

12531-12000

Engineering News

A JOURNAL OF CIVIL ENGINEERING
AND CONSTRUCTION

ISSUED WEEKLY

LIBRARY
UNIVERSITY OF CALIFORNIA
LIBRARY

VOLUME LXXVII

January 1 to March 31, 1917

McGRAW-HILL PUBLISHING COMPANY, Inc.
10TH AVENUE AT 36TH STREET
NEW YORK

250-Ft. Concrete Arch Across Spokane River Collapses During Construction

On Feb. 6, 1917, the Post St. bridge, crossing the Spokane River at Spokane, Wash., collapsed without warning while concrete was being placed on one of the arch ribs. Three of the workmen who were carried down in the fall were killed instantly and several others were quite seriously injured. The bridge was to have been a reinforced-concrete twin-rib arch of 250-ft. span and 33-ft. rise. The crown section of the arches was 6x6 ft. and the haunch section 6x8 ft., the spacing of the ribs being 20 ft. c. to c. The twin arches were being erected on framed timber falsework, footing on timber pile bents driven presumably to rock in the river bottom. The concrete was being poured in transverse units with sectional openings between and at the time of collapse the ribs were completed with the exception of one opening on one side of both ribs and the crown key section which was to have been poured last. High water conditions prevailed in the river.

The bridge is midway between, and only 30 to 50 ft. from, the Great Northern Ry. steel bridge and the Washington Water Power Co. steel bridge. It is also near the Monroe St. concrete bridge, the 281-ft. arch in which was for some time the longest in the world.

The bridge and falsework were designed by P. F. Kennedy, Engineer for Olsen & Johnson, the contractors. The erection of the falsework, together with the pouring of the ribs, was in direct charge of Mr. Kennedy until Jan. 31, one week before the collapse, when he either fell or was knocked off the service bridge and was drowned. The general supervision of the work was under the direction of Morton McCartney, City Engineer, and his assistant, B. J. Garnett. Before his connection with the contractor on this bridge Mr. Kennedy had been an Assistant Engineer in the City Engineers' office.

Mr. Kennedy seems to have had exclusive knowledge of the design and construction of the falsework, so that it is



FIG. 1. POST ST. COLLAPSE AT EAST ABUTMENT



FIG. 2. LOOKING TOWARD WEST END OF THE FALLEN POST ST. BRIDGE

difficult to get any information regarding its condition. An analysis of the situation, however, has been made for *Engineering News* by a local engineer, but did not reach New York in time for publication in this issue. A complete description of the failure and of the falsework will therefore appear in next week's issue of this journal.

The two views herewith were taken immediately after the collapse of the structure and show the conditions at each end of the bridge.

ENGINEERING SCHOOLS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

Massachusetts Institute of Technology has arranged a series of lectures and experimental demonstrations in physics, chemistry and applied science for high-school pupils in and near Boston, utilizing the laboratory equipment of various departments. These lectures will be given in the large auditorium at Cambridge on certain afternoons at 4 o'clock. This work will be done through the institute's "Society of Arts," an organization provided for in the institute's charter and which for over 50 years has offered public lectures in popular science.

COLUMBIA UNIVERSITY

Because of the growth of research work in Columbia University, a plan for the organization of an administrative Board of Research has been placed before the trustees by President N. M. Butler. This board would be separate from the University Council, but responsible to it: its function would be (1) to secure suggestions from departments and individuals for specific researches, (2) to fix the order of precedence in apportionment of available funds, (3) to eliminate duplication of efforts in separate but related departments.

Report on Collapse of Falsework on Spokane Concrete Bridge

BY JOHN C. RALSTON*

SYNOPSIS—The 250-ft. twin-rib reinforced-concrete arch bridge on the line of Post St., across the Spokane River at Spokane, Wash., collapsed during construction on Feb. 6. The following report gives the details of the falsework that failed.

