C A N A D I A N   E N G I N E E R I N G   H E R I T A G E   R E C O R D

THE RAILWAY TUNNEL AT BROCKVILLE, ONTARIO

March 29, 1974

Judith C.M. Roberts

CONTENTS

The Railway Tunnel at Brockville, Ontario

A. Introduction

The Historic Sites and Monuments Board of Canada referred the C.P.R. tunnel in Brockville, Ontario to the Canadian Engineering Heritage Record for study and evaluation. This report will outline the history of the tunnel.

B. Historical Background

During the 1850's the Province of Canada went through a frantic railway-building era. The rail mania swept through large centres and small towns alike. Everyone felt that the railway was the key to prosperity. The residents of Brockville were no exception. The town was on the path of the Grand Trunk Railway that was to run between Montreal and Toronto. As early as 1852 the town council approved a scheme to link Brockville by rail with a point on the Ottawa River. Acting as a feeder line to the Grand Trunk, the proposed railway would transport supplies to the lumber camps of the Ottawa Valley and return the timber for loading on the ships that docked at Brockville.

Accordingly, a bill to incorporate the Brockville and Ottawa Railroad (B.& O.R.R.) was introduced in the Canadian House of Assembly in Toronto on March 10, 1853.[1] Money to finance the project came from the town of Brockville and adjacent municipalities, with help from the Municipal Loan Fund. Sykes, DeBergue & Company of Sheffield, England were awarded the contract to build and equip the road from Brockville to Pembroke, with a branch line from Smith's Falls to Perth. This company was obliged to obtain additional capital from British sources. An air of optimism must have prevailed, because the contract called for completion of the railway within three years at a cost of £930,000.[2] Work on the right of way began almost immediately.

C. The Old Tunnel, 1854 - 1860

c.1 Completing the Tunnel

The Brockville and Ottawa Railroad Company had planned to build their terminal and roundhouse near the waterfront. A steep bluff prevented direct access to the waterfront. The builders had to choose from two alternatives:

a) they could excavate their way by means of a tunnel under the centre of the town; or

b) they could use a western, more rambling approach crossing the rear of the town.

The contractors favoured the more direct tunnel method. Perhaps this decision reflected the railroad philosophy that no railway would be complete without a tunnel. Accordingly, the cornerstone was laid on September 16, 1854, with pomp and ceremony.

Work proceeded on the tunnel, directed by an English firm of sub-contractors, J.& D. Booth.

In mid-1855 the railroad company ran into financial difficulties, and the excavation was halted. By 1857 the company had resolved most of its problems, and work was resumed. The tunnel was officially opened on December 31, 1860. In 1881 the C.P.R. assumed responsibility for its operation and maintenance, and still retains ownership today.

c.2 Physical Description

The finished tunnel was arch-shaped, measuring 14ft. 9in. from the top of the arch to the ground and 14ft. across. The overall length was 1,721ft., and the tunnel contained a single track. The tunnel was completely lined with stone held together by water lime. At either end the tunnel was faced with limestone, the southern end being more extensive than the northern. At the northern approach to the tunnel, there is a stone retaining wall on either side of the track. The tunnel possessed a unique feature, wooden doors which were locked at night. The doors maintained an even temperature in the tunnel and prevented stray animals from wandering into the structure.

c.3 Method

Since records on the building of this tunnel do not appear in the C.P.R. files, the method of construction is not clearly known. One can only speculate. At that time, dynamite was unknown; nitro-glycerine was not ready for use in blasting; rock-drilling machines were in a primitive, experimental stage. [3] In the case of this tunnel, the contractors "blasted their way through the rock and earth". Water apparently was a problem. At one point a steam engine had to be erected at the top of a shaft. Water was then pumped out of the shaft, and the blasting resumed. [4]

c.4 Designer

There were two engineers involved. Samuel Keefer was the Consulting Engineer for the B. & O.R.R.; at the same time he was Superintendent of the Grand Trunk Railway from Montreal to Kingston. George Dixson, a former employee of the contractors, Sykes and DeBergue, was Resident Engineer of the B. & O.R.R. Since the idea for the tunnel rested with Sykes & Co. [4], it is quite likely that Dixson was the designer of the tunnel. In fact, the town council instructed him "to prepare the plans for the tunnel line" late in 1856.[5]

D. The Tunnel Today

d.1 Operation

Up until 1954 the tunnel was in use. For about ten years after that, diesel switching engines ran through the tunnel. Since then, it has rarely been used, and the doors remain locked.

d.2 Condition

Because the boards of the doors are split at the top, entrance can be gained. Several planks have been torn away. The tracks that extend as far as Block House Island are still in place. Water has seeped through the walls of the tunnel and lies on both sides of the track. Litter also covers the ground. Outside, a number of stones are missing from the facing. In addition, one of the lampposts has been removed.

