Substructure of the Lake St. Bascule Bridge at Chicago

By Hugh E. Young*

SYNOPSIS—Foundation work on one of the heaviest drawbridges ever built, a double-deck double-leaf bascule. Anchor piers in open wells. Steel sheetpile coffer-dam for main piers.

The double-deck double-leaf bascule bridge now being built across the river at Lake St., Chicago, was described by the writer in *Engineering News*, Nov. 4, 1915. The substructure consists of a tailpit and an abutment at each side of the river. The tailpit is a concrete box resting in four cylinder piers carried down to solid rock, the walls of the pit acting as beams. The piers are spaced 34 ft. laterally so as to provide for a possible future double-track subway on Lake St. North of the tailpit are foundation walls for the operators' houses. These rest on pile foundations. The abutments are supported on groups of piles driven on each side of the street, and act as beams, spanning the space that would be occupied by a future subway.

The depth of excavation for the tailpit necessitated special care to protect adjacent buildings and the elevated railway structure. Work did not proceed simultaneously on both sides of the river due to the fact that the scows for delivering material and removing excavated material effectually blocked the channel adjacent to the pier under construction, and it was necessary that one draw be left clear for the passage of the river traffic. Work was started Mar. 30, 1914, by the Fitzsimons & Connell Co., contractors for the subway.

General Method of Working

The general method of conducting the work on the east side was as follows: Excavation was carried down to a general elevation of about 3 ft. above datum, giving about 38 to 40 ft. clear headroom under the elevated structure. A land piledriver was rigged up to clear the elevated structure, and all piles were driven. It was occasionally necessary to dig a hole for the point of the pile, in order to get the butt in under the hammer. By doing this piles about 25 ft. long could be driven.

As the four-story brick building on the north side apparently rested on floating foundation, steel sheeting was driven to protect it. The contractor braced the structure by tying the outside walls together by means of rods connected to timbers on the outside faces. During the excavation a reinforced-concrete wall inclosing the subsidewalk basement of the building on the south side of the street had to be removed. This was broken up by light charges of dynamite without any accident. The foundation piles under the operator's house on the north side of the street were also driven.

The coffer-dam was next constructed. This consisted of a double row of Lackawanna steel sheet-piling for the portion in the river and a single row of steel or wood piling for the portion on land. Where channel clearances permitted, two rows of sheeting were driven about 7 ft. apart; but the rows for the front wall of the coffer-dam were 3 to 5 ft. apart. The two rows were tied together with rods and the space between filled and puddled with clay dredged from the river. The sewer on the north side was diverted through a trough outside of the coffer-dam.

A derrick was then erected on the north side to handle the excavation from the coffer-dam. Its mast was carried by a group of piles near the north support of the rear girders supporting the elevated structure, and the stiff-legs were anchored to the coffer-dam. The derrick hoist was erected on a pile foundation outside the coffer-dam.

As the excavation for the tailpit proceeded the coffer-dam was braced by four horizontal tiers of 12x12-in.

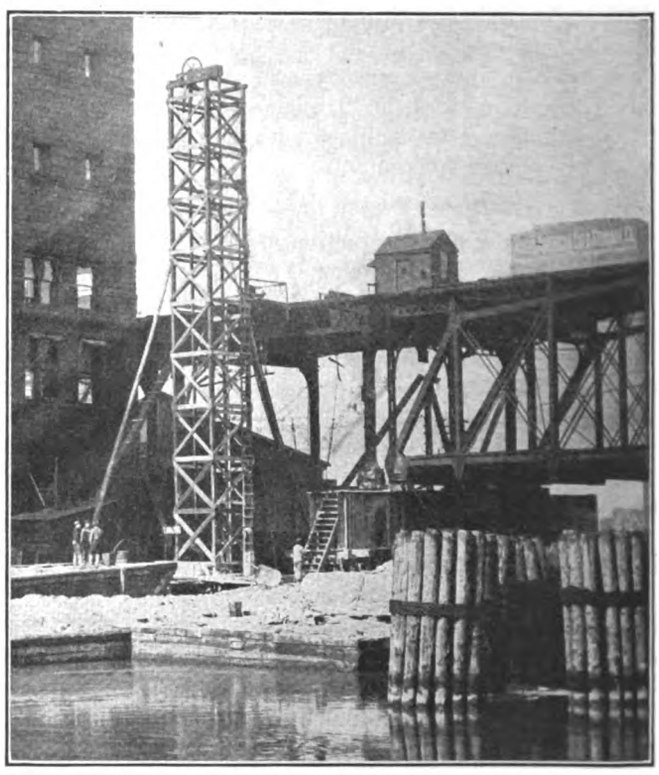

FIG. 1. CONCRETING PLANT AND TOWER

The materials are delivered on scows. The view shows the west end of the old swingbridge, with the columns of the elevated railway approach carried temporarily on a box girder spanning the tail-pit of the new bridge

