A Problem in Economics of Mountain Railway Location at Rogers Pass, B.C.

By J. G. Sullivan, M. Can. Soc. C.E., Chief Engineer, Western Lines, Canadian Pacific Railway.

The data to be taken into account is as follows: Present location, total distance 23.1 miles, revised location 18.68 miles, as shown in fig. 1; grades are as shown in fig. 2, and consist, on the present location of 16.65 miles up hill for westbound traffic on maximum grade of 2.2%, 6.45 miles down grade same maximum with a total rise of 1,726 ft. and a drop of 692.1 ft. wth 1,860 degrees of curvature on the up hill and 1,288 degrees on the down hill portion of the line. The revised location consists of 16.77 miles up hill with about 5 miles of 2.2% pusher grade, the balance 1% and a down hill run of 1.91 miles with a maximum 2.2% grade; a total rise of 1,178.2 ft. and a drop of 144.3 ft., with 635 degrees of curvature on the up hill grade and 66 degrees on the down hill. The average traffic for 1912 and 1913, which is made the basis of calculations, was 1,342½ passenger trains in each direction; the average weight of the passenger trains, exclusive of locomotives, was 443 tons; 980 of the passenger trains required pusher locomotives; the weight of the passenger and pusher locomotives for passenger trains was 175 tons each; there were 1,738½ freight trains in each direction per year; the average weight of the freight trains eastbound, exclusive of locomotives, was 950 tons; the average weight of freight trains westbound was 898 tons; all freight trains had to be pushed in both directions; weight of freight locomotives and pushers, 181 tons each. The tonnage eastbound and westbound was as follows:

EASTBOUND.

	Tons.
1,342½ trains @ 443 tons each	594,727.5
2,322 locomotives @ 175 tons each ..	406,350.0
1,738½ freight trains @ 950 tons each	1,651,575.0
3,477 locomotives @ 181 tons each ..	629,237.0
Total	3,281,889.5

WESTBOUND.

1,342½ trains @ 443 tons each	594,727.5
2,322 locomotives @ 175 tons each ..	406,350.0
1,738½ freight trains @ 898 tons each	1,561,173.0
3,477 locomotives @ 181 tons each..	629,237.0
Total	3,191,487.5

Comparison of Comparable Factors affecting the Cost of operating over Rogers Pass, via Present Line and via Tunnel Line, now under construction, Average Traffic for 1912 and 1913.

Eastbound tonnage per year, including weight of locomotives, 3,281,890 tons.

Resistance to overcome, on present line.

Actual rise, 692.1 ft.	692.1 ft.	
Curve resistance, 1,288°×.04 ft.	51.5 ft.	
Friction resistance, 6.45 mls.×15 ft.	96.7 ft.	
Total		840.3 ft.

Resistance to overcome, tunnel line.

Actual rise, 144.3 ft.	144.3 ft.	
Curve resistance, 66°×.04 ft.	2.6 ft.	
Friction resistance, 1.91 mls.×15 ft.	28.6 ft.	
Total		175.5 ft.
Difference		664.8 ft.

3,281,890 tons × 664.8 ft. equals 2,181,800,472 foot tons.

Westbound tonnage per year, including weight of locomotives, 3,191,488 tons.

Resistance to overcome, present line.

Actual rise, 1,726 ft .....1,726.0 ft.		
Curve resistance, 1,860°×.04 ft.	74.4 ft.	
Friction resistance, 16.65 mls.×15 ft.	249.7 ft.	
Total		2,050.1 ft.

Resistance to overcome, tunnel line.

Actual rise, 1,178.2 ft.....1,178.2 ft.		
Curve resistance, 635°×.04 ft.	25.4 ft.	
Friction resistance, 16.77 mls.×15 ft.	251.5 ft.	
Total		1,455.1 ft.
Difference		595.0 ft.

3,191,488 tons × 595 ft. equals 1,898,935,360 foot tons.

Total work done extra ... 2,181,800,472 foot tons
1,898,935,360 foot tons.

Total ..... 4,080,735,832 foot tons

1,000 foot tons equals approximately 1 horse power hour. Assuming that 5 pounds of coal is consumed in doing one horse power hour's work and that coal on locomotive costs $4.60 per ton, the saving in fuel will amount to:—

4,080,736×5 lbs.×$4.60 / 2,000 lbs (one ton) =.....$46,928 46

EXTRA WAGES, TRAIN AND ENGINE CREWS.

Present Line.
6,162 trains for 23.1 miles.
5,437 pusher engines for 23.1 miles.
142,342.2 train miles.
125,594.7 pusher engine miles.

Tunnel Line.
6,162 trains for 18.68 miles.
5,437 pusher engines for 13 miles.
115,106.2 train miles.
70,681.0 pusher engine miles.

Amount saved—27,236.0 train miles; 54,913.7 pusher engine miles.