E. Present Status

Local interest in the tunnel is growing. Since Canadian Pacific has no need of the tunnel now, it is willing to sell it to the City of Brockville for $1.00 provided that the City takes over complete responsibility. The City is not too sure of what it can do with the structure. Inquiries were made to Heritage Canada but the latter is not yet in a position to help financially. Therefore, the Rideau Lakes and Thousand Islands Tourist Council is to ask the Ontario Ministry of Industry and Tourism to conduct a feasibility study of the tunnel. It will assess its tourist and historic values as well as the costs for repair and maintenance. It will also consider the future use of the tunnel as part of a rapid transit system for Brockville. The province will pay for the entire study which will take several months to complete.

F. Conclusion

A number of publications proclaim the railway tunnel to be the oldest of its kind in Canada. This is undoubtedly true as the Ontario Archaeological and Historic Sites Board has put up a plaque to commemorate it as such. Some have even thought it to be the oldest in North America; however, this is not true. The oldest tunnel is in the United States where it was built for Allegheny Portage Railroad during 1831-33.7.

Tunnels were to become a feature of Canadian railroads. In 1854, though, this type of engineering was relatively unknown. Canadian engineers had little experience with tunnelling; bridges & canals were more their area of expertise. What little they learned was probably from books on European rail systems, from contact with English engineers who had worked on tunnels or from working on American railways that incorporated this feature.

The engineers for the Brockville and Ottawa probably had little such experience. Yet from the limited information available, they managed to construct a tunnel which is still standing over one hundred years later. It's a pity more technical information was unavailable for evaluation. The engineers seemed to have encountered no unique problems in construction. Work proceeded in a straightforward manner as long as enough money was forthcoming. While there were other Canadian railway tunnels that were longer or posed more complex engineering problems (e.g. LeMont Royal tunnel, the St. Clair tunnel), the Brockville tunnel remains the oldest in Canada and a testimonial to early railway engineering in Canada.

Footnotes

1. The Recorder, Brockville, Ontario, March 17, 1853.

2. Ibid., September 8, 1853.

3. Gösta Sandström, A History of Tunnelling, London: Barrie and Rockliff, 1963, pp. 283,96.

4. The Recorder, April 29, 1857.

5. Ibid., December 18, 1856.

6. Among them: The Recorder, October 26, 1854; Ruth Mackenzie, Leeds and Grenville: Their First Two Hundred Years, p. 142; Adrian G. Ten Cate et al., Brockville: a Pictorial History, p. 76; Philip Mason, The Scenic St. Lawrence, p. 81.

7. Sandstrom, p. 95.

WORKS CONSULTED

1. ________________. Collier's Encyclopedia, Vol 22. Crowell-collier Publishing Company. 1965.

2. ________________. Encyclopedia Britannica, Vol. 22. William Benton, Publisher. 1968.

3. Bibliographical List of References to Canadian Railways, 1829-1938. Ottawa: King's Printer, 1938.

4. History of the Railway Tunnel at Brockville. Brockville: Chamber of Commerce. 1970.

5. The Recorder. Brockville, Ontario. 1852-1861.

6. Breithaupt, William H., C.E. "The Railways of Ontario", reprinted from O.H.S. Papers and Records, Vol. XXV (1929).

7. Canada, Dept. of Transport. A Statutory History of the Steam and Electric Railways of Canada, 1836-1937. Ottawa: King's Printer. 1938.