The Post St. bridge, the collapse of which at 3:20 p.m., Feb. 6, 1917, caused the death of three workmen, was intended to be a reinforced-concrete arch, twin-rib, open-spandrel, highway city bridge. It is located in the heart of Spokane, Wash., spans the Spokane River midway of the two falls and was to have had a clear span of 250 ft. with a rise of 33 ft. The two arch ribs

tractors. The erection of the falsework, together with the pouring of the ribs, was in direct charge of Mr. Kennedy until one week prior to the collapse, when Kennedy either fell or was knocked off the service bridge and was drowned. Thereafter the work was carried on under the direction of H. O. McC'Call, General Foreman, who no doubt followed the schedule of progress as laid out by the engineer. General supervision was under Morton Macartney, City Engineer, and his assistant, B. J. Garnett.

The falsework consisted of 18 bents spaced 12 ft. 4 in. c. to c., and each bent contained six carrying piles and one tie pile, capped with 12x12's, drift bolted with one $\frac{3}{4}$ -in. round bolt per pile. False bolsters of 4x10 in.,

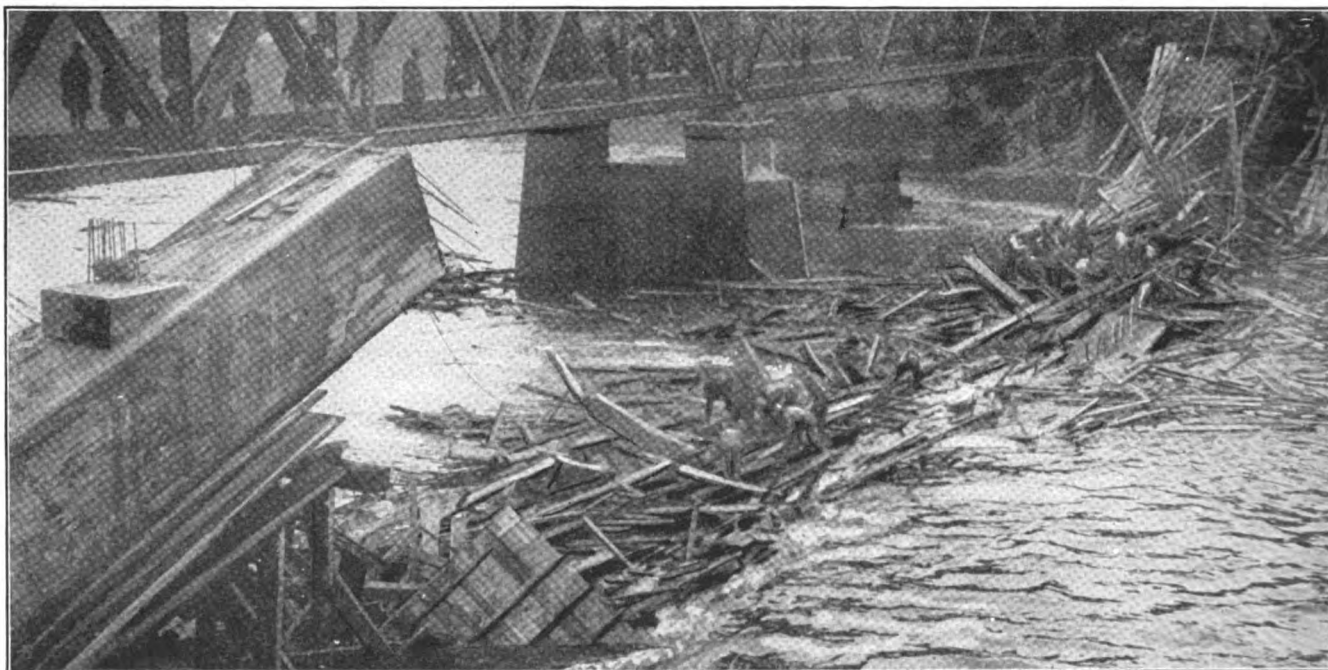


FIG. 1. VIEW OF POST ST. BRIDGE LOOKING WEST AFTER COLLAPSE
The projecting rib in the foreground fell some three hours after the initial collapse

were 6x6 ft. at the crown and 6x8 ft. at the haunch, connected by seven diaphragms.