cross-bracing. One tier of bracing was placed about 18 in. above datum; the others were 6, 13 and 19 ft. below datum. The bracing was supported by means of old piles and partly by suspension rods from the temporary box girders carrying the columns of the elevated approach. The material was loaded into buckets, which were lifted out by the derrick and dumped into a scow alongside the coffer-dam. The excavation was rushed day and night, with men working in three shifts.

When the excavation for the tailpit was practically completed, that for the subpier wells was started. The 8-ft. anchor-pier wells were started first and were dug as open wells, being excavated about 5 ft. at a time and then lined with 3x6-in. tongued-and-grooved maple lagging in

*Bridge Designing Engineer, Department of Public Works (Bureau of Engineering), Chicago.

lengths of 4 ft. 8 in., each length being held in place with two or three rings of 1x4-in. steel. These rings were made in two sections, with a lug bent on the end of each for bolting together. The wells were excavated in this manner to solid limestone rock, the bottom of the well extending 1 ft. into the rock to insure a good bearing.

The material encountered in these wells was blue clay from 20 ft. (where the well started) to about 60 ft. below datum. This ranged from soft clay at the top to very stiff clay at the bottom. From 60 to 75 ft. below datum the material was a mixture of tough blue clay with gravel and boulders; from 75 to 90 ft., a mixture of soft clay and sand; from 95 to 105 ft., gravel and sand. At 105 ft. a water-bearing stratum of sand was encountered, extending to rock at 107 ft. below datum. The quantity of the water was not enough to necessitate an air-lock, the water being removed by a centrifugal pump; but progress was much retarded. It took from Aug. 14 to 28 to excavate these two wells.

Concreting Plant Erected

While these wells were being put down the concreting plant was erected. The mixer plant was placed alongside the dock of the building at the south side of the street, on a pile foundation. In front of the mixer was erected a tower, similar to that shown in Fig. 1 (which is the tower at south side of west coffer-dam), for elevating the concrete to metal chutes that distributed the concrete to the forms. Handling concrete in barrows was unnecessary except for minor parts of the work beyond the reach of the chutes. These chutes were supported from the elevated structure by means of tackle and blocks, and were easily adjusted. Material was delivered to the river plant on scows, being wheeled from the scows in barrows to the mixer hopper.

When the excavation of the wells was completed the concrete filling was started. The concrete was mixed wet and dropped through pipes into the well. The work was inspected at regular intervals during the pouring of the concrete to see that it was being properly filled around the reinforcement and that too much water was not accumulating on top. As the concreting proceeded, the lagging and rings were removed, except for the bottom 15 to 20 ft. of the well. The concreting of the anchor-pier wells was completed on Aug. 31.

Excavation Started

The excavation for the 12-ft. wells for the river pier was started Aug. 31, as soon as the anchor-pier wells were concreted, and proceeded uninterruptedly until Sept. 10, the wells having been carried down to 95.5 ft. below datum. Work was then suspended temporarily, as the contractor encountered some difficulty in getting proper sand for concrete, and decided not to finish the well to rock until the proper materials were available. After a short delay excavation was again started, and rock was reached Sept. 15. Fig. 2 shows the rings and lagging in place, the line of electric lights in the well to illuminate it, and the pump for keeping the well dry.

Concreting was started immediately after the excavation was completed and concrete brought up to 93 ft. below datum, when work was again suspended due to the rejection of the sand by the inspector. This was lake sand from the eastern shore of Lake Michigan, and was finer than that called for in the specifications. After a delay of about a day suitable sand was procured and delivered in cars to a dock a short distance from the bridge, from which place it was brought to the site on scows. The work was then started again, the wells being concreted to the top. The lagging in these wells was left in place from the bottom up to 90.4 and 91.6 ft. below datum for the north and south wells respectively. The wells were completed on Sept. 21.