8. Canadian Pacific Railway. Annual Report. Montreal. 1883.

9. Canadian Pacific Railway. Official Memorandum. Montreal 1882.

10. Gibbon, John Murray. Steel of Empire. New York: The Bobbs - Merrill Company. 1935.

11. Glazebrook, G.P. de T. A History of Transportation in Canada, Vol. II Toronto: McClelland and Stewart Limited, 1964.

12. House of Commons. Sessional Papers Relating to the C.P.R., 1882-83, Vol. 12. Ottawa: Queen's Printer 1883.

13. Leavitt, Thad. W.H. History of Leeds and Grenville, Ontario, from 1749 to 1879. Brockville: Recorder Press. 1879.

14. MacDougall, J. Lorne. C.P.R.: A Brief History. Montreal: McGill University Press. 1968.

15. Mason, Philip. The Scenic St. Lawrence. Niagara Falls: Travelpic Publications. 1968.

16. McKenzie, Ruth. Leeds and Grenville: Their First Two Hundred Years. Toronto: McClelland and Stewart Limited. 1967.

17. Pennington, Myles. Railways and Other Ways. Toronto: Williamson & Co. 1896.

18. Sandström, Gösta E. The History of Tunnelling. London: Barrie and Rockliff. 1963.

19. Shanly, Walter and Francis Shanly. Daylight Through the Mountain, F.N. Walker, Ed. Montreal: The Engineering Institute of Canada. 1957.

20. Smith, Cecil, Ma.E. Railway Engineering. Toronto: Biggar, Samuel & Co. 1899.

21. TenCate, Adrian G. and H. Christina MacNaughton, Eds. Brockville: A Pictorial History. Kingston: Hanson & Edgar Ltd. 1972.

22. Thompson, Norman and Edgar, J.H. Canadian Railway Development from the Earliest Times. Toronto: The Macmillan Company of Canada Limited. 1933.

23. Trout, J.M. and Trout, Edw. The Railways of Canada for 1870-71. Toronto: Monetary Times, 1871. Reprinted by Coles Publishing Company, Toronto, 1970.

FROM - THE CANADIAN ENGINEERING HERITAGE RECORD 1974

Douglas M. Grant

Examination of Railroad Tunnel - Brockville, Ontario

In accordance with the terms of reference, this report considers two subjects:

A. An appraisal of the tunnel as a technological achievement, in the terms of the "state of the art", in the 1850's;

B. An appraisal of the stability of the tunnel in its present condition.

Background Information

Little information is available concerning the type of ground through which the tunnel was driven. According to CPR records of 1919, the tunnel was driven through clay for the most part with a short central section through rock (Figure 1). This information is supported by a visual examination of the tunnel which reveals that the lined sections of the tunnel co-incide exactly with the clay sections shown on the railway profile. There is a central 465 foot-long section of bare rock.

The clay is probably similar to the soil exposed in the open cut at the north portal; that is, it is probably stiff to very stiff*. The rock is a quartzite and is hard and sound.

Water seeps through the roof of the tunnel at various locations. It never exceeds more than a small jet at any one location, although water resembling light rain falls at a number of points. The

---

* With a shear strength exceeding 1000 psf.

water must carry calcium or even quartz in solution since hard, marble-like deposits have been laid over the brick lining and rock surface at many locations (see photographs). The amount of water falling in the tunnel seems to vary directly with the amount of rainfall. After a period of dry weather, the amount of water is very small indeed.

Even less information is available concerning the method of construction which was used. It is reported that the tunnel was started at the south portal and emerged at the north. It is apparent that the south portion between Water and King Streets was constructed as cut-and-cover.

As will be seen, however, the exact nature of the ground and details concerning the method of construction are of secondary importance. Subjects A and B can be resolved without this information.

A. An appraisal of the tunnel as a technological achievement:

Tunnelling through soil - whether it be clay, sand, silt, gravel, etc. - is referred to as soft ground tunnelling. This is to differentiate it from hard ground or rock tunnelling.

Hard ground tunnelling has been known in the mining industry for thousands of years. It was generally a slow, laborious process since the compressed air drill was not invented until 1849 and was not used in tunnelling until some 10 or more years later. It is likely, therefore, that "hand steeling" was used in the rock portion of the Brockville Tunnel.

Dynamite was not invented until 1864. Chances are that gunpowder would be used as the explosive in the hand steeled drill holes, gunpowder having been in use for two centuries prior to the start of the Brockville Tunnel.