Its site lies midway between the Great Northern Ry. main-line double-track steel bridge on the north, distant about 50 ft., and the Washington Water Power Co. double-track steel bridge on the south, distant about 30 ft. A sheer escarpment of about 40 ft. of solid basaltic rock marks both banks of the river and thus constitutes an ideal site for the type of bridge contemplated. The bedrock presents nearly a level profile across the channel. River débris of small boulders, sand and gravel covers most of the bedrock to a depth of 4 to 6 ft., excepting at the west side of the channel, where the bedrock is exposed for a short distance, according to information given by the City Engineering Department.

The falsework for the bridge was designed by P. F. Kennedy, the engineer for Oleson & Johnson, the con-

laid flat, over each pile, presumably continuous, constituted the longitudinal ties of all the bents at the top of the first story. This tie, however, seems to have been omitted between Bents 8 and 9 west, as shown by Fig. 4, although a partial substitute was put in in the form of a flat sway brace and spiked to the posts. This substitute seems to have been an unfortunate one. It is not apparent that the flat bolsters were drift bolted to each cap. On the contrary, it would appear from such meager evidence as now exists that the connections were made by toe-nailing with wire spikes these insufficient bolster members.

The accompanying elevation (Fig. 2), compiled on Feb. 8, 1917, by the city engineer's office from sketches in the contractors' office, shows that four lines of longitudinal sway bracing were carried from end to end. Existing evidence shows that this system of sways, with possibly two exceptions at the east end, was spiked to

*Consulting Engineer, Spokane, Wash.

the piles instead of being bolted. One workman stated that from one to three spikes were used. Fig. 3 shows that two or three spikes were used, but no bolts. None of the piles now standing nor any of those enmeshed in the debris that could be seen had been barked, so that clearly the sways were spiked through the bark, which generally is about 1 in. thick. This thickness, together with from 1 to 2 in. of soft sapwood, plus the thickness of the sway brace, gave a very insecure hold to an 8-in. spike and practically no holding value to a 6-in. spike, if such were employed.

A 3000-lb. hammer was used in driving the piles, and every pile is said to have been driven to refusal. General Foreman McCall and his workmen are clear on this point. The writer's long acquaintance with McCall

transverse sway bracing was used, according to the plan; but it is not shown whether it was bolted or spiked.

SCHEDULE OF SECOND-STORY POSTS

Mark	Number of Bents Required	Size of Posts *	Length of Posts Ft. In.
Bent 1	2	6x8	22 11/8
Bent 2	2	6x8	22 3/8
Bent 3	2	6x8 or 8x8	21 1/8
Bent 4	2	8x8	19 1/8
Bent 5	2	8x8	16 6/8
Bent 6	2	8x8	13 7/8
Bent 7	2	8x8	9 7/8
Bent 8	2	8x8	4 8/8

* The 6x8-in. posts were made from 6x8-in. sticks, but the 8x8-in. posts were made up of two 4x8-in. sticks.

Longitudinal sway bracing seems to have been used on alternate panels only.

The joists, with one or two exceptions, were 3 1/2 x 15-in. Douglas fir and, together with some of the other stuff,

