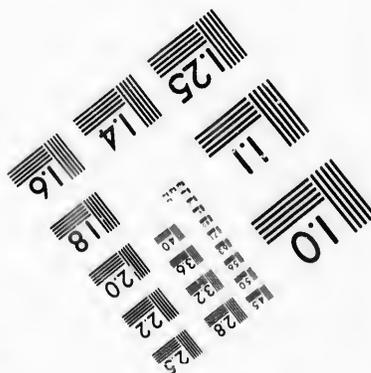
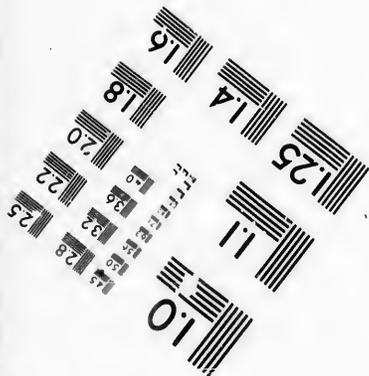
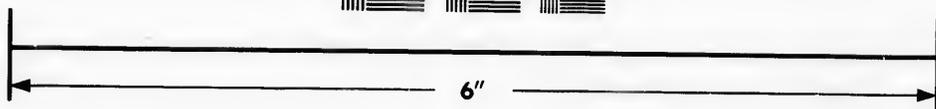
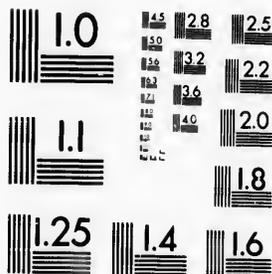


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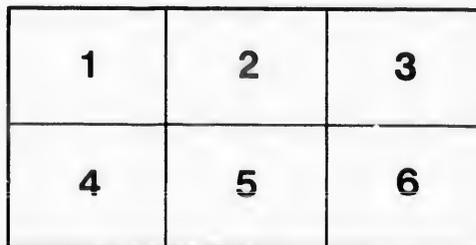
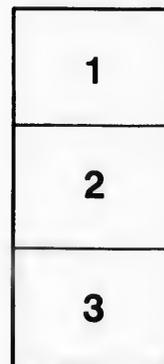
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Canadian Society of Civil Engineers.

ESTABLISHED 1887.

To be read on 6th or 20th October.

CONSTRUCTION OF A GUARD LOCK.

By L. N. RHEAUME, M. CAN. Soc. C.E.

The work being carried out at the Head of Rapide Plat, a distance of about three and a half miles above Morrisburg, Ontario, consist in the enlargement of a channelway, the construction of a new lock, the conversion of the old lock into a supply-weir, and the building of a guide-pier at the upper entrance of the canal.

The full extent of the section, now under contract, is 2950 feet in length, and the total cost is estimated at about a quarter of million of dollars.

To give in detail an account of the different classes of work would prove somewhat voluminous, and the scope of the present paper will, therefore, be confined to a description of the construction of the new guard-lock.

The location of this structure is immediately north of the old lock, the length of its walls is 363 feet, the distance between gate quoins is 270 feet, the width between side walls is 45 feet, and their thicknesses at the base are, in the chamber 8 feet 9 inches, in the recesses 10 feet, recess buttresses 13 feet 9 inches, and the counterforts are 3 feet in width by 6 feet in length. The height of walls is 23 feet, and the level of the mitre sills is 8 feet below those of the old lock.

The excavation of a lock-pit has met with some unforeseen difficulties, causing delay and necessitating operations of varying character.

For a depth of 7 feet, the material being of ordinary formation, ploughs and scrapers were used; but in excavating lower down, picks and shovels were resorted to, and the progress of the work was thereby materially impeded. Below the above mentioned depth, the material met with consisted of clay, gravel and boulders firmly cemented together, and an occasional pocket of quicksand of no greater extent than a few cubic yards. The material when exposed to the wash of water would loosen, so that portions of it could be pumped out; but immediately after it became dry, it would assume the form of a rubber clay which, when exposed to the sun, would become as hard as ever.

