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“ Some Major Problems in Railway Civil Engineering Maintenance ” †

by

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Mr W. T. Wilks was of the opinion that the civil engineer in, say, the chemical or petroleum industries needed a larger measure of theoretical training, practical experience, and common sense than, as suggested by the Author, the engineer responsible for maintenance on the railways. In those industries, the engineer had to deal frequently with gases which could not be seen, heard, or controlled as could, for example, trains.

Referring to the re-flooring of Charing Cross Bridge (see p. 120), Mr Wilks expressed surprise that the steel deck plates had been riveted to the rail bearers and cross-girders. Despite the deflexion in the floor of a bridge, the use of electric welding was not precluded if the right design and technique were used. There existed many bridges in which the deck-plate rivets had worked loose—allowing water to percolate through the joints. He suggested that electric welding would have reduced considerably the time of reconstruction of that particular bridge.

Mr Wilks could not understand the reason for the renewal of the bottom flange of the cross-girder in such heavy sections, and costly method of construction, of the bridge over the River Thames at Staines (*Figs 10*). The bending moment at the ends of that simply supported girder was very small and was provided for in the material which remained in the vertical leg of the existing flange angle and a portion of the web plate. The welding of the bottom flange of the cross-girder to the main girder might overcome the difficulty of corrosion but might well introduce secondary stresses in the latter to its ultimate detriment.

The Author should have given a word of warning to the engineer with limited knowledge of electric welding on its indiscriminate use for repairs to bridge work, since the expansion, contraction, and distortion induced in the riveted work might produce excess stresses which could be serious; also the danger of notch brittleness had to be borne in mind. Before 1939, German engineers had strengthened some of their old riveted bridges by welding, but abandoned the practice after a short time when it had been discovered what was happening.

One of the most important bridge works undertaken by the old Great Western Railway in the past fourteen years was the reconstruction of the

† Proc. Instn Civ. Engrs, Part II, vol. 2, p. 106 (Feb. 1953).

Kidwelly Viaduct in South Wales. The preparation of the design, erection scheme, and contract had been entrusted to Mr Wilks. That structure carried the up and down South Wales main lines over the River Gwendraeth Fach, at a distance of 234 miles from London. The original viaduct, built about 1852, had been in timber, but had been replaced in 1894 by the wrought-iron structure which had also had to be renewed.

The viaduct was made up of four 68-foot spans; the sub-structure consisted of two stone abutments and three piers in the river bed. Each of the piers comprised three wrought-iron cylinders 6 feet in diameter, set 15 feet $1\frac{1}{2}$ inches apart, filled with concrete, and braced transversely at the top with wrought-iron girders to act as one unit. The old superstructure which had been replaced was of the plate-girder through-bridge type, having one line of centre girders and two lines of outside girders which carried cross-girders 4 feet apart, supporting timber decking on which was laid the ballast and permanent way.

The cylinder piers were found to be in such good condition that small repairs only were necessary to put them in order, and those had been carried out by (electric) welding patch-plates to the affected parts. The re-use of the piers had decided the type of new superstructure, which was similar to the old, except that steel deck plates riveted to rolled-steel-beam rail bearers were used, instead of timber decking. There was nothing of unusual interest in that construction, apart from the fact that the viaduct was set out on a curve. The interesting work was the erection scheme which in principle was to renew, first of all, the half of the viaduct carrying the up line, while keeping the down line open for all traffic.

The first operation had been to slew the down line away from the centre girders, in order to permit the cutting away of a portion of the timber decking carrying that line, to give access to the ends of the cross-girder, and also erect in the space so provided a temporary erection girder alongside an existing centre girder, and, from the former, to carry the ends of the cross-girders by means of suspension bolts. The existing centre girder, relieved of all load, was then removed, also the outside girder, timbers, and cross-girders supporting the up line. With that portion of the span free, the new centre and outside girders, cross-girders, rail bearers, and steel deck plates were then fixed.

