

cost of permanent way throughout, including rails and fastenings, sleepers, ballast and track-laying, amounted to £1,221 8s. per mile, including duty on the imported material. The trans-shipping arrangements at Goondah Siding consist of a trans-shipping shed, in which the 2ft. gauge line is brought along the main line siding in such a manner that the bags or casks of cement can be loaded downwards from the main line trucks on to the lower-built trucks of the 2ft. gauge; while, for the handling of heavy machinery, a gantry is erected over the main line siding, and the 2ft. gauge track is laid inside, and on the same sleepers as the siding rails. This enables a heavy load to be lifted out of a main-line truck, which is then pushed away, the 2ft. gauge truck taking its place, and the load being lowered thereon. A useful method, as it avoids the danger of swinging the load.

Throughout the line the bridges have been built of iron-bark, so far as the super-structure is concerned, 14in. by 14in. beams being used, with maximum span of 14ft., with corbels in every case.

The line crosses four public roads on the level, and it is of importance to recollect in this connection that, with a few exceptions, these roads are now vested in the shires, and that it is advisable to consult these bodies and obtain their concurrence before putting in these crossings, unless a special Act of Parliament has been obtained, in which provision for such crossings is made. In any case, Act or no Act, it is always better for an engineer to approach the public bodies who are concerned, no matter how remotely, with the works on which he is engaged, and to courteously consider their point of view. Endless trouble may be saved with land-owners and public bodies by the exercise of a little courtesy and consideration. On the Goondah-Barren Jack Railway the notices which have been recently adopted in America are used, in addition to the ordinary one warning the public to "Beware of the Trains." This notice is, "Stop, Look, and Listen," and it is easy to imagine the defence which would be set up by counsel in the case of a claim for compensation to a person who had ventured upon the line in the face of this warning.

The difficulty with regard to the supply of sleepers had scarcely been overcome when a fresh difficulty was encountered respecting the supply of water. The last year was an excessively dry one in the Yass district, and it became necessary to haul water on the main line from Yass to Goondah, and thence along the track, so far as it was laid, both for locomotive purposes and the supply of the workmen. Works of water supply in connection with the line when completed had been put in hand, and an excavated tank at Goondah com-

pleted, immediately after the work started, but no rain fell to enable these works to be made use of until the line was almost completed. At the present time the whole of these tanks carry a good supply of water. The following particulars give some idea of the cost of the water supply for this line:—

At Goondah—Tank and dam, capacity about 4,000 cubic yards, in clay and rotten rock, cost ... £238 18s. 6d.
 Also, service tank, 20,000 gallons, buckle plate on chairs and concrete blocks, costing, including rising main £188 4s. 6d.
 Steam pump cost £87 4s. 7d.

3-Mile Dam—Overshot concrete dam, 60ft. on crest, 15ft. high, flanked on one side with a clay puddle wall, 3ft. wide and 18ft. deep, in places through made ground and drift to granite bottom, 250ft. long. Service tank on stage, 10ft. high, 7,000 gallons, 22 gauge corrugated galvanised iron, 13ft. 6in. diameter by 8ft. high, filled with 14ft. Simpson windmill, lift 28ft.

Total cost £566 10 6

7-Mile, Manildra Creek—Small concrete dam, 4ft. high.

Cost £40 18 11

13½-Mile—Summit tank and dam—About 5,000 cubic yards capacity, earth dam, clay puddle core, gravity supply by 3in. pipe, carried from bottom of excavation under the dam.

Cost £280 0 3

18½-Mile, Lake de Burgh—Curved concrete dam, 66ft. radius, 99ft. on crest, 16ft. high, 18in. wide on top, and reinforced with 20lb. rails, set 10ft. apart vertically and 5ft. apart horizontally; service tank, 20,000 gallons, buckle plate tank, steam Blake pump.

Cost £529 13 2

After leaving Lake de Burgh, at the 18½-mile post, the line enters the mountainous country along Carroll's Creek. Where the creeks on the head of the gullies are crossed stone banks are used instead of openings. This system was adopted for the sake of economy. The flow in most of these gullies is very small, and in order to save the cost of constructing culverts a solid foundation was obtained for the embankment, and large rocks from the adjoining side cutting were deposited thereon. The water will, for a considerable time at least, flow through the interstices of the stone forming these banks, but should the spaces between the stones be silted up in future the water will be led over the stone work at the rail level. It will also be seen that, especially in one instance, a great length of line has been constructed to head a gully, the distance across the entrance to which could have been spanned by a comparatively short

viaduct; but here it may be pointed out that, putting the expense of constructing such a viaduct on one side, the ruling gradient of the line would not admit of this short cut being taken.

