THE SINKING OF THE PIERS FOR THE GRAND TRUNK PACIFIC BRIDGE AT FORT WILLIAM, ONT., CAN.*

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This paper outlines the construction methods used in sinking the piers for the Grand Trunk Pacific Railway bridge crossing the Kaministiquia River at Fort William, Ontario, Canada.

The proposed terminals of the Grand Trunk Pacific at the head of Lake Superior are separted from the main line by the Kaministiquia River. At the bridge site the river has a maximum depth of about 20 feet at low water being at that stage 325 feet in width. The north bank of the river, to which the draw span of the bridge swings, is steep, and rises to a height of about 35 feet above water. The south bank is low, sloping from the river at a grade of 1 in 10.

Test borings, taken at the bridge site during the winter of 1906-7 by the railway engineers, showed a stratum of firm, blue clay, about 35 feet thick, covering a layer of water-bearing gravel, varying in thickness from 3 to 7 feet. The water contained in this gravel was under sufficient pressure to maintain a steady flow through several of the abandoned test holes, and, when confined, it rose to an elevation of 4 or 5 feet above the river level. This gravel is underlaid with bed-rock, from 57 to 60 feet below the water surface. The rock surface is comparatively level, dipping to the north about two degrees.

The plans prepared by the railway showed only the general design of the two piers, the details and construction methods being left for field decision. The pivot pier consists of a steel shell, 31 feet in diameter, sunk to bed-rock and filled with concrete. The south pier is composed of two smaller shells, set side by side. These are 15 feet in diameter, and 18 feet apart from centre to centre.

SKETCH SHOWING FOUNDATIONS
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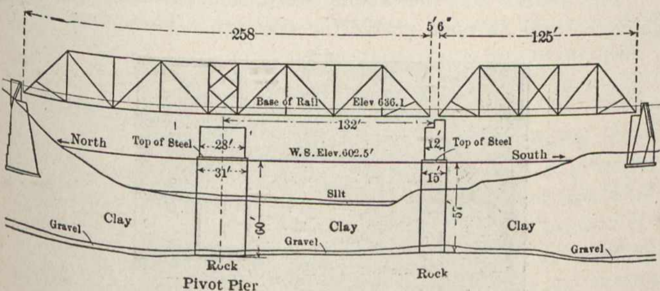

The plans called for ½-inch plate, single-riveted on the horizontal seams and double-riveted on the vertical seams, and ¾-inch rivets with round heads. The contract for the work having been let in the latter part of August, 1907, an interval of about three months remained before severe cold weather would set in, closing navigation and rendering all outside work more costly. Therefore, operations were begun immediately.

For the falsework at the pivot pier, two rings of piling were driven about the centre of the pier, the diameter of the inner ring being 37 feet and of the outer one 54 feet. These piles were cut off and capped 8 feet above the water. The caps were of 12 by 12-inch fir timber, radial from the centre of the pier, and overhanging the perimeter of the steel shell two feet. There were twenty piles in each ring. These were cross-braced and tied securely, making the structure as rigid as possible, to lessen any movement that might be caused by the current, which varied from three to six miles per hour. The piles were driven to gravel, to prevent settlement in the finished falsework. The structure was then decked and a circular track built upon it. This track was for a small derrick car, the purpose of which was to pick up the plates forming the shell, carry them to place, and hold them in position while being bolted up ready for riveting.

A slot, 2 by 8 inches, was cut through the caps where their centre lines intersected the perimeter of the steel shell, and a casting, through which "hanger rods" worked, was set on each cap. The hanger rods were for holding a course of plates during riveting, supporting the finished shell until the river bottom was reached, and for controlling the movements of the shell until it rested on bed-rock. The rods were 8 feet long, of 1½-inch steel, threaded, and an eye of Swede iron was welded to the lower end of each. Hook-plates, hung in these eyes, connected the hanger rods and the plates forming the shell. There were two hanger rods at each cap, four inches from centre to centre, one outside of the shell and one within it. The hook-plates covered four rivet holes, and were bolted to the steel plates while the derrick car held them suspended, the weight of the plates being transferred to the hanger rods by slacking the chain blocks with which the derrick car was rigged.

The plates were of ½-inch steel, 10 feet long and 5 feet wide; they were curved to a radius of 15½ feet, and weighed about 1,100 pounds each. There were 130 plates in the shell, thirteen vertical courses of ten plates each. The time required to swing the plates for one course from the storage yard to the derrick car, and to bolt them up ready for riveting, averaged about 2½ hours, or 15 minutes for each plate. Five courses were riveted up when the shell touched bottom. The weight of the shell caused it to penetrate the bottom to an average depth of one foot. A 2-inch water-jet was then rigged from a single-cylinder, 6-inch steam force pump, and by this means the material at the cutting edge was disturbed sufficiently to permit a further settlement amounting to about one foot.

Each outside hanger rod was then carried back to the pile carrying the cap from which the rod was suspended, and bolted to the pile, thus tying the inner end of the cap in place. Jacks were placed under each cap, resting on the edge of the shell, and the combined action of the water-jet and twenty jacks forced the shell about five feet farther into the bottom, the total penetration being at this time seven feet.

The shell was then pumped out. As the water was removed, a course of bracing was placed at each horizontal seam of the shell. This bracing was 12 by 12-inch hemlock, four timbers being set in the form of a square. Two squares were placed together, one being turned 45° about the centre of the pier, thus forming a star-shaped set of bracing, giving eight points of support to the sides of the shell, and leaving an octagonal central opening about 18 feet across.

Five days after the shell was cleared of water, the material under the cutting edge gave way, and the shell filled, the blow being confined to about 4 feet of the perimeter. This hole was carefully filled, and the shell pumped out again, only to blow out, about five hours later, at a different point.

At this time a flow of water within the shell was noticed, coming apparently from one of the holes left by the test borings, and being approximately equivalent to the flow from a 4-inch pipe. It was evident that there would be great difficulty in keeping the shell cleared of water, and an attempt was made to sink it still farther into the river bed. It was loaded with 175 tons of steel rails, the jacks were placed in position as before, and it was forced downward another 5 feet, the total penetration then being 12 feet. Another attempt to clear the shell of water, resulting in failure, indicated that the flow from the gravel had destroyed the integrity of the material within the shell. This method was abandoned and the work proceeded as follows:—

The overhanging caps were cut off, and two more courses of steel were riveted up. Timbers were placed across the top of the shell, and a tight floor, about one foot from water level, was hung from these timbers within the shell. A form was built, following the octagonal outline of the inner opening left by the timber bracing, and concrete was deposited between this form and the steel shell. Meanwhile, a derrick was erected on a fender crib which had been sunk immediately up stream from the pivot pier, and excavation was commenced within the shell, using an orange-peel bucket. The settlement of the shell was constant from this point, and, as it sank, the ring of concrete was carried

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