SEWER OUTLETS AT NIAGARA FALLS, ONT.

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The accompanying illustrations and the following description apply generally to the three outlets, the distances of course varying somewhat with circumstances.

At points in the river water, which skirts the Canadian bank of the river, vertical shafts 5 x 7 ft., as shown in the longitudinal section, are sunk to a depth equal to the height of the cliff. These are lined at the top by 12-in. brick walls, backed by concrete, and supported by four-course arches set in the rock. The trunk sewers and each other drains as were necessary are securely built into this lining, also iron steps and platforms for purposes of inspection. The covering consists of 1-beam and back plate, filled in with concrete and macadam pavement, a cast iron manhole top and cover. The Samuel Alberga 5 ft. deep. The base are solid constructions of paving brick set in concrete backing, with such curve as to form a bump and water cushion from 2 to 3 ft. deep, as the case demands. On the river side of each shaft is a heavy brick wall, with an arch to hold the overhanging rock wall.

From the base of the cliff a tunnel 5 x 6 ft. in section was driven to the bottom of each shaft, and on a grade of 10%. This was lined on the top, only, by an invert consisting of one ring of paving brick laid as stretcher and set in concrete, as shown in the cross-section. In the case of the two smaller trunk sewers, a smaller invert is formed by concrete. At the portal of each tunnel a chamber is built, having in front a heavy iron retaining wall, 4½ ft. thick at the toe, and built into the rock face of the cliff so as to securely support the hanging wall. The interior part is built of brick, backed with concrete, and has steps and supports for a platform. An arch opening, 6½ x 4 ft., is made in the retaining wall to afford ventilation, means of overflow, and access to the interior. This is covered by a grating on the river side. For purposes of inspection, an iron ladder is built into the retaining wall.

One of the most novel features of these outlets is the means of getting down the slope or talus of the river gorge. The material composing the slope has assumed an angle of repose of about 35°. From examinations which have been made in places in the gorge, it appears that the solid rock shows some profile as is indicated, and that the regular slope is formed over this, consisting of loose stones, detritus and earth. Percolating through this loose material is a considerable amount of water, arising from springs in the cliffs and rocks, all of which is impregnated with lime. In view of these difficulties, the design of a substantial and economical culvert down the talus demanded careful attention. Masonry, either brick or stone, was out of the question, unless it were possible to excavate through the loose slope to the stable rock foundation beneath, a work of uncertain and very costly extent. Cast iron pipes of a sufficiently large size were not considered practicable, on account of their weight and inextensibility. In an unstable ground, they being very liable to part at the joints. Riveted plate pipe would, it was considered, be quickly attacked by the quantities of lime water coming through the slope, and would very soon become disjointed and collapse. The design as now constructed is of wood stave pipe, built of first quality pine, of staves 4 in. thick, the whole hauled every 2 ft. with round iron, as shown in the illustration.

In two of the outlets the interior size of this pipe is 2 ft. (the sewer being 15-in. pipe and 24 x 36-in. brick) and in the third, 3 ft. (the sewer here being 30 x 48-in. brick). The staves of the pipe are larger than required, but experience with other small pipes down these slopes has shown that gorging frequently occurs, and when such is the case the matter is serious under such velocity. It is claimed for this design that the pipe is very strong, is comparatively light, is enduring, being preserved rather than attacked by the water and moisture, is flexible throughout, and is perfectly smooth, offering but little resistance to the passage of water. The rear end of the sewer is reduced to a minimum in these outlets on account of the extreme angle of the grade and the fact that the system, being separate, carries but little sand or silt, and that only occasionally.

In the construction it was necessary to excavate from the top of the talus downward and construct the drain from the bottom. A firm foundation for the anchorage at the water's edge was obtained upon a bed of boulders in shale and gravel. The anchorage consists in each case of 70 cu. yds. of stone masonry, and the pipes are firmly embedded in the main portion and anchored by two cast-iron collars. Another collar is placed above each anchorage at a distance of 14 ft. and supported by posts from the face of the masonry. A water channel 3 ft. deep was obtained at the foot of the pipe.

The lengths of the staves in the pipe varied from 14 to 16 ft., and they were cut to a width of 6½ ins. on the outside face. The staves were painted on all surfaces with two coats of carbolinum, and joints were made in white lead, end joints being secured by a steel tonguing. The staves were lowered over the cliff and built into the work singly, as the pipe could not be built in sections. The inclination at which the work required to be carried on rendered it doubly difficult, especially in the unstable material. The mud sills, 10 ft. apart, were first set to grade, the bottom section laid thereon, and templates placed, when the upper staves were put in place, the last ones requiring to be driven home beneath the loosened bands. When the staves in a section were all in, they were driven to their true position from the interior and the bands tightened, after which the back filling was proceeded with, from the bottom upward.

The two outlets now built under this design have cost about $3,000 each. The sewerage system has been carried out under the direction of the writer as chief engineer.