Experiments were made by blasting it with dynamite, and proved unsuccessful except in winter, when parts of it were frozen hard.

The required depth of 25 feet having nearly been attained, pump holes were dug at each end. Two pumps were erected for the purpose of keeping the lock-pit dry.

When the full width towards the south side was reached, fissures and leaks were discovered, proceeding from the foundation and chain wells of the old lock, which lay south within a berme of 16 feet on top. The leaks proved of sufficient magnitude to endanger the north wall of the old lock and a change in the method of working had to be made. It was found necessary to extend the lock-pit 10 feet further north, and a dam was erected throughout the whole extent, to protect the south bank of the pit.

In order to form the dam, piles 26 feet long and 12 inches diameter, with cast iron shoes weighing 27 pounds, were driven every 4 feet at the foot of the south slope. A special pile driver was constructed for that purpose, with a hammer weighing 1800 lbs. The pile driving extended over a month. An average number of about six piles per day were driven, and the number of blows given to each pile often averaged from 80 to 105. With a fall of 15 to 20 feet, the first blow drove the pile 6 inches to 1 foot, and at the last blow $\frac{1}{2}$ an inch.

The piles were braced together, throughout their whole extent, by round timber waling pieces, firmly bolted at the crossing of each pile.

The piles were driven to a depth of about 12 feet, the remaining 14 feet standing above the surface. They were prevented from spreading by iron straps and rods, in the following manner:—

Along the face of the north wall of the old lock, 18 inches below the top of the coping, holes 12 feet apart were drilled 1 foot deep. Flat iron straps 16 feet long, 4 inches wide and $\frac{1}{2}$ inch thick were secured to the wall with 12 inch fox-tail bolts. At the end of these straps, a set of three connecting rods of $\frac{3}{4}$ inch iron were hooked through holes punched so as to retain the full strength of the strap. The end of the rods passed through the head of a pile securing it by means of an iron nut and washer. On the inner face of the piles, three rows of 4 inch plank waling pieces were spiked and afforded a bearing to a double row of 2 inch sheet piles driven, each plank breaking joint over the other. Inside the sheet piling, puddle was rammed down to an average height of 4 to 6 feet.

The dam being complete no more fears of leakage were anticipated, the unwatering of the lock-pit was resumed, and without further delay the entire excavation of the pit was concluded.

The operations of building the lock foundation were then proceeded with as follows:—

1st. Six pile trenches from 3 to 4 feet wide and $4\frac{1}{2}$ feet deep were excavated, one at each end of the lock-pit 50 and 73 feet long respectively, and two at each end of the two mitre sill platforms 73 feet long. In each of the trenches an anchor timber of pine 12 inches square was placed, embedded in cement grouting 3 inches thick. In the end trenches, the anchor timbers afforded a proper bearing for the sheet piles, and in the trenches on either side of the mitre sill platforms 14 feet apart, 3 anchor screw bolts 5 feet long and $1\frac{1}{2}$ inches diameter were secured to the timbers by means of a heavy nuts and washers. Pine sheet piles, 4 inch in diam and 6 feet long, were driven so as to bear against the timbers, the toe of each pile being bevelled off 6 inches, and embedded in cement mortar.

The trenches were filled to the top and closely packed with concrete. A space of 2 inches between the inner face of the piles and the trench was filled with cement grouting, thus making the whole perfectly water-tight.

2nd. Over the whole extent of the lock-pit, a stratum of concrete 9 inches thick, and averaging from 65 to 73 feet wide, was carefully packed down to a uniform level.

3rd. Two mitre sill platforms 14 feet wide, made up of pine timbers 12 inches square and 72 feet long, and well jointed with a plane, so as to make joints water-tight, were then laid. Each of the platforms were secured by five wrought iron screws bolts $1\frac{1}{2}$ in. diameter, passing through horizontally. Both ends of each of the three middle bolts had double nuts and washers, and formed connection with heavy iron shackles 12 inches long and $1\frac{1}{2}$ square. They were secured to the anchor running through the timbers at the bottom of the trenches.

