The Canadian Society of Civil Engineers.

INCORPORATED 1887.

ADVANCE PROOF—*(Subject to revision).*

TORONTO'S EXPERIENCE WITH CONDUITS,

With Description of Methods Adopted in Laying the 6-Foot Steel Conduit.

By C. L. Fellowes.

(Read before the Annual Meeting, January, 1906.)

In the year 1872, an Act was passed authorizing the city of Toronto to construct water works.

The Commissioners, after consulting Messrs. T. C. Keefer, of Ottawa, and E. G. Chesbrough, of Chicago, decided to adopt the plan recommended by them, viz., to construct a filtering basin on the south shore of the Island in the vicinity of the Light House, located about 80 feet back from the shore line. This basin was constructed some 2,700 feet in length parallel to the shore with an arm running inland a distance of about 400 feet. The dimensions were 24 and 80 feet, bottom and top widths, with a depth of 13.6 inches below zero level of lake. A 4-foot wooden conduit conveyed the water a distance of 6,000 feet to a connecting crib at Hanlan's Point; from this crib it was carried to the engine house well at the foot of John Street, through 4,095 feet of 3-foot cast iron flexible jointed pipe. This work was completed in 1875.

An attempt was made during the winter of 1875, between November and December, to ascertain what quantity of water the basin could supply by filtration. In making this test the water

was drawn down about 7 inches below the top of the 4-foot wooden pipe, which brought a considerable length of it, some 2,500 feet, to the surface. This was occasioned by the contractor's neglect to cover it with sand to the depth specified. The test, however, demonstrated that about 4½ million gallons per diem could be obtained, or about 1 million gallons more than the consumption per 24 hours. In order to increase this quantity, in 1877 two cuts were made out into the lake a distance of about 300 feet, in one of which was placed a 4-foot wooden pipe, bored with 2-inch augur holes spaced about a foot apart, and covered with gravel. The other cut was filled with small boulders and flat stones topped with gravel. With these additions it was found that 10 million gallons could be obtained.

These two cuts worked admirably for about a year, till 1878, when they failed. On examination they were found to be completely choked with sand, the department eventually being forced to abandon the basin and obtain the supply at Hanlan's Crib, until such time as a pipe could be laid out into the lake.

It was not till the year 1881 that work was commenced on what is known as the Lake Extension, the whole work being completed the following year. This extension consisted of some 2,300 feet of 6-foot wooden conduit, built up in lengths of 100 feet, and constructed entirely of oak staves, banded together with wrought-iron hoops 3" x ¾", spaced 2 feet apart, the pipe terminating in an inlet crib 40 feet square, 11 feet high, in 30 feet of water, with a centre well 10 feet square, covered with a grating into which the conduit opens. The portions of the pipe not protected by sand covering were anchored in position by cribs 22 feet square, filled with stone and spaced 100 feet apart.

In 1884 the manager reported the daily consumption to be about 12 million gallons and the capacity of the conduit system under the maximum head available during periods of low water about 13½ million gallons per day, to increase which he recommended the laying of a 4-foot cast iron pipe from the engine house well to the shore crib, a distance of 10,500 feet. It was not, however, till the year 1889 that any action was taken, the work then decided on consisting of the laying of a 5-foot steel pipe from the shore crib to Hanlan's crib, a distance of a little over 6,000 feet and a 4-foot steel pipe with flexible joints, from Hanlan's crib to the engine house well, some 4,400 feet more. It was also decided to extend the 6-foot intake pipe some 365 feet farther into the lake, where the water was 75 feet deep, the new intake being constructed with the opening some 25 feet above the bottom or 50 feet below the surface of the lake. This work was completed about August, 1891.

It was believed that with the above improvements completed, the city could rely on obtaining a supply of about 40 million gallons per day, or sufficient for a population of about 400,000 consuming 100 gallons per head per day. As the system then stood it consisted of 2,300 feet of 6-foot wooden conduit out into the lake with an extension of 365 feet of 6-foot steel conduit, then 6,060 feet of 5-foot steel conduit to Hanlan's crib and 4,400 feet of 4-foot steel conduit and about the same length of 3-foot cast iron pipe from Hanlan's crib to the engine house well.