27,236 train miles at 22 cts.	$ 5,991 92
54,913.7 pusher miles at 25 cts.	13,728 40

NOTE.—25 cents to cover engine crew wages, cost of repairs to pusher locomotives and extra cost of maintenance account of running pushers.

Extra cost of maintenance of way:

4.42 miles at $200, plus 27,236 train miles at 20 cts.	6,331 20
Extra cost, maintenance of way, account of extra number of degrees of curvature, assuming that 400° of curvature per mile would increase rate at 20 cts. per train mile for maintenance by 30%.	
6,162 trains × 2,447° × 1-40 cts	3,769 60
Special maintenance, account 4½ miles snow sheds	85,000 00
Extra cost, maintenance of equipment, 27,236 train miles at 21 cts.	5,719 56
Extra cost, maintenance of equipment, account of extra number of degrees of curvature, assuming that 400° of curvature per mile would increase rate of 21 cts. per train mile by 40%.	
6,162 trains × 2,447° × 21-1,000 cts...	3,166 47
Total annual saving in cost of operation	$170,635 61

The rate at which traffic has been increasing would indicate that shortly after the work of constructing the tunnel was completed the traffic would have doubled. In this case, if no further economics were made in methods of operating this section of track, the annual saving on account of operating over tunnel line would be:—

$85,635.61 × 2 plus $85,000.00=$356,271.22

In arriving at the above figures no account is taken of whether line was single or double track, and for comparative figures it was assumed that methods of operation would be the same. Now, as a matter of fact, the present single track line with double the present traffic would make the business too congested for economical single track operation. Therefore, it was apparent that it was time to study the question of double tracking the present line or seeking a new line for double track. It was decided to double track on the five mile tunnel location as shown in fig. 1, with grades as shown in fig. 2. Now to operate successfully a five mile tunnel we will require the installation of an electric plant and the purchase of electric locomotives. All the details of the proposed electrification have not been worked out, but even if they were, the reader is not interested in the details of cost. He can see at once that the problem was to find out if the cost of operating and maintaining the tunnel line, taking into account the extra costs of operating on account of having a short section

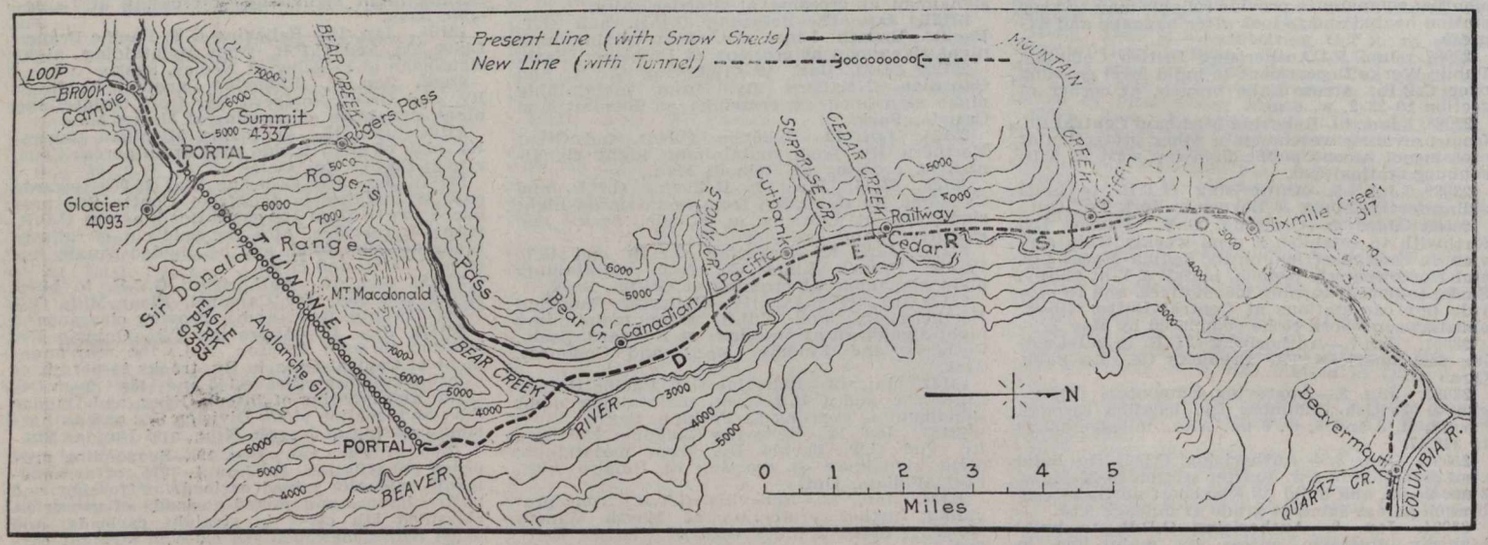

Fig. 1.—Rogers Pass Tunnel. Map of Old and New Lines.