SECT. II.—OTHER SELECTED PAPERS.

(Paper No. 3710.)

“Some Railway-Bridges on the West Coast of Tasmania.”

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ALTHOUGH the bridges described in this Paper present no unusual features of design or construction, an account of their erection may be of interest to the engineer having to undertake similar work with limited resources, and without technical assistance.

The railways on which they occur, on the West Coast of Tasmania, traverse difficult country: the ground is steep, much broken by water-courses, heavily timbered, and covered with dense undergrowth; and the area is subject to an exceptionally heavy rainfall. The original Emu Bay Railway between Burnie and Waratah (Mt. Bischoff) was constructed over 20 years ago. The present Emu Bay Railway Company, having leased this line from the original company, began at a point about 10 miles from its terminus to build the line to Zeehan. Mining discoveries on the West Coast appearing to render it advisable to complete the line as expeditiously as possible, the construction gangs were kept closely following the survey parties, who were feeling their way with difficulty through a practically unknown country. The construction gangs worked also under great disadvantages. The ground being steep, the batter of the cuttings was fixed at $\frac{1}{4}$ to 1, and not infrequently, whilst one side was level with the rails, the other would be perhaps 100 feet up the hillside. All the material required beyond the head of the road had to be packed, until the last two sections of the line were constructed; a wooden tramway was then laid along the surveyed route, on which three horses could draw about 30 cwt. at a time. The other railway referred to, connecting Macquarie Harbour and Queenstown (Mount Lyell), was constructed under similar conditions by the Mount Lyell Mining and Railway Company, the route, however, necessitating the construction of a great portion of the line on the Abt system.

Pieman River Bridge, Emu Bay Railway.—This bridge crosses the Pieman River where it traverses a narrow gorge, the rocky walls standing about 80 feet above the water at its ordinary level. The

main span is 150 feet. Before its erection, a wire rope, to which was slung a wooden cage, was the only means of crossing the river. Cement, etc., for the piers and abutments was carried in on pack-horses. The bridge was designed by Mr. J. H. Fraser, of the Victorian Railway Department, and was originally intended to be erected on the bank, drawn across on to stages at each end, and lowered into position by hydraulic jacks ; but it being considered on examination that this plan

Figs. 1.

would present too many difficulties, the following method of erection was adopted. A cantilever stage was erected at each side, bridging a little more than half the span, and a platform was suspended on cables between them, upon which the bridge was to be erected. The suspended stage was tested with a load of rails equal to the weight of the bridge. It supported this weight during the night, but the following morning, as the men went on to remove the rails, the

cables slipped out of their fastenings, and the platform fell to the river-bed, all but one of the men being killed. It was at this period that the Author took charge. The work having so far advanced, it was decided to adhere to the method of erection adopted, against which there were several practical objections in the Author's mind. In his experience, the simplest and most economical method of bridge-erection, where practicable, is first to construct a staging sufficiently substantial to carry the completed bridge without serious deflection, and also to erect any plant necessary for erecting the bridge in position. When this method is impracticable, it is usually best to

Figs. 2.

adopt the nearest approach to it possible under the circumstances, and it might appear that the plan adopted in this case was a near approach to the method recommended. If it were possible to load the stage equally at all points at the same time, and to take up the stretch of each cable equally at the same time, the method might be a good one, but the actual result obtained in practice is shown in *Figs. 1*. While re-erecting the staging the Author experimented with various fastenings for the cables. These were second-hand Melbourne tramway-cables, worn very smooth by the effect of the gripper, but shown by tests made in the Melbourne University testing-machine still to possess ample strength. The original fastenings (*Figs. 2*) had clips at one end (*a*), which failed when overloaded by the cables sliding one on the other (*b*), and at the other end they were let into sockets, where they were secured solidly to screw couplings, which were secured in their turn to the anchorage.

As it was impracticable to have these socket fastenings at the other end also, the Author adopted other clips (*c*) which gave a better result than the flat ones. The method adopted for testing the fastenings was as follows:—A convenient gully was selected and a tree on each side was chosen, round the butts of which the ends of the cable were secured. Chain blocks were attached to the centre of the cable, carrying a sling in which rails were placed, which were then lifted by the chain blocks until they swung free. The sag was measured with a levelling staff. The load was gradually increased, a rail at a time, until the fastenings at one end gave way. This was a rough

and ready method, giving only approximate results, but it had the advantage of securing conditions similar to the case to which the information gained had to be applied.

