BACKFILLING THE RED RIVER TUNNEL

Concrete Poured Around 60-In. Cast-Iron Pipe in 10x10-Ft. Rock Bore by Dropping it 70 Ft. From Trestle Across River

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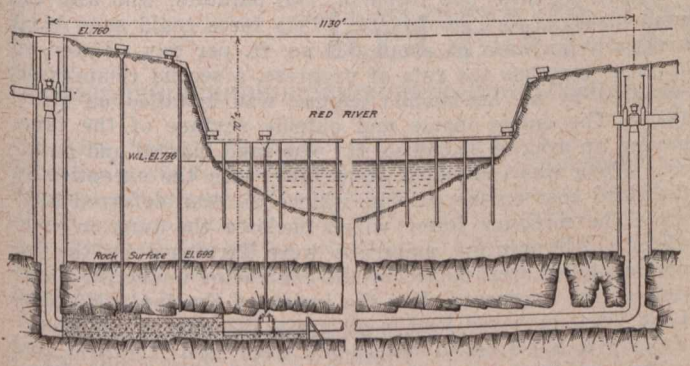
OVER 1,100 ft. of the new Winnipeg aqueduct is in tunnel under the Red river, with the roof of the tunnel about 70 ft. below the high part of the ground and 40 ft. below the river level. The 60-in. cast-iron pipe carrying the water was concreted here into the 10 by 10-ft. tunnel by concrete dropped through holes bored at intervals from the surface.

The tunnel bore is through the solid limestone rock, the rock roof being some 17 ft. in thickness, with overlying soils of various clays, silts, and other river deposits. The rock was found to be fairly hard but badly seamed both horizontally and vertically and containing many pockets of varying size up to two or three cubic yards, evidently the result of water action at some remote period, but now filled with a white, chalky clay. The first 400 ft. of the tunnel from the eastern end discharged considerable water into the boring from these seams, although not in sufficient quantity to require the aid of compressed air, a 4-in. submerged centrifugal pump handling the water at all times with ease. The remaining 600 ft., although seamed and checked, seemed tighter, and comparatively little water was added from this portion.

Practically Perfect Hydrostatic Action

The original tunnel section was designed with a circular roof, but owing to the seamy condition discovered the section was changed to a 10 by 10-ft. square. The eastern shaft is some 2 ft. lower than the western shaft, to facilitate drainage during construction.

The water is conveyed through this tunnel in a 60-in. cast-iron lining. The contract required that after this lining was in place the remaining space in the tunnel bore be backfilled with concrete in such a manner as to guarantee an



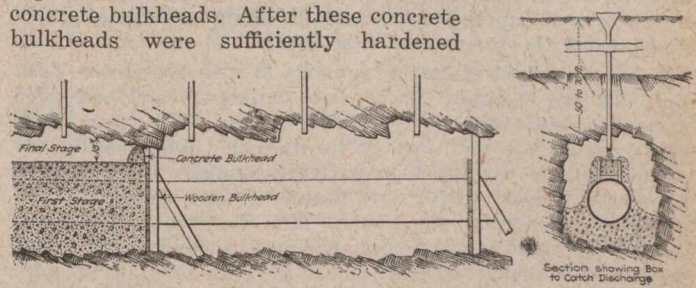
Section Through Red River Tunnel of Winnipeg Aqueduct, Showing Method of Concreting Pipe

absolute filling of all irregularities and pockets. The specifications specifically prohibited the use of compressed air in placing the concrete. After much study the method adopted was by means of well holes bored from the surface through the roof of the tunnel. These holes were drilled with an ordinary well-drilling machine and lined with a 6-in. well casing from the surface to the rock. The spacing of the holes was somewhat irregular but averaged 40 ft., the holes being bored to this spacing at the nearest high spot in the tunnel roof.

For the river crossing a light trestle was built consisting of two-pile bents spaced 8-ft. centres with four longitudinal 8 by 8-in. stringers to act as bracing and to bear the light industrial track carrying the concrete cars. A mixing plant was provided at each end of the tunnel consisting of a ¾-yd. mixer, industrial tracks and concrete cars of various types.

The first operation consisted in the pouring of a concrete floor in the tunnel carefully graded to facilitate the placing of the 60-in. cast-iron lining. This concrete, some 250 yds., was all poured down one hole at the western end and distributed by cars using the same track previously employed in the tunnel excavation and later used to transport the cast-iron pipe.

When the lining was in place the tunnel was bulkheaded off in sections of various lengths and concrete poured until within 18 ins. or 2 ft. of the roof. This was allowed to set and succeeding sections were poured. During the operation a concrete dam or bulkhead was built back on the set concrete, these dams being about 120 ft. apart, thus leaving three well holes between each two concrete bulkheads. After these concrete bulkheads were sufficiently hardened



Sections Showing Details of Concreting Aqueduct by Dropping Through Pipes

to withstand the pressure the final concrete was poured. The two end holes in each compartment were used to discharge the concrete, leaving the middle hole for observation purposes. In every instance when the end holes were filled the concrete rose in the middle or observation hole to the same level, showing a practically perfect hydrostatic action. As these holes provided a head of from 55 to 70 ft. of fluid concrete there seems no doubt that all cavities and seams adjacent to the tunnel section must be completely filled.

For pouring the floor and the main tunnel concrete a mixture of 1 cement to 4 of aggregate was used, all stones passing a ½-in. ring. The stone was kept small to avoid a possibility of choking the pipes. A fairly wet mix was used although nothing approaching sloppiness was required. Observation indicates that aggregate containing stone as large as 1-in. might be safely used in holes of 5½ or 6-in. diameter. Various devices were used to prevent any tendency to segregate the materials of the concrete, the most successful of which was a wooden box slightly larger than a standard nail keg fixed on top of the cast-iron pipe and directly underneath the pipe. The force of the concrete discharging into this box full of concrete gave the constituents a very thorough remixing. As a further precaution an inspector and two workmen were kept in the section being concreted, and properly distributed the concrete. These men were able to work in the concrete until it was within 3 ft. of the roof and it was at this stage the concrete dam or bulkhead was built on previously set concrete preparatory to the final or grouting operation. These men usually sank half way to the knees in the concrete, which will give some idea of the wetness of the mixture. Spouts with a hopper swiveled under the holes were also used successfully but were awkward to handle and seemed to involve more extreme effort than collecting in the box and then working along by shovel and tramping. The inspector had a field telephone installed in the tunnel giving ready communication with the mixer when instructions were necessary.

Filling Top Three Feet

The final stage was the filling of the space left as just described, the mixture used being 1 of cement to 3 of aggregate, the aggregate being in district parlance "rejected sand"; in other words, the excess finer materials screened from the pit run during the process of assembling the standard aggregate. This material was fairly well graded from a coarse sand to fine sand. As before indicated, this concrete was poured down the two outside holes of a three-hole set. A few batches quickly formed a cushion under the hole thus preventing segregation, as was easily proved by samples taken from the middle or observation hole.