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DERWENT VALLEY BRIDGES:

REPORT BY W. C. KERNOT, M.A., C.E.

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REPORT on Derwent Valley Bridges by W. C. KERNOT, *Esq., M.A., C.E., Professor of Engineering, Melbourne University.*

University, 26th August, 1886.

SIR,

IN compliance with the request contained in your letter of the 10th instant, I beg to submit the following remarks upon the Derwent Valley Railway Bridges.

I would premise that my knowledge of the railway works is obtained solely from the plans and reports that have been supplied me, but that I am acquainted with the general character of the river and the country through which it flows, having paid two visits to the district several years ago.

BRIDGE No. 1.

The site of this bridge appears to be well chosen, the reef of rocks affording an excellent and accessible foundation. The waterway of the bridge is practically co-extensive with the channel of the river,—as it should be in so rapid a stream as the Derwent. The approaches, as far as my information goes, appear to be judiciously laid out, and to alter them as proposed by the Commission would be a most unjustifiable waste of public money.

The statement made on page 4 of the Report, that "the girders have to resist the centrifugal force brought into play by the action of the curves," is not only wrong but is preposterous, and shows on the part of those making it an utter misapprehension of the first principles of dynamics. Centrifugal action (usually, but unscientifically, called centrifugal force) ceases absolutely the instant the moving body resumes a rectilinear path. Whatever other prejudicial actions the structure may be called upon to resist, it certainly will not, and cannot in the nature of things, be affected in the slightest degree by the centrifugal action of the train.

Should it be urged that a train leaving the line on the curved approaches to the bridge might fall into the river, and thus cause a disaster greater than would be involved by its leaving the line at curves in other positions, I would point out that check or guard rails, as used in England and America, could be added at a very small cost, and would render derailment practically impossible.

I would, therefore, protest in the most emphatic manner possible against the costly alteration insisted upon by the Commission.

As Mr. Fincham has pointed out that the grades of the approaches really conform to the requirements of the Commission, I need not discuss that question.

The proposal to space the girders 8 feet apart instead of 6, I also object to as entirely unnecessary. They are at present further apart than the girders of the South Australian bridges, against which no complaint has been brought. Nor do I see that a deck 14 feet wide would in any way injure the structure, especially as the cart traffic would be confined (according to a sketch Mr. Fincham has furnished me with) to the central 7 feet 6 inches, the remainder being used merely for foot passengers.

The most unfavourable state of things as regards lateral stability would be when the overhanging foot-path on the leeward side of the bridge was crowded with people and the rest of the bridge empty. Under these circumstances it will take 50 lbs. per square foot wind pressure to overturn the girders, supposing they were not bolted to the piers at all. Exactly how much additional stability will be afforded by the bolting it is not necessary to calculate, as without it the resistance of the bridge is nearly three times that of the rolling stock that passes over it. The apprehension that the girders will be endangered by wind pressure is utterly chimerical.

I do not agree with either the Commissioners or with Mr. Mais in requiring additional transverse bracing between the girders. On the contrary, I consider the bracing proposed by Mr. Fincham to be

excessive and extravagant. With 25 per cent. less metal the bridge would still have a lateral resistance to hurricanes far in excess of many bridges of old standing elsewhere. I have recently had to examine and report upon a large number of plate-girder railway bridges in New South Wales which are *absolutely devoid of all wind bracing whatever*, that have stood for many years without showing the slightest sign of distress. I do not commend them, but, in view of their escaping injury, I am positive that Mr. Fincham has considerably overdone the bracing of his bridges.

Bridge No. 2.

In this case, as well as the last, the waterway has been judiciously made co-extensive with the section of the flood. The depth of the water at this site being always considerable, the difficulty of erecting piers is much greater than at Bridge No. 1, and the propriety of using a larger span suggests itself. A span of at least 180 feet would be needed to clear the deep channel, and, as the girders would need to rise above rail-level, they would have to be placed at least 12 feet apart; this would necessitate expensive cross-girders as well as very wide piers. Taking all these points into consideration, I think it is probable that Mr. Fincham did the right thing when he decided to adhere to small spans. I cannot, however, come to any very positive conclusion without further data. If Mr. Climie's evidence (Questions 1944, &c.) be correct that hundreds of trees, from 100 to 200 feet long, and weighing 20 tons each, come down the stream at 10 miles an hour, then it is madness to attempt small spans and light piers,—nothing but gigantic structures can stand. But I must say I find it quite impossible to believe this witness's testimony on several important points, of which I have special knowledge, this amongst the number. The construction of the piers in this bridge is peculiar, differing considerably from anything I have hitherto seen. Not knowing in what way it is proposed to erect these caissons, I am not able to criticise them fully. Provided that they can be erected and filled with concrete, I do not see why they should not answer; but, if it is proposed to pump them dry before inserting the concrete, they will need to be greatly strengthened in order to resist the hydrostatic pressure of the surrounding water. In any case the process of ramming the concrete will, I think, bulge the thin iron between the stiffening T irons, and give a peculiar appearance to the outside of the pier. The 3 in. by 1 in. tie-bars will not, in my opinion, have the slightest prejudicial effect on the continuity of the concrete filling.