Each platform was raised sufficiently to admit the spreading of thin mortar over its berth.

Hydraulic jacks were used in lowering the platforms which were well beaten down to their proper bed and bearing on sub-sills 4 inches thick embedded in mortar.

The joints throughout were caulked with two threads of oakum, and the piles on each side of the platforms were secured with 7 inch iron spikes.

4th. The remaining part of the foundation consisted of 12 inch square pine timbers of full length to reach across the space occupied by the walls, laid on two rows of 4 inch sub-sills under the seat of the walls. The sub-sills were embedded in $1\frac{1}{2}$ inch cement mortar and the timbers placed crosswise on top, 6 inches apart, being also embedded in $1\frac{1}{2}$ inch of mortar.

The spaces between the timbers were carefully packed with concrete and a layer 1 inch thick of cement mortar to level off. The top of each timber was dubbed to a uniform surface, so as to ensure a true bearing for the planking.

At each end of the foundation the sheet piles were secured to the adjoining timbers with 7-inch spikes.

5th. The mitre sills were of white oak timber, framed, morticed, tenoned and dressed with a plane. The main sills were 49 feet long, and 19 x 16 inches square, the mitre sills, main braces and side braces were 19 inches square, and of such length as to correspond to an angle of 27° 30' from the half width of the lock. A cheek 3 inches

deep was cut in the lower edges of the mitre sills to let in the plank-ing.

Before putting the sills together, a check 3 inches deep by 19 inches wide was cut into the platform, and a strip of canvas saturated in boiling tar was placed in the check so formed. Into this the mitre sills were tightly embedded. All mortises, tenons and joints of the sills were coated with white lead.

Each sill and brace were connected and fastened with straps of iron $3\frac{1}{2}$ inches wide and $\frac{3}{8}$ in. thick, let in flush and fastened with rag bolts 28 inches long and $1\frac{1}{2}$ in. diameter.

6th. The flooring consisting of 3 inch pine plank was then laid over the whole area of the foundation. Each plank was jointed with a plane, and driven up with wedges to water-tight joints, every 3 feet in width breaking joints at 4 feet, and spiked down with 7 inch spikes, two at each end of a plank and one at every crossing of timber.

The above concludes a full description of a perfectly uniform and water-tight foundation.

The masonry of the lock was built of limestone in courses varying from 29 ins. to 15 inches.

The principal cut face stones and gate quoins were of the best gray limestone. The gate or hollow quoins were 5 ft. long and 6 ft. deep. The nose of the quoins being rounded to a radius, starting at $13\frac{1}{2}$ ins., and gradually decreasing upwards to a radius of 6 ins. and the hollow was dressed to a radius of 8 ins.

The recess quoins 5 ft. long and 6 ft. deep were cut to an angle forming a recess of 3 ft. 9 ins. in depth at the base, and decreasing upwards according to the batter of the chamber wall which was 1 in 24.

The chain-well sills averaging 7 ft. in length were cut on an inclination, suitable to the angle required to admit of the play of the chains for the lock-gates.

In building the lock-walls, the four hollow or gate quoins were first located, and in each a check 2 feet long, 19 ins. x 19 ins., was cut to receive the ends of the mitre sills. The recess quoins chain-well sills and stop log grooves were then located. At each end of the lock chamber walls, two stop log grooves 1ft. wide, $15\frac{1}{2}$ ins. deep at the base, were cut into the face and carried up plumb making them at the top 4 ins. deep. Both stop log grooves were 3 ft. apart.

All the principal face stones having been located, the backing was laid, allowing an equal proportion to be built on either side each day.

In rear of the walls, at every 12 feet, counterforts 6 ft. long and 3 ft. wide were built throughout the chamber up to a height of 18 ft.

The recess abutments were 50 ft. long and 6 ft. from each end, a chainwell of cut face stone 2 ft. square was formed to connect with each inclined tunnel below.

