stiffened by angles and a horizontal base plate riveted on for anchorage to the abutment.

The Canadian Pacific Railway crosses Surprise Creek on a