A bad leak in the south wall of the coffer-dam was noticed on Sept. 14; and it required considerable pumping to keep the water low enough to continue to work. The water entered at the connection of the double row of steel sheeting with the dock, and then through the wood sheeting which forms the part of the coffer-dam on the land. Considerable material was dumped in the river along the dock where the leak started, and finally stopped the leak, on Sept. 24.

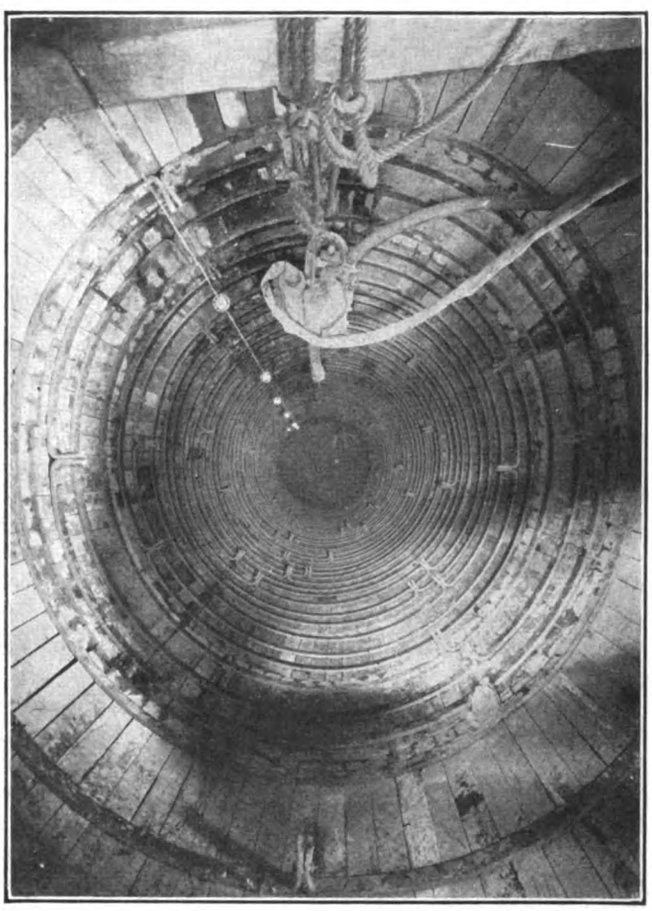

FIG. 2. INTERIOR OF SHAFT FOR ONE OF THE FOUNDATION PIERS

The shaft is 12 ft. in diameter and 107 ft. deep, extending 1 ft. into solid rock. The pump and the electric lights are shown. The shaft is ready to be filled with concrete

Forms for the tailpit proper were prepared at the time the piers were being constructed, and as soon as these piers were finished (Sept. 29) the concreting of the tailpit was started. The floor of the pit, a 5-ft. slab, 62x64 ft., was finished Oct. 3. The construction of the floor requires all piles and other supports for the bracing of the coffer-dam to be cut off above the top of floors, in order to avoid holes in the slab. The bracing is made to hold itself by trussing. The side walls and the river and anchor piers (forming the end walls) of the pit were then brought up to an elevation 1 ft. below datum, and were completed on Oct. 22. The overhanging parts of the side walls were temporarily omitted, so as to clear the piles

under the girders supporting the elevated structure. The outside walls for the operator's house were also brought up to the bottom of the cross walls joining them to the tailpit.

In order to make the pits watertight, a 6-in. layer of cement mortar, made of 1 part portland cement and 2 parts fine aggregate, was placed in the floors and on the outside faces of the walls, up to above datum. The mortar facing on the walls was applied by means of a mortar board, used as a form, which was placed inside the wall forms at the proper distance to give the required thickness of facing, the board being raised as the facing course was carried up with the concrete. The mortar was made in a mechanical mixer, and was delivered in chutes to a box, from which it was carried to the forms in coal scuttles or pails. The concrete was delivered by chutes directly into the forms. From the time the coffer-dam was first pumped out until the concreting was finished the work was carried on continuously, the men working in three shifts, except on Sunday (midnight to midnight), when no work was done.

East and West Abutments

At this stage of the work excavation was started for the west abutment, and the excavation for the east abutment was finished and the forms were constructed. After the concrete in the tailpit had set the girders supporting the elevated structure were shored up on the masonry, as described in the previous article (and shown at *A* in section *CC* of Fig. 3). The piles were cut off so that the overhanging walls and top of the walls under the operator's house could be finished. This work was finished on Nov. 12. The concreting of the east abutment was started Nov. 13 and finished Nov. 25. The concrete plant was then moved to the dock on the west side of the river (Fig. 1). Foundation piles for the west abutment were then driven in the same manner and under the same conditions as those for the east abutment.

