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**REPORT ON THE TUNNEL BY SIR DOUGLAS FOX**

It was Submitted in May, 1891, to the Hon. George E. Foster, then Minister of Finance for Canada.

In view of the recent controversy between Mr. S. A. Macdonald, President of the Associated Boards of Trade, and Captain John L. Read, of the "Carrery" steamer, the following report of Sir Douglas Fox in regard to a tunnel under the Northumberland Straits will be of exceptional interest.

This report was submitted by Sir Douglas Fox in May, 1891, to the Hon. George E. Foster, then Minister of Finance, in the Government of Sir John A. Macdonald. It speaks for itself, and will give our readers correct information and much enlightenment regarding the proposed work. As the report had been made public some thirty-six years ago, there then followed considerable discussion, editorially and otherwise in the Island press. It was universally conceded, however, that the feasibility of constructing a tunnel had been brought down to a practical point where it might be dealt with by the Government. However, it was not taken up with a view to its construction, and much water has flowed between New Brunswick and Prince Edward Island, at the points mentioned in the report, since it was submitted. However, as Mr. Macdonald has now revived the question of tunnel construction no doubt the report of that great Engineer, Sir Douglas Fox, which has been kindly handed to the Patriot by Mr. Macdonald will be read with more than ordinary interest today.

28 Victoria St., Westminster, S.W., London, May 5, 1891.

Proposed Railway Tunnel under the Northumberland Straits, between New Brunswick and Prince Edward Island.

Report of Sir Douglas Fox, Member of Council of the Institution of Civil Engineers and Corresponding Member of the American Society of Civil Engineers.

To the Hon. George E. Foster, Minister of Finance for the Dominion of Canada, Ottawa.

Sir—In accordance with instructions received by me on the 17th of September, 1890, through the Hon. Senator G. W. Howland, I detailed Mr. Alfred Palmer, a Civil Engineer upon my staff to make a preliminary inspection of the proposed site for the Railway Tunnel under the Northumberland Straits, to connect the railway systems of New Brunswick and of the Dominion generally, with that of Prince Edward Island.

He was accompanied by the Hon. G. W. Howland, and by Mr. Francis Bain, whom I understand to be a local geologist of repute.

Mr. Palmer reports, that having reference to the opinion of Mr. Bain as to the strata under the bed of the sea on the line of the Tunnel, the proposed location, under the narrowest portion of the Straits between Money Point in New Brun-

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wick and Carlton Point in Prince Edward's Island, is well selected, both from a constructive and a traffic point of view.

The greatest depth of water is shown being 96 feet at High Water with a rise of tides of 6 feet at Springs, and 3 feet at neaps, and the speed of the current as not exceeding 3 knots, with two hours of slack water each tide.

The distance from shore to shore is given as about 13,200 lineal yards, or say from shaft to shaft 1,500 yards, exclusive of the land approaches on either side of which about 2,000 lineal yards would be in tunnel.

Mr. Palmer further reports that the shores upon either coast are well adapted for railway approaches, varying from 15 feet to 35 feet in height above high water mark, with a mean altitude of about 25 feet, the soil being of a red clayey nature. It appears also that the higher land on the Prince Edward's Island shore, falls away towards the interior, which will therefore shorten the approaches on that side.

Mr. Palmer considers that about 5 1/2 miles of railway, including some 2,000 lineal yards of tunnel as before mentioned, will be necessary beyond the shafts to connect the tunnel with the respective systems of railway, which, however, are of a different gauge, viz: 4 ft. 8 1/2 inches in New Brunswick and the Dominion generally, and 3 ft. 6 inches in Prince Edward's Island.

Brick clay free from lime is said to exist at several points in Prince Edward's Island, and a sample brick of good quality has been forwarded to me, together with a report by Mr. Bain thereon, dated the 9th of December, 1890, of which a copy is annexed hereto. (Appendix A.)

Coal of good quality from Pictou and timber, could be delivered at the shafts at moderate prices.

I assume that any materials, or machinery required to be imported for the works would be admitted free of duty.

I am informed that ordinary labor is worth about 4s., and skilled labor about 6s. per day.

The ruling gradient on the main lines of New Brunswick is given as 1 in 81, or 65 feet per mile, and that in Prince Edward's Island, as 1 in 58, or 90 feet per mile. From the approximate cross section of the Straits, accompanying Mr. Bain's report hereinafter referred to, it appears that no difficulty would be encountered on the question of gradients, as the levels of the tunnel could be so arranged, as approximately shown on the cross section (Appendix F.) as to give a sufficient thickness of solid strata, between the extrados or crown of the tunnel and the bed of the Straits, without involving any steeper incline than 1 in 100, or 32.8 feet per mile, whilst the approach tunnel can be laid out with a ruling gradient of 1 in 66 or 80 feet per mile, both tunnels draining into one pumping shaft as shown.