In the fall of 1892, repairs required at the engine house well, necessitated the removal of the screens of the well, which were taken to the shore crib and placed directly over the entrance to the 5-foot steel pipe, a man being engaged to keep the screens free from weeds entering from the lake. This, unfortunately, was not done carefully enough, the result being that the entrance to the pipe became blocked with weeds, thus cutting off the supply, and causing 1,400 feet of the 4-foot pipe north of Hanlan's to come to the surface, with sufficient force to break its way through six inches of ice, the 5-foot pipe also rising in two places for a distance of 100 feet each. It might here be stated that up to the time of the accident, the Water Works Department was not under the control of the Engineer's Department, but immediately after the Engineer's Department was given control and the necessary repairs completed.

The examinations made of the conduit discovered, first, that the steel lake extension, which had been resting on trestles part of its length, had broken in two and was lying on the bottom and filled with sand. Second, that the level at which the 5-foot pipe was laid would not admit of more than 27 or 28 million gallons of water passing through it during periods of low water.

The city, prior to this rising, had been troubled with a large quantity of sand coming into the engine house well, which was attributed to a break in the old 4-foot wooden pipe at Hanlan's Point, caused by driving a pile through the pipe in extending one of the docks there, so that no further trouble was anticipated after the repairs had been made to the breaks in the steel pipe, the 6-foot steel lake extension restored, and the screens removed from the shore crib to the engine house well. Further examinations, however, of the 6-foot conduit from the shore crib outwards brought to light several openings at the joints, which were not bolted together properly (in one case there were no bolts coupling the pipe), and that there was a deposit of 2½ feet of sand in the pipe, extending at least from the shore crib to a point about 800 or 900 feet south or as far as the diver dare venture in. To remove this sand, manholes were sunk to the top of the pipe, and

openings made, into which the suction of a centrifugal pump was introduced (the diver manipulating it), and the sand pumped out between the shore crib and the lake shore. It was not possible to extend the pumping out into the lake, so that any sand beyond the shore had to be left, although it was known to be there.

On the 5th September, 1895, with the water in the lake 13½ inches below zero, 2½ feet of sand in the 6-foot conduit and a water logged plank 3″ x 16″ x 8′ 6″ standing vertically in the conduit at the lake shore manhole, the combination proved more than the system could stand and the 5-foot pipe rose in two places and the 4-foot one its whole length, cutting off the supply. Temporary relief was obtained by separating the 4-foot pipe north of Hanlan's so as to provide water for fires or flushing sewers, a limited domestic supply being maintained by water waggons. There being reason to fear a further fall in the lake (it dropped to 25 inches below zero), the means taken to maintain the supply were as follows. The old 4-foot wooden pipe was connected to the shore crib and at a point 2,500 feet north of the shore crib a small basin was constructed, both the 4-foot wooden and 5-foot steel conduits were opened and disconnected in this basin and made to discharge the water delivered by them into it, the supply from this point going to the city through the 5-foot steel conduit as formerly. The effect of this, in the reduction of friction head, was the same as if the lake level had been raised two feet. After the repairs were completed the conduits, where there was danger of their again rising from any cause, were covered with an embankment, and an electrical alarm and float placed in Hanlan's crib and connected with the main pumping station.

Mr. Mansergh having reported in favor of Mr. Keating's recommendation of a tunnel under the Bay, connected with a 6-foot steel conduit carried across the Island and out into the lake, as the proper means of supplying the city needs, contracts were let in 1896 for the construction of the pipe, tanks, flexible joints and connections, necessary for carrying a new 6-foot steel conduit out into the lake and connecting it with the 5-foot steel conduit and 4-foot wooden conduit at the existing shore crib. Contracts were also let for laying these and the work was completed by the 14th September, 1898. In doing this work the contractor was required to disconnect the 365 feet of 6-foot steel conduit from the old 6-foot wooden conduit and connect it to the new 6-foot steel conduit, the construction of a new intake and 365 feet of steel conduit being thereby rendered unnecessary.

In 1904, the city determined to proceed with the construction of the tunnel under the bay and the 6-foot steel conduit from the shore crib across the Island to the south tunnel shaft. Contracts