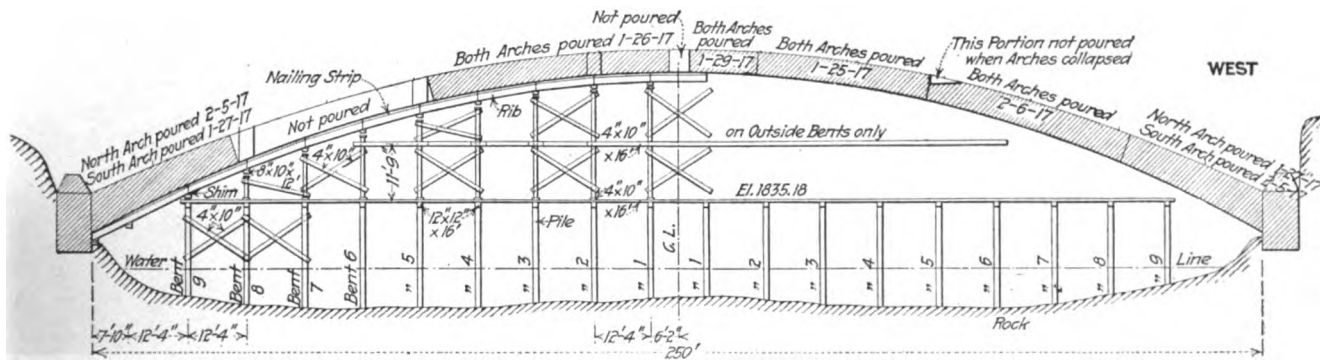


FIG. 2. OUTLINE OF POST ST. BRIDGE FALSEWORK, SHOWING PROGRESS OF PLACING CONCRETE

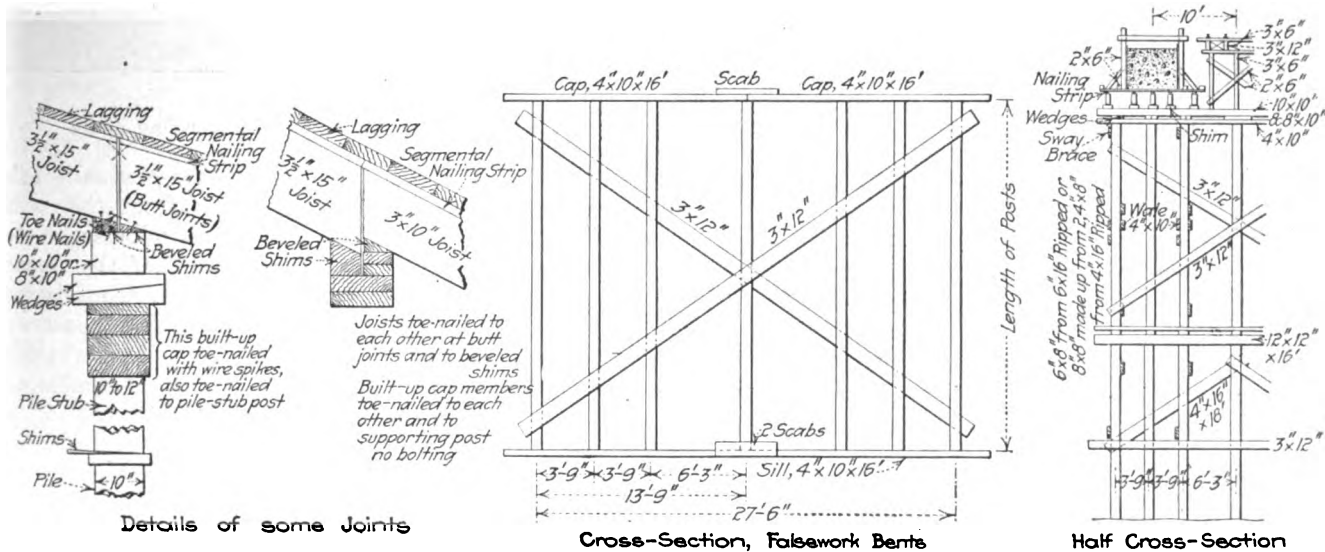


FIG. 3. DETAILS OF THE FALSEWORK DESIGN OF POST ST. BRIDGE AT SPOKANE

justifies complete confidence in any statement he may make. The nature of the river bed is such that some piles might have come to refusal on boulders; and inasmuch as the depth of penetration at best was small, rigid horizontal and diagonal bracing would be necessary with a liberal use of through bolts and washers. It is reported by some of the workmen that, where known boulders were encountered, the piles in such cases were driven off center from a few inches to nearly 3 ft. in one instance.