It has been stated that the work of constructing the line started in March, 1907, and in March, 1908, the formation had been carried right through, but unfortunately delay in the arrival of a cargo of rails from Europe retarded the completion of the plate-laying, so that the first train did not run into Barren Jack until 2nd June, the plate-layers laying about one-third of a mile of road a day after the rails arrived.

Two points may be specially mentioned in regard to this line:—

First, the joints of the rails are not laid opposite to each other, but are “staggered,” the object being to give greater stiffness to the road round curves, and to avoid the necessity for cutting rails, which cutting would be incessant on account of the small radius of the curves and their frequency.

Second, the rails are laid flat, and not canted inwards, and to match this practice the wheels of the rolling-stock are flat on the treads, and not bevelled. The necessity for the use of bevelled wheels where the correct super-elevation is given round curves, and the possibility of so fixing the super-elevation and the bevel as to give satisfactory results at all speeds is a matter which need not be discussed here. The flat wheel, flat-bedded rail, and a super-elevation on the curves calculated for the average speed, will be found to give satisfactory results, and does so in the case under consideration.

Turning to the preliminary work at the site of the Barren Jack dam itself, two matters had to be promptly dealt with during the months succeeding the authorisation of the work.

First, the accommodation for the men to be employed thereon, together with the water supply for and the sanitation of their camp.

Second, the necessary plant had to be ordered immediately, as the greater part of it would come from either Europe or America.

With regard to the housing of the men, it was originally intended, if the terminus of the railway or road had been at a point 800ft. above the dam site, as it was at first supposed was inevitable, to construct a township at that place, and pump water for its supply from the Murrumbidgee. Unless mechanical means had been provided, such a location for the camp would have necessitated a very arduous climb for the men after their day's work, and when the last surveys for the railway succeeded in bringing the terminus down to the level of the dam site it was, of course, decided to establish the camp on the level of the railway. As, however, the whole of the

flat land in the vicinity of the line would be flooded as the impounded water rose with the construction of the dam, the best arrangement which could be made was to place the barracks for the single men, the hospital, Government office, and stores above the full supply level, and to allow the remainder of the town to be built on the slope below the full supply level, a location which will, of course, have to be vacated before the dam is completed. Seeing, however, that the greater bulk of the work of construction occurs in the lower and thicker part of the dam, the greater portion of the township which is below full supply level will probably remain clear of the water until the work is close to completion. As the authority to proceed with the work was received in December, the start was made under summer conditions, and the first camp was established under the oak trees along the bank of the river—a very suitable camp in summer. The employees were allowed to draw water from the river itself, strict regulations being enforced with regard to washing, bathing, etc., while dogs were absolutely excluded from the camp. The present township was then laid out, and a water supply provided by pumping from the river at a point upstream of the camp to a tank upon the hillside directly above the township, and about 50ft. above the full supply level of the reservoir; and as soon as the streets had been laid out and the water supply made available, the married employees were encouraged to build on allotments in the town, for, with winter drawing in, the river fogs made the temporary camp, which had been healthy enough in summer, very unsuitable, and almost unhealthy. With regard to the men's barracks, the system adopted was to erect what might be called "cubicles" of galvanized iron, in long rows, above the full supply level of the reservoir. These cubicles are about 9ft. square each, and are intended for two men, two wire stretchers being provided by the Government. For the use of these cubicles and stretchers, together with the water supply, sanitary services, and the attendance of the doctor in case of illness, a fixed charge per week is made from each man. A charge is also made for sanitary services, water supply, and medical attendance to persons to whom permission to erect stores in the township has been granted.

Regarding the supply of the plant, a good deal of useful machinery was available from the Cataract Dam, which had just been completed, but, as it was intended to use much larger blocks of stone in the construction of the Barren Jack dam than had been used at Cataract, it was necessary to obtain new and powerful cableways and cranes for the handling of these blocks, and, as cableways cannot be ordered until their span is known, and as the span of the cableways required cannot

be fixed until the dam itself is exactly located, the close investigation of the valley, with a view to obtaining absolutely the best site, had to be pushed on simultaneously with the establishment of the camp. Arrangements were, however, made, by letter, with the manufacturers in America, establishing cable code words for the different machinery which was anticipated would be required, and it only remained, when the site was definitely fixed, to add in the cable span finally determined on to complete the order, and it may be stated that the Lidgerwood cableways, which are capable of lifting a load of 10 tons at a speed of 200ft. a minute, and traversing it at a rate of 1,200ft. a minute, and which are among the largest machines of their class in use, arrived from America before the excavation of platforms necessary for their erection could be completed.