When the staging was reinstated, with further struts to the cantilever portion, a wire rope with a carrier running on it was taken across, and used for assembling the different members of the bridge. The bottom member of one girder was first placed in position and bolted up with service bolts. The bottom member of the second girder with the cross-bracing followed, and then the lattice and top member of the first girder were put in position, stayed and tied temporarily to the bottom member of the second girder, thus forming a self-supporting structure of triangular cross-section. The staging was thus relieved of any load, the service bolts being sufficient to take the load of the bridge itself. The second girder was then erected, cross girders were put in position on the top members, and the whole riveted up. Owing to constant rain, the wet cooling the rivets before they could be closed, it was found necessary to erect temporary awnings over any joints where a large number of rivets were needed. *Fig. 3*

shows the temporary structure with erecting cableways.

Teepookana Bridge.—This bridge of 140 feet span carries the Mount Lyell Mining and Railway Company's extension from Teepookana to Strahan on Macquarie Harbour over the King River. It was designed and supplied by an English firm at a very low rate, but the economy was not apparent when a comparison was made with the Pieman Bridge of 150 feet span. The Teepookana Bridge was 7 per cent. shorter, 50 per cent. heavier, cost 20 per cent. less per ton, needed about 100 per cent. more riveting, and was designed to carry a lighter load. It also had other disadvantages; for instance, it consisted of large areas of thin plate, and the bridge was not designed for erection by the method it was found necessary to adopt. The decking, however, was carried on the lower members of the girders, perhaps necessitating more material in the construction of cross girders and bracing. There was no apparent opportunity here for staging across the river, as there was no bottom at a reasonable depth for piling, nor could the traffic on the river be interfered with. It was decided to construct the bridge on a spare piece of ground adjoining the railway, traverse it into position, and launch it across the river. For erecting the bridge a travelling crane was constructed out of bridge timber running on wagon carriages and worked with a winch on one side and chain-blocks on the other side. It was always difficult to obtain experienced men, and on this bridge there were never more than two men who had been employed on bridge construction before; and riveters were hard to get.

After construction the bridge was lifted by hydraulic jacks on to trolleys running on rails specially laid, and was then traversed sideways to the line along which it had to be launched. A steam-crane used for loading and unloading lighters was utilized for this purpose, the lifting rope being unreaved from the jib-pulley, passed through a snatch-block, and attached to the bridge. At the same time men pinched over the wheels of the trolleys with crowbars. The bridge was not designed for launching, and as the tension members, which were only flat plates, would not bear compression, temporary compression members were added. These were made of heavy bridge-timber sections fitted in between and parallel with the tension members, and wedged up. These were not satisfactory, as they crushed into the wedges, and gave much trouble. When the bridge was brought across to the line on which it had to be launched, it was lifted off the trolleys by hydraulic jacks, lines were laid down to carry it forward, and the trolleys were turned and placed underneath in the direction in which it was to go. The same means were used to send it forward, until the forward part overhung the lighter that was to carry it across the stream. This had been prepared by being ballasted with

sand, and a substantial staging was erected on it to carry the bridge. On account of the bridge running diagonally across the river, it had to be supported on the staging nearer the centre than the end, in order that the lighter might carry it far enough to engage with the further abutment. It was found impracticable to get it as far forward on the lighter as was required, partly owing to the cover plates on the bottom of the bottom booms, although these had their ends reduced to feather edges, and also on account of the bridge jamming on the sides of the space prepared for it on the top of the staging, this contingency not having been provided against. It was sufficiently far forward, however, to get some bearing on the farther abutment when the lighter was drawn across.

The bridge was well braced to the lighter with wire ropes attached to chain plates on the sides of the lighter (*Fig. 4*). A lighter

Fig. 4.

moored up-stream, with a winch and cable, kept the moving lighter with the bridge on the right line. A winch on the other bank and on the direct line of the bridge pulled it forward, and the steam-crane previously referred to also pulled it forward by means of a snatch-block. Stacks of railway sleepers on the farther abutment received the end of the bridge, which was of course some 4 or 5 feet above the finished line. As soon as the lighter was as near the bank as its shelving nature would permit, and the end of the bridge was over the stacks referred to, the lighter was successfully scuttled, and floated clear of the bridge, despite the rapid rise of the stream, due to heavy rains. It was then moored to the bank, plugged up, and the water pumped out.