The second story of the falsework (Fig. 3) was made up of 6x8-in. and 8x8-in. posts, built up of 4x8's, and in lengths from 4 ft. 8 in. to 22 ft. 11 1/8 in., according to the schedule in the accompanying table. It does not appear how the two pieces making up the member were fastened, whether with spikes or bolts. The ordinary

were salvage materials from the floor of the old steel bridge that the new structure was to replace. This material, however, was all sound and not much over a year old. All joist had butt joints and rested without dapping on beveled shims, thus giving a minimum bearing. Unfortunately, the joists were toe-nailed to each other and to the shims, and the shims were similarly nailed to the caps. The end elevation shows the three joists immediately under the arch rib to have been spaced 2 ft. centers and the two outside joists spaced 2 ft. 8 in., without bridging or intermediate struts or spacing strips.

The elevation (Fig. 2) shows the sequence of sectional pouring. It will be noticed that all but a small part of the rib had been poured over Bent 5 west, when the collapse occurred. Half-yard batches were trammed from



FIG. 4. CLOSE VIEW OF BENTS 7 TO 9 ON WEST SIDE OF POST ST. BRIDGE
Pile tops from 9 to 12 in. diameter. Note absence of bolts and presence of shims under half-story round posts

the mixer and dumped onto an inclined chute, from which the concrete floated or was spread to place. The writer's information from the workmen is that the dump over this bent was nearly a vertical drop. This would give a drop ranging from about 9 to 15 ft.

Mr. McCall examined all the points at which he believed any distortion might occur due to loading, about 30 min. before the collapse came. He found everything apparently undisturbed and in normal condition. Not-

withstanding that the drop distance was gradually being decreased as the forms filled, it was from this point, in his judgment, he stated, that the collapse started. It is possible that the cumulative result of the impacts finally developed the critical weakness in the falsework and thus tumbled the whole structure into a mass of inextricable débris.

The writer is deeply sensible of the deplorable and untimely end of the designer within a week of the collapse and ventures to believe that, were Mr. Kennedy alive, he could explain away much that may seem obscure and perhaps even justify a structure that to some of the profession would appear inadequate for the purpose it was designed to serve.

[A later telegram from Mr. Ralston states that the coroner's jury has decided that the structure fell from insecure piling and the falsework was unable to bear the weight of the concrete. It recommends that the city inspect all such falsework. Mr. Ralston also reports as follows: Fuller investigations show that the piles had little if any penetration, although driven to refusal and that the spiked bracing was the only means of preventing the kicking off of the frame from the sloping rock surface. The piles were shamefully small and the upper frame of insufficient size, there being 3000 lb. stress in the three joists under each rib. The voussoir sections as poured were too long and the neglect simultaneously to pour opposite sections in the two ribs undoubtedly distorted the falsework which, combined with the general flimsiness of the frame, the impact of the dumped concrete and the overstressed joist, caused the wreck.—Editor.]

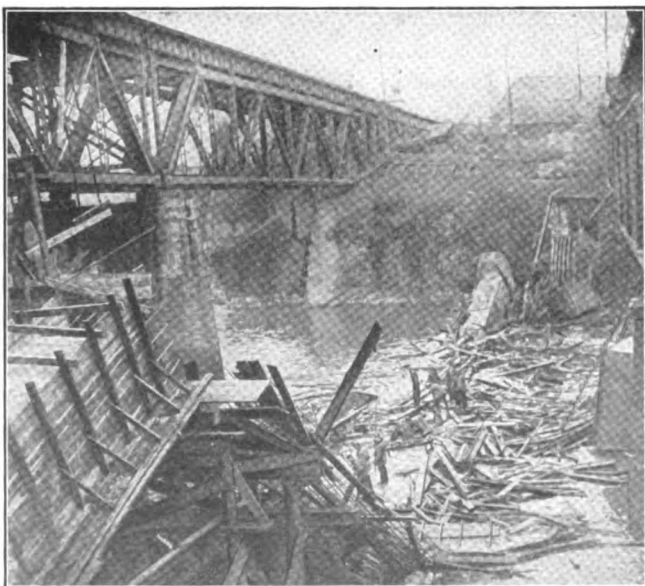


FIG. 5. LOOKING EAST OVER BRIDGE RUINS