The site for the Barren Jack dam originally surveyed, and on which the estimate for the work, as placed before Parliament, was based, was situated near the entrance to the gorge from the valley, and a close investigation of the site after the work was authorised led to a decision to place the dam nearly half a mile further down-stream, as already mentioned. At the site selected, the rock on the left hand side of the river is practically bare, and no excavation is needed to define its position or examine its character; while on the right hand bank of the river the rock is overlain by a certain quantity of soil, but of such small depth as to be unimportant. The bed of the river was, however, filled with enormous boulders of granite, and it was quite impossible to determine by boring or any other means the position of the solid rock underlying the river at the site. It would be impossible by boring to differentiate between these boulders and the granite itself, and the position of the solid rock had, therefore, to be assumed. It is satisfactory to find, now that the water has been diverted from the site of the dam, and these great boulders broken up and removed, that the solid granite formation runs uniformly from side to side of the river, affording a foundation which has probably never been equalled in a similar structure.

Although the flow of the Murrumbidgee River in a dry season is comparatively small, it must be borne in mind that the drainage of 5,000 square miles of country is concentrated in this gorge, and that there is no possibility of diverting the water entirely from the gorge—that is, by means of any other valley or outlet—during the construction of the dam, and the question of dealing with the water of the river so as to enable the work of constructing the foundations to be carried on was one which required grave consideration. First, as to the quantity of water which it was possible to deal with



FIG. 2.



FIG. 3.

by means of diversion; and, second, the best means of diverting that water. It may be assumed, on the basis of 16 cusecs to the square mile, that a flood volume of something like 80,000 cusecs would rush through this valley, and, of course, to divert such a volume of water during the construction of the work would be an impossibility. Consideration was given to the practicability of cutting a tunnel through the granite rock in the side of the valley, starting at a point above the dam site, and terminating at a point below it, and diverting the low flow of the river into this tunnel; but the cost of such a work was found to be prohibitive, and, as an alternative, a channel was partly cut and partly built on the right hand bank of the river, having a width of 30ft. and a depth of 15ft., and capable of discharging something like 7,000 to 8,000 cusecs. The cost of carrying out this work was very great. The rock was extremely hard, and, as it was of the utmost importance that the channel should be completed while the river was low, its construction could not be postponed until machinery for operating rock drills could be installed. Even access for the men to the site of the dam was extremely difficult, and led to great loss of time. As against this additional cost must be set the great advantage gained in time in the construction of the work, for had the volume of water which is at present flowing down the Murrumbidgee been running at the time the channel was constructed the work could not have been undertaken. As the channel neared completion a temporary rubble and earthen dam was thrown across the river upstream and downstream of the dam site, and inside of each of these temporary dams the boulders lying in the bed of the river were removed, and, after the greatest difficulty had been encountered in dealing with the inrush of water, the engineer in charge of the work, Mr. F. M. Smith, succeeded in founding on the solid rock the two concrete dams which are shown in the illustrations, and which complete the diversion of the water of the river into the diversion channel. In the space kept dry by these temporary concrete dams the work of clearing the excavation for the main dam is now carried on without interruption, although, should the flow of the river exceed 8,000 cusecs, a stoppage of the work must inevitably occur until the river falls again. The nature of the country in the gorge adjacent to the dam is such that it is impossible to obtain even the smallest level space for the erection of buildings or machinery without costly excavation, and the whole of the site occupied by the powerhouse, where the electricity for actuating the machines used on the dam is generated, is excavated out of the solid rock in the hillside or filled in with spoil from the excavation for the cableway platforms. Here, again, it is manifest that the most

economical way of constructing a work of this class would be, first, to complete the railway to the site; second, to establish the men's camp and erect power-house, with all generating plant and machinery, and when these facilities were available, and not till then, to begin operations on the site of the dam itself. Had this course been adopted at Barren Jack the position to day would be as follows:—The construction of the railway would have been carried out, but the power-house would not have been erected if the delivery of the machinery and material in connection therewith had been delayed until the railway had been completed, nor would any work whatever have been done on the site of the dam, nor could such have been started until about December next. As it is, owing to the simultaneous carrying on of all these works, the difficulties with regard to the construction of the Barren Jack dam may be practically considered at an end. The railway is completed, the power-house and machinery established, and the river diverted simultaneously, and that in a period of 18 months from the authorisation of the work.

It is to be regretted that Mr. L. A. B. Wade, the Chief Engineer for Rivers, Water Supply, and Drainage, has found it necessary to take a rest after some years of very severe work, and is not in Australia to see the result of the efforts made to clear the bottom of the river; but it is hoped that till his return, at the end of the year, the rate of progress which has been indicated in the preceding notes will have been maintained, and that he will have the satisfaction of finding the foundation prepared, and, perhaps, contracts let for the greatest dam yet constructed in Australia, and one of the greatest dams in the world.