The work occupied about a day and a half, and was accomplished without a serious hitch or an accident of any kind. Subsequently, by

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means of the hydraulic jacks and greased plates, the bridge was pushed further forward, traversed sideways to the exact line (on account of buildings, etc., it could not be launched on that line), and lowered on to bedplates and rockers. It was found that, on a work of emergency, a large reserve was required with hydraulic jacks, for they were always getting out of order owing to washers giving out, etc. As the ground was soft, it was frequently difficult to get a foothold for them and the local green timber used to spread the pressure was unsatisfactory, the feet of the jacks punching holes in it.

In designing the staging on the lighter and fixing its exact height a close observation of the river was necessary, and in pushing the bridge on to the staging, allowance had to be made for the submergence of the lighter due to the weight of the bridge. The steel work was being painted at the time of the launching, and

Fig. 5.

except when their assistance was required for a heavy lift or pull, the painters continued at their work.

The two bridges next to be described were designed by the Author, and are of the simplest description, it being necessary to keep in view the difficulties of transport and erection, and of obtaining suitable labour.

Stitt Bridge (Fig. 5).—This structure consists of one span of 60 feet, and four spans of 25 feet, of web-plate girders of simple design erected on trestles of X cross-section, four angles back to back with space between for the gusset plates for tie-rods, etc., and riveted together at intervals through thimbles to preserve the spacing. The bridge was erected without staging. Two wire ropes carrying "flying foxes," worked by a ship's winch at one side, carried and lowered the pieces into position, where they were fixed temporarily, or permanently, as might be possible. The large

girders, on account of the sag in the ropes, were taken across on their flat side, stiffened with a simple truss to prevent them from sagging down, and were then lifted up on edge and lowered into position by derricks attached to the trestles. The cost of this bridge was £2,057 12s. 10d., or less than £13 per foot, including freight, concrete work, excavation and special gearing for erection: bridgework was also protected by a 20 per cent. duty. The bridge was 60 feet above the stream, and was designed to carry 80-ton engines.

Ring River Bridge (Fig. 6).—On account of the exigencies of the

Fig. 6.

site this bridge had to be built on a gradient of 1 in 30, and a portion at one end on a curve of 20 chains radius. A trestle form of construction of 30-foot spans was adopted, resulting in a cheap structure easily erected. It was necessary to erect some of the trestles on concrete piers in the bed of the stream, and the only difficulty in the construction was here encountered, as the bed consisted of heavy shingle for some depth. Square coffer-dams were used, the planks forming the sides being driven down as the boulders were removed from beneath them. The walings were then also driven, or fresh frames placed inside, clay being rammed down

outside and bags of clay deposited also. Hand spear-pumps, practically constructed on the spot, were used to keep the water down. Some form of pump worked by steam would have been preferable and cheaper to work, but it would have taken a month to get it to the site, and the difficulties of transport were almost insurmountable. Time was also of importance. By the time the concrete piers were finished the formation was completed and the rails were laid to the site of the bridge. The erection of the steel superstructure was then a simple matter. A travelling derrick-crane, built up of Oregon pine which had been used in temporary structures, was constructed to run on the carriages of some Bochum trucks, the steam ship's winch employed at the Stitt bridge being used for this crane. Sufficient traverse was given to the jib to command the width of the bridge, and the length of the jib was sufficient to command one bay at a time. With this the first bay was erected and decked. Rails for the crane were laid on the decking and the crane was moved forward to build the next bay in the same manner. The bridge was speedily and cheaply erected by this method. The total length was 290 feet, height 100 feet, and the cost complete £4,088, or a little over £14 per lineal foot.

The only other bridge of interest was the Wey Bridge, on the original Emu Bay line to Waratah, which had to be strengthened to carry the new locomotives. This consisted of two simple trusses of 60-foot span. The Author introduced another truss of double the strength midway between these and connected with them by cross-bracing. This was done without interfering with the traffic, and proved a simple piece of work. On examination it was found that the existing cross-bracing was strong enough to carry the new girder and the necessary staging until it was completed. The girder was consequently erected on the bracing, riveted up, and braced to the other main girders, the cross girders being then bedded on it.

In the Author's opinion the bridge-designer should have had some experience of bridge-erection under colonial conditions. This is not always the case in practice, and as a consequence, bridges are designed without sufficient regard to the material available (a serious oversight where practically all the material has to be imported), the cost of workmanship, and the conditions of erection.

The Paper is accompanied by a sheet of drawings from which the Figures in the text have been prepared, and by twelve photographs.