Soft ground tunnelling in clay is usually straight-forward unless the clay is soft and the tunnel is deep. In fact, Trevithick was digging under the Thames in 1807-1808 in clay. The tunnel at Brockville is relatively shallow, less than 40 feet of soil/rock cover over the roof. If it is assumed that the maximum height of clay from ground surface to the floor of the tunnel is 50 feet, then the critical shear strength of the clay would be of the order of (assuming the clay weighs 110 pcf).

$$\frac{50 \text{ feet} \times 110 \text{ pcf}}{6} \approx 900 \text{ psf.}$$

In other words, in the deepest clay section the clay would have to have a shear strength of at least 900 psf. (unconfined compressive strength of 1800 psf.) if it were not to squeeze into the tunnel at an open, working face. It is very likely that the clay is at least this stiff. Even if the clay were softer than 900 psf., squeezing would only be a problem at the deeper sections. In the deep sections, tunnelling techniques were available to solve problems of this nature.

The art of soft ground tunnelling was perfected between 1800 and 1840 during the boom years in canal building. No doubt soft clay could be handled readily, using a shield if necessary. Even quicksand conditions were being handled by 1828. The first tunnel through soft, sandy ground (which is usually more difficult than clay), is reported to have been driven in 1803.

While we do not use the same methods to-day, methods were available by 1850 that could have handled the probable Brockville conditions without difficulty. Sandstrom sums up the state of the art thus:

> "By 1850 a respectable number of canal and railway tunnels had been built in England, on the Continent, and in the USA, and a great deal of experience in tunnelling had been accumulated. Whereas in nearly all countries miners were at first employed to advance the tunnels, now everywhere there were men skilled in driving tunnels of much larger areas than those used in mining. Special methods had been developed, particularly in respect of timbering, to overcome the obstacles encountered underground. Books began to be published, and methods were analysed and criticized."

Some idea of the extent of tunnelling by the mid-1850's, for railroads alone, can be had from the following data given by Sandstrom:

> "France had at least 126 tunnels totalling 135,000 ft.
>
> Austria had 60 tunnels totalling 43,300 ft.
>
> Italy had 32,600 feet of tunnel.
>
> And, Britain had completed a 3-mile long railroad tunnel through rock in 1845."

In the United States, Sandstrom claims, there were 29 railroad tunnels by 1850, along with 16 tunnels on the Croton aqueduct carrying water to New York. The first American railroad tunnel was built between 1831 and 1833 near Johnstown, Pennsylvania.

From the foregoing, it would appear that

(a) The design and construction of the Brockville Tunnel was probably a routine operation, given the additional fact that qualified engineers were available and that immigrants would bring the necessary construction skills with them.

(b) No engineering or construction innovations would have been necessary to cut the tunnel. This is not to say that innovations would not have been welcome from the point of view of economy. However, no data was found to indicate that anything new resulted from the Brockville Tunnel. Judging from the financial difficulties incurred by the original contractor, the old, slow costly methods were used.

(c) With the exception of the doors, which are unique according to Legget, the Brockville Tunnel appears to have no technical merits when compared with other tunnels in North America or elsewhere. The doors were not completely meritorious since they caused some additional expense, having to be opened every morning and closed every night during winter. One winter, the local roadmaster is reported to have decreed that the doors be left open to cut this expense. The water dripping from the roof of the tunnel promptly built up stalagmites of ice which had to be chipped away by hand at even greater cost. The order was promptly rescinded. As will be seen in the next section, a second possible technical merit is the fact that since the tunnel has stood up so well, its construction must have been first class.

B. An appraisal of the Tunnel in its present condition:

From a visual examination, the tunnel appears to be in a sound and stable condition. In fact, it appears to be in very good health. A number of photographs are appended which illustrate some of the salient features of the tunnel's construction and maintenance. The photographs are arranged in sequence along the length of the tunnel starting from the south and progressing northwards.

The first photograph illustrates the first 100 feet of brick lining from station 0 + 00 (south portal) to 1 + 00. This section was re-pointed in 1965 and is in excellent condition.

More typical wall and ceiling shots are shown next. No re-pointing work has been carried out (at least in the last 25 years). Still the lining appears to be sound and no distress is evident. The mortar between the bricks has deteriorated but since the lining is in compression, the sand/lime grains have been held in place except where they have been washed out by seepage water. In fact, the poor condition of the mortar is advantageous in the sense that it allows seepage water to pass through the lining freely and so prevents the build up of hydro-static pressure on the walls.

One of the two shafts located at station 3 + 00 is shown next. The shafts are reported to come up through the City Hall to roof level and served as chimneys for the smoke belching from the steam loco-motives when they started up the tunnel from the lake. The shafts appear to be in good condition although they were not inspected closely.