Those operations constituted all the work necessary to complete the erection of steelwork for carrying the up line for one span. Work was first begun on the span nearest Kidwelly station, and on completion of that, the next span was fixed, still for the up line, until the four were finished. Afterwards, the permanent way of the up line was temporarily re-laid and the traffic diverted over it, while the down line was closed for reconstruction.

It should be noted that before the erection girder could be moved to another span, the weight of the existing cross-girders had to be released from it and transferred to the new centre girder.

In fixing the steelwork for the down-line section, the erection girder was unnecessary, since there were no cross-girders to be held up at that stage of operations. Consequently, the speed of erection was accelerated, and two spans were fixed at one period of occupation, which usually was from Saturday night to Sunday noon.

The erection girder used on that job had been built originally for the reconstruction of Saltash Viaduct; it had, however, to be lengthened for the work at Kidwelly. Provision had to be made for supporting the end of the girder from the old structure, and that support comprised double 17-inch-by-4-inch rolled steel cross-channels slung underneath the floor and hung by heavy flat steel bars from cross-head-channels resting on top of the existing outside and centre girders.

The heaviest piece to be lifted was the 27-ton erection girder, and two of the Company's cranes, each of 15 tons capacity, were requisitioned for the lifting of that and all main girders. Those cranes occupied the up line during its reconstruction and vice versa for the down line, thus keeping one line free at all times.

Each of the major operations described above had had to be worked out in detail to ensure that the cranes could manoeuvre in restricted spaces, and stand in predetermined positions, without unduly overloading the new and old structures. Also, it had been necessary to make an accurate estimate of the time taken for each operation, so that a time schedule could be compiled, acceptable to the Traffic Department, enabling that department to give permission for complete occupation of the lines while the principal and heavy members of the viaduct were lifted into position. Further, the co-operation of the steelwork fabricators was essential, to obtain delivery of steelwork at specified times, and in the correct order.

Although there was approximately only 15 feet clearance between low-water level and the soffit of the girders, the scheme was very much cheaper than the alternative one of erecting temporary staging from the river bed, on which to carry the new superstructure. Also, the limited headroom for driving temporary piles for carrying the temporary staging would have presented a problem which could not have been easily solved without much interference with traffic.

The Author, in reply, stated that welding the deck plates of Charing Cross Bridge had been considered in the initial stages of preparing the scheme, but it had been decided that a quicker and more convenient job could be carried out by riveting. That method, when carried out efficiently, should not lead to rivets becoming loose although he was aware there were some cases in which that had happened. In the design of the new floor at Charing Cross, dished plates had been used, with drainage space along the centre-lines so that there should be no accumulation of water near the rivet heads. The floor was fabricated in the shop and erected in large panels at the site, and therefore any saving in time that might be claimed for welding, as compared with riveting, would not be material since there

would be no effect on the time required in erection at the site. Little difficulty had been experienced in maintaining riveted floors on the large number of old bridges.

The reason for the renewal of the bottom flange of the cross-girders of the bridge at Staines, in the manner shown, was that severe corrosion had taken place at the cross-girder ends and it was therefore necessary to renew the bearings on the main-girder flanges. To avoid damage to the main girder, the lower portion of the cross-girder was burnt out slightly above the level of the outstanding leg of the lower angle, and it was cheaper and more satisfactory to provide a substantial bearing plate to fill up the space available and give good distribution on the main girder, than would have been the case with other methods. The whole of the work had been carefully carried out and planned to ensure that secondary stresses were not introduced by the welding. Detailed examination with magnifying glasses had not revealed any cracks in the welds although some of them had been made more than 2 years previously.

The Author agreed that a word of warning on the indiscriminate use of electric welding repairs to bridges might have been given, but the care required and the serious results which might occur after a badly conceived repair were well known and therefore the omission was not serious.

The experience gained by the Germans before 1939 was also gained in Great Britain, and before the war, repairs by welding on bridges—on the former Southern Railway—were carried out, but great care had been used in their design. They had proved quite satisfactory but tests were made and stresses measured before schemes were prepared.