were accordingly let for the construction and delivery of the 6-foot conduit and the necessary valves and expansion joints. The conduit was specified to be of ½-inch "Railway Bridge" steel, rivetted together in 60-foot lengths, having 5″ x 5″ x 1″ steel flanges drilled for forty-four 1¼-inch bolts with lead gaskets, each length of pipe to be tested to a pressure of 25 lbs. per square inch and to be coated both inside and out with mineral rubber asphalt at a temperature of 300 degrees. It was constructed in Pittsburgh, as were also the expansion joints; the valves, of which there were two 6-foot and two 5-foot, being built by the Bertram Engine Works of Toronto. As nearly all the material was delivered on the site of proposed work by September of 1904, tenders were called for the laying of the conduit and the work awarded to Mr. Frank Simpson, of Toronto. The plant used consisted of one land clam shell dredge or derrick; one floating clam shell dredge; a dipper dredge (not much used); a pile driving scow of unusual construction; a couple of scows for divers to work from, and a pontoon for lowering the pipe in place, constructed of two of the 60-foot lengths of steel conduit with buttons on each end, made perfectly watertight and held in place by means of wooden saddles placed at intervals transversely with a space between of sufficient width to enable a length of pipe to be floated in, the buttons taken off and the pipe lowered in place by winches.

The contractor commenced work at the north side of the shore crib (where the land clam shell was built), uncovering the branch on the north side of the shore crib provided for this extension, so that a flexible joint could be connected to start the conduit in the direction required; the trench was at this point about 15 feet deep from the surface of the ground and about 80 feet wide on top and not less than 12 feet on the bottom. The material consisted of sand and gravel, chiefly sand. The excavation was specified to be carried down 2 feet below the grade line of the bottom of conduit and at the joints not less than 5 feet, to enable the divers to screw up the bolts and nuts on the under side as well as to enable the inspector to examine the same. As soon as the excavation had advanced sufficiently, the pile driver was brought up and work commenced on driving the pile bents upon which the pipe was laid. The bents were spaced 20 feet between centres. The piles were 10 feet long and spaced 6 feet centre to centre and held together with a 12 x 12 cap 6 feet long, rag bolted to the head of each pile. Each set was brought up and placed in the lowering frame, a piece of pipe attached to hose of sufficient length and connected with the force pump, was lashed alongside each pile and as soon as the frame carrying the bent rested on the bottom and was in proper alignment, the pumping began. In

order to prevent the bents from floating up during pumping operations two hammers weighing about a ton each were lowered on the cap immediately over the head of each pile. A level and rod with a disc were used to set the piles, the rod resting on the cap, and on a signal from the leveller the pumps were stopped as soon as the bents were within 6 inches of the correct level, the last five or six inches being hammer-driven without the use of the pump. Sometimes a bed of large gravel would be struck, in which case, if sufficient pressure could not be obtained, the hammers were raised two or three feet and dropped on the piles till driven through it. In the meantime men were employed placing buttons on the ends of pipe ready for launching, and when a sufficient number of piles had been driven, the pontoon with the pipe in slings was brought up, the gaskets fastened on with thin wire and the pipe lowered by winches, the diver inserting four long bolts and drawing the pipes together, when the slings were cast off and the remaining bolts put in and screwed up. Three divers were employed, two completing the joint and the third coupling the next length of pipe ahead.

The conduit as laid, extends from the shore crib to the south tunnel shaft, having a 6-foot valve placed just north of the small basin, with the 5-foot branch and valve connecting with the basin, a second branch and a 5-foot valve being inserted about 300 feet south of the tunnel shaft.

The 5-foot branch with valve opposite the basin was provided in order to utilize the new 6-foot conduit to this point, by allowing it to discharge into the basin till such time as the tunnel was completed.

As soon as the conduit was covered as far as the basin, the 6-foot valve just north of the basin was closed and the pipe between the shore crib and the basin pumped out and carefully examined from the inside. Any small leaks found were then caulked.

Just before bringing this portion of the conduit into use, it was flushed out with clean water and the entire surface scrubbed down with brooms, after which it was filled and the 5-foot valve on the connection into the basin opened.

It might be of interest to know that the greatest number of pile bents driven in a day was eleven, and generally two pipes were laid during the same time. Anchor piles, 20-ft. long were also driven where the pipe crossed open channels upon which it was impossible to place fillings. These piles were driven one on each side of the pipe with a timber bolted to them over the top of the pipe to hold it down, and at the level of the bottom of the

excavation a stick of timber 8 feet long, placed lengthwise of the pipe, was bolted to each pile, forming an anchor or dead man. The anchor piles were spaced longitudinally 15 feet apart and the filling carried up to the level of the top of the pipe.

The cost of the steel pipe delivered in Toronto was $14.48 per linear foot. The cost of each expansion joint was $586.00; the 6-foot flexible joint $400.00; the 6-foot valves $1,580.00 each; the 5-foot valves $1,020.00 each. The cost of the pipe includes the cost of some seven or eight manholes and two branches. The contract price for laying it was $84,745.00.