The forms for the east tailpit being removed, the space between the coffer-dam and tailpit was filled with water. Under full head of water the pit showed a small leak in the north wall at an elevation of about 1 ft. below datum at the junction of the side wall and overhang. This stopped as soon as silt filtered into the crack, and the pit was then accepted by the city. The coffer-dam was then removed and the channel dredged of all excess material, such as puddling and excavation.

At this same time the west coffer-dam was being constructed and foundation piles for the operator's house were being driven. Excavation was also made for the new portion of the 5-ft. sewer on the west side, and the sewer constructed up to the abutment, where a temporary bulkhead was placed and an outfall constructed under a freight house into the river.

Work on the West Pier

Pumping out of the west coffer-dam started Jan. 11, and as the excavation proceeded the dam was braced as described for the east dam. Excavation for the foundation wells under the west anchor pier was started Jan. 23 and for the river wells Jan. 25. On Jan. 31, due to a rise in the river, the water overflowed the puddle wall of the coffer-dam and partly filled the wells, which were then pumped out. Excavation in the anchor-pier wells was done after the river-pier wells were finished. Water was encountered in the wells at 101 ft. The excavation for the river-pier wells was completed Feb. 7, having been carried to a depth of 109 ft. below datum and 1 ft. into solid rock. Concreting was finished in these wells on Feb. 12, the lagging below 94 ft. and 87.25 ft. below datum being left in place.

The excavation for the north anchor-pier well was completed on Feb. 10 and the south well Feb. 11. They were immediately concreted, work being finished Feb. 15. The lagging was left in place below 82 ft. and 80 ft. below datum for these walls. The tailpit forms were then constructed and concreting commenced Feb. 16. The floor was finished Feb. 20, and by Mar. 6 the walls were brought up to about 1 ft. below datum.

On Mar. 5 a leak developed in the south wall of the coffer-dam adjacent to the building, and this flooded the coffer-dam to river level. This break was repaired and the dam pumped out again.

During the time that excavation for the operator's houses was proceeding the forms for the west abutment were erected and the wall was concreted. This work was started Mar. 12 and finished Mar. 19. The box-girder supports of the elevated structure were then blocked up on the masonry and the overhanging walls and operator's house walls concreted, finishing Mar. 29. As a precaution against freezing the finished work was covered with tarpaulins.

The test of the west pit was made Mar. 31, and the coffer-dam was removed Apr. 2. The plant was then removed, docks were repaired where they had been cut for the coffer-dam, backfilling was placed, the permanent pier protection constructed, and the site cleaned up. The substructure contract was completed Apr. 28, or about 13 months after starting work. The girders supporting the elevated structure on the west side were left in place.

Activities at a War Port

Engineers on this side of the ocean who are concerned in the development of port works in an orderly, and sometimes in a dilatory, fashion will be interested in the feverish activity forced upon the port authorities of Archangel, Russia, in order to make that port equal to the greatly increased trade of the war. United States Commercial Attaché H. D. Baker reports upon this activity as follows:

> Information has been received of continued improvement in conditions at Archangel since the time of my visit there early in August. Notwithstanding increasing arrivals of steamers, the goods are shipped out now within a reasonable time after they arrive, and considerable cotton and other merchandise that had accumulated there early this year have now found their way to interior destinations.
>
> It is reported that very good progress has been made during the last month in railway improvements between Vologda and Archangel. It is possible now to run broad-gage cars from any part of Russia direct to Archangel, and for half the distance from Vologda to Archangel the line is double-tracked. The narrow-gage line will be retained, so that it will still be possible to make use of the narrow-gage equipment. Rapid progress is also being made on the line through Lapland between Kandalaksha and Kola. It is expected that it will be possible to run cars over this line after Jan. 1, 1916, so that Kola during the winter season can be substituted for Archangel as a port, there being no heavy ice there as there is at Archangel.
>
> Three cargo ice breakers, one of 2,500-ton capacity and two of 500-ton capacity, will be put on the run for the winter season between Kandalaksha and Sorotskoe, the voyage probably taking about 24 hr. each way. Owing to their limited capacity, the ice breakers will probably be reserved for freight urgently required by the government service.