It would be convenient but not essential for constructive purposes, that the tunnel alignment should be a straight line from shaft to shaft.

Upon the all important question of the stratification on the proposed alignment, Mr. Palmer quotes the following opinion, given to him verbally by Mr. Francis Bain on the occasion of his visit.

"In his belief a bed of red clay shale varying in thickness from 50 to 80 feet extends right across the Straits of Northumberland. It lies almost horizontally upon a carboniferous or grey sandstone base, and is said to contain small occasional lenticular masses of fine red sandstone."

Mr. Palmer adds, as the result of his own investigation:

"The geological outcrop on either shore, in which the strata are distinctly visible, the formation of the surrounding country, the stratification seen in neighboring wells, combined with the opinion of Mr. Bain, the geologist, who is a native of the Island, and has a knowledge of its entire formation, prove that a most favorable and impervious stratum does exist for sub-aqueous tunneling."

Accompanying Mr. Bain's report upon the brick clay same a cross section of the Straits plotted to a distorted scale, (Appendix B), together with samples of shale and sandstone, as found in the neighborhood.

Having communicated through the Hon. G. W. Howland, my desire for further and more distinct information, I received the reports of Mr. Bain dated respectively the 18th of December, 1890, and the 14th March, 1891, of which copies are annexed (Appendices C & D), together with a cross section of the Straits to a natural scale (Appendix E.)

In this report Mr. Bain remarks: "The great shale beds are persistent and uniform, but the small argillaceous or coarseness deposits, which occur in them, are local, lenticular and discontinuous, and not likely to form leads for water. . . . These shales are impermeable to water. The carboniferous base of sandstone will possibly form a dangerous source of water, and it should be avoided, but, as already remarked, it does not break up under the bed of the Straits here."

"It is my duty to state that, though convinced of the accuracy of what I now present, a more minute and detailed geological investigation should be made before active engineering operations are begun."

I have also before me a copy of a letter addressed on January 9, 1891, to the Hon. G. W. Howland by Sir William Dawson of McGill University, Montreal, which runs as follows:

"I beg to say that I have read and examined the report and section prepared by Mr. Bain, with reference to the proposed tunnel from

Carlton Head to Cape Jourmain, which you were kind enough to show me, and that, from my knowledge of the geological structure of the locality, I have no hesitation in stating that I believe the report and section fairly represent the character of the beds to be penetrated by the proposed tunnel, and that these will not present any serious difficulty, the ground being in fact as favorable as could be desired for such a work."

It is evident from the cross sections supplied by Mr. Bain that it is possible to locate the tunnel entirely above the carboniferous sandstone strata and care should be taken not to tap these strata either by shaft or borings in the immediate neighborhood of the intended work.

So far as I can judge from the small specimens of the shale in my possession I agree that it is likely to be impermeable to water and to form a favorable material for tunneling operations. The cross section however shows that owing to the slight inclination of the beds the tunnel cannot be made to pass entirely through this stratum but must necessarily cross at an oblique angle, and therefore for some distance, through certain sandstone beds, which are shown thereon, and which I understand to be red sandstone similar to samples in my possession. Judging from sub-aqueous work carried on under my supervision in sandstone of a somewhat similar

character, I should expect a certain amount of percolation, but not large feeders of water, from this rock. It is, of course, impossible to speak with certainty upon this point, but I am strengthened in this opinion by the conformable nature of the strata in the neighborhood, which I understand from Mr. Palmer to be remarkably free from faults, showing that the beds, as mentioned by Mr. Bain, have not been exposed to strain.

Owing to the great depth at which the tunnel in some portions of its length, will lie below the level of high water, viz: 156 ft. to the underside of invert, it would be impossible for men to work under the full hydrostatic pressure, which would amount to about 68 lbs. per square inch, whereas 40 lbs. per square inch can only be endured at considerable risk, and for a short time. Whilst therefore a reduced pressure might be found useful at certain points to check the flow during construction, it would be necessary to make provision for pumping such feeders as might be met with, reduced also by exposing at one time as short a length of ground as possible.

Since I reported upon this subject to the Hon. (now Chief Justice) Sullivan on the 7th April, 1886, much progress has been made in the driving of sub-aqueous tunnels in water-bearing strata by means of shields similar to that introduced by Mr. I. H. Greathead, Mem. Inst. C. E., for the Subways under the River Thames in this city, afterwards adopted for the "Sarnia" tunnel, on the Grand Trunk Railway and now working with some modifications of detail in the tunnel under the River Hudson in New York, and in the "Vernoy" Tunnel under the River Mersey. By means of such a shield, suitably designed in wrought iron or steel work can be carried on with much greater safety to the men employed, and without the use of temporary timbers, which, whether left in permanently, or withdrawn, constantly prove a source of weakness to the permanent work.

(Continued on page 8.)

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