Caisson piers are by no means unknown, and are very suitable for rapid rivers. I am not, however, acquainted with any in which the height is so great in comparison with the width, nor in which the outside shell is so thin. Were the plan of the caisson made elliptical, about 17 feet long by 8 feet wide, it would correspond more nearly with examples I am acquainted with.

I regard this subject as one of considerable difficulty, and with regard to which difference of opinion may be expected. In this respect it differs from questions of strength and stability of girders, which can be definitely solved by a calculation every step of which can be thoroughly verified.

The superstructure of this bridge corresponding to that of No. 1, the same remarks will apply.

Bridge No. 3.

At this bridge the waterway has been encroached upon rather more than at the others, but not, I think, dangerously. It is, however, an apparently debateable question whether it would not be worth while to lengthen this bridge by one span, thus giving a little more waterway, and reducing the size of the abutment nearest Hobart, which, as at present designed, is an enormous and very costly mass of masonry.

This bridge differs from No. 2 in being on the skew, and in not having so great a depth of water under it as the preceding; hence there should be less difficulty and risk in erecting the piers.

The skew position of the piers is not inimical to their stability.

The proposal to adapt this bridge for ordinary road traffic is a reasonable one, and the details of the means of effecting it are good. In this structure the curve of the approach extends partly over one span of the bridge; hence the girders of this span will be exposed to the centrifugal effect of the train, which, on a curve of 6 chains radius, may, at high speeds, amount to as much as one-fourth of the weight of the train. In this case, and *in this case only*, do I agree with the Commissioners in recommending transverse bracing at the top as well as the bottom of the girders.

Strength of Girders.

The strength of the girders against the load to be carried has not been called in question, and I should not have referred to it were it not that it has an important bearing upon the allegations made in evidence as to vibration, oscillation, &c.

I have gone through the calculations of these girders, and find them to possess extraordinary strength and stiffness. To show how they compare with girders elsewhere, I have prepared the following table showing the stress on the metal in several typical cases:—

	Compression per square inch.	*Tension per square inch.*
1. 60-ft. spans, plate girders, Solitary Creek, Western Railway, New South Wales	4·3	6·7
2. 60-ft. spans, plate girders, Southern Railway, New South Wales	4·5	5·4
3. Cross-girders of old Cremorne Railway Bridge, Melbourne	5·2	7·5
4. Derwent Bridge girders	2·8	3·3

The girders in cases 1, 2, and 3 are from 10 to 25 years old, and have been subject to incessant traffic. Compared with them, it will be seen how light the stress on the iron in the Derwent Valley bridges is. The tension in cases 1 and 3 I consider unduly high, exceeding, as it does, so considerably the British Board of Trade rule of five tons per square inch. On the other hand, I do not hesitate to say that had I been asked to design Mr. Fincham's girders, I should have considered three-fourths of the metal he has used to be ample.

In addition, it is to be noted that Mr. Fincham's girders are 6 feet deep, while those in New South Wales, with which I have compared them, are only 4 ft. 7 in. Quite apart from the extra strength, this greater depth will give extreme rigidity and freedom from deflection and oscillation: in fact, so strong and stiff are Mr. Fincham's girders, that I would not have the slightest hesitation in taking the heaviest broad-gauge engines in Australia,—the great 75-ton American engines used on the Blue Mountains, in New South Wales,—across them at full speed. This being so, it will be seen how utterly absurd are the statements that have been made about oscillation, deflection, &c. The loose road, condemned by the Commissioners, is the standard practice in Victoria.

My general conclusion is, therefore, in brief, as follows :—

1. That the original approaches of Bridge No. 1 should be adhered to.
2. That the girders and transverse bracing of all the bridges should remain as at present, except in the case of one span of No. 3 Bridge, where the rails, being on a 6-chain curve, it would be judicious to add top bracing.
3. That there is not the slightest objection to an extended deck 14 feet wide for ordinary road traffic, or to a loose road.
4. That the caisson piers are of novel form, which, I think, should answer, but about which I am not prepared to give a very definite opinion.

Yours obediently,

W. C. KERNOT.

To the Honorable NICHOLAS J. BROWN,
Minister of Lands and Works, Hobart.

WILLIAM THOMAS STRUTT,
GOVERNMENT PRINTER, TASMANIA.