The position of the chamber, recess walls and counterforts being secured, wing walls on the north side and at upper end of the south side 18 ft. long and cut to radius of 45 feet, were then located in their place. The lower end of the south wall forming almost a semi-circle of a radius of 17 ft. $11\frac{1}{2}$ ins. at the base, was completed at a later date on an extended foundation similar to that of lock chamber.

The lock-walls comprised 13 courses, varying from 29 ins. to 15 ins., diminishing upwards. Each course was successively built, and from the height of 18 ft., a frost batter at the rear was formed up to the top of the coping, except around the chainwells, which were carried up plumb to the coping.

All quoins were laid alternately headers and stretchers, headers being checked so as to bond one foot over the face stones of the recess.

Throughout the walls, no face stone less than 3 feet was allowed, each stone in every course bonding more than 1 foot over the subjacent stone, and headers being placed 11 feet apart from centre to centre. All vertical and horizontal joints were $\frac{3}{16}$ in. thick.

The coping of the chainwells were cut semi-circular to a 6 ft. radius, and the man holes circular, 2 ins. in diameter.

The remaining portion of the coping was 4 ft. wide on top, its inner arris, next the lock, being rounded off to a radius of 3 inches.

A dowel 4 inches long and $1\frac{1}{2}$ in. diameter was inserted in every joint 15 inches back from the inner face and 1 inch below the top line. A hole was drilled through the middle of each cope stone, nine inches into the course underneath, and 20 inches back from the face, into which a bolt of $\frac{1}{2}$ inch diameter, 18 ins. long, was driven when hot, and the space over and around it filled with melted sulphur mixed with sand.

The mortar used throughout the masonry was made of the best Canadian cement mixed with clean sharp sand, in the proportion of two of sand and one of cement, except in the coping joints where the mixture was one of sand and one of cement.

During the progress of the masonry, puddling in rear of the walls and counterforts, 3-ft. deep, was carried up to a height of 18-ft. A 2-inch pine flooring was also laid, breaking joints both lengthwise and transversally with the 3 in. flooring underneath.

At each end of the north wing wall, a rock face wall of random coursed masonry was built in the shape of a reverse curve. The portion connecting the lock was a continuation of the curve of the wing wall for a length of 13 ft. 9 ins., and from thence a reverse curve was carried on for a length of 86 ft. 6 ins.

The thickness of the retaining wall at the base was 8 ft. 9 ins., with a face batter starting at $\frac{1}{2}$ in. and ending at $1\frac{1}{2}$ in. to the foot. The back of it was built plumb up to 18 ft. high, and from thence a frost batter was formed up to 23 ft. high, varying in width from 3 to 5 feet. The top of the coping was 3 feet wide.

At the end of the above, a cross wall with steps 16 ins. high was built on an inclination corresponding to the adjoining slope of the bank of the channel way. The thickness of the wall was 8 ft. 9 ins. at the base, with a face batter of $1\frac{1}{2}$ ins. to the foot, and in rear a frost batter was also carried up to the top of the step coping.

The foundations of both retaining and cross walls were built in a manner similar to that of the lock, with the exception that the timbers were placed 1 foot apart.

From the end of the South-East semi-circular wall, a rock face wall of random coursed masonry was also built to make connection with that of the old lock. Its foundation was similar to that of the retaining walls. It was built in two portions, the former, 16 ft. long, stepping up 6 feet above the lock foundation, and the latter portion, 49 feet long, stepping up 2 ft., being on the same level of the old lock walls.

For the erection of the latter, a pile dam had previously been built.

At the upper end of the South-West wing of new lock, a square face return wall was carried up plumb to the same height as lock walls. Its thickness at the base is 9 ft., and it has a frost batter similar to the adjoining walls. Its length is 32 feet. To ensure the erection of this wall, a pile dam had also been built.

From the end of that upper return wall will commence the abutment of the proposed supply-weir.

The construction of the supply-weir, as well as that of the lock-gates and cross-dams, will form a subject which it is proposed to describe at some future date.