The start of the rock section of the tunnel is shown in the following photograph. The rock is generally sound with little loose surface rock in evidence. In fact, new rock has been deposited over large areas of the surface by seepage water - an interesting and unusual feature. (New rock is also found over areas of the brick lining, and in at least one location ties are encrusted in "marble").

The location of the largest 'stream' of water is shown next. This is a shot of the roof of the tunnel showing what appears to be sound rock that contains a fissure through which the water flows. As was stated earlier, the amount of water varies with the prevailing rainfall. In wet weather the stream is continuous resembling the spurt of water that issues from a container that has a small hole punctured in its side. This is at station 6 + 00.

At station 6 + 50, a small, localized area of rock spalling was encountered. Pieces of rock lying alongside the track are shown. The largest of these is about 18 x 18 x 24 inches and would weigh about 500 pounds. The fresh rock surface which was exposed in the roof of the tunnel is shown in the next picture.

A central adit or shaft is located at station 7 + 50. Its outlet appears to be bricked over, probably just below street level. No distress of the shaft is evident from track level.

No photographs were taken of the transition from bare rock to lining which occurs gradually from about station 9 + 70 to 10 + 10. At first only the roof is lined.

The last 100 feet or so of the tunnel appear to have been gunited at some time in the past. Guniting is the process of spraying mortar over a surface, in this case the brick lining. It seems to have been unsuccessful since only small patches remain. A photograph of a patch is appended.

The lined portion of the Tunnel including the portal wall was grouted in June 1950. Some 277 holes were drilled through the lining and grout (sand and cement with water) was injected to fill any voids. A total of 871 bags of cement were used. This is the only record of maintenance carried out on the tunnel other than the re-pointing described earlier.

In summation, the tunnel is in very good condition, and no immediate repairs are required. It is recommended that a masonry expert be engaged to examine the lined section in detail if the tunnel is to be preserved. The CPR states that it would be necessary to re-point the entire tunnel if rail traffic were to resume. They estimate the cost to be $5,000 using their forces. If at any time the tunnel is re-pointed, it is recommended that openings be left through the mortar at regular intervals to permit the seepage water to flow through in a controlled manner.

In addition, if the tunnel is to be opened to the public, the bare rock section of the tunnel should be scaled at least twice a year. Scaling involves poking at the rock surface with a long rod or stick to dislodge any loose rock that could fall with time.

General Comments:

(1) The most immediate requirement to preserve the structure would be to repair and strengthen the doors. This work is necessary to prevent vandalism inside the Tunnel. In the past few days, an attempt

was made to burn down the south doors. Luckily, only minor damage was done.

Both the south and the north doors have openings through which people can pass through easily. Increasing amounts of debris are being left in the Tunnel. The ties and roadbed are wet and slippery in many places. Serious injury could result as people stumble along through the tunnel in the dark.

As is shown in the photographs some masonry and iron work will be required to preserve the portals and strengthen the doors. This work should receive urgent consideration.

( ) The City Engineer, Mr. Metcalfe, made a request concerning the south portal. As the south end of the tunnel emerges from the ground, it creates a hump in Water Street. This has led, on occasion, to the uncoupling of the trailer unit from tractor-trailer trucks which try to negotiate the hump. Mr. Metcalfe suggests that the hump can be removed if the south portal is moved northward, clear of Water Street.

(3) A number of residents of Brockville referred to the cave-in which occurred in Victoria Avenue over the north end of the Tunnel. A short section of the road surface dropped some 300 feet south of the north portal on April 18, 1956. Digging revealed a cavity 2 feet deep and 3 to 4 feet wide at a depth of 16 feet (some 12 feet above the tunnel roof).

The cavity appeared to run to some length in the direction of the tunnel. Considerable excavation was carried out over the next year or so but the extent of the cavity was not determined. No movement or distress of the Tunnel was noted on careful inspection. The City finally backfilled their excavation and left the cavity remain. No problems are reported since.

Conclusions:

Although the Brockville Tunnel is the first railroad tunnel in Canada, it does not represent a technological achievement.

The tunnel is in good condition but urgent work is required to protect it from vandalism.

References:

1. Beaver, P., A History of Tunnels, Peter Davis, London, 1972.
2. Legget, R.F., Railways of Canada, David and Charles, Newton Abbot, 1973.
3. Sandstrom, G.E., The History of Tunnelling, Barrie and Rockliff, London, 1963.