*(Paper No. 3613.)***“Engineering Work in Australasia: a Retrospect.”**

By EDWARD DOBSON, M. INST. C.E.

*(Abstracted from a Letter addressed to Mr. James Forrest,
Honorary Secretary Inst. C.E.)*

THE Author, who joined the Institution in 1842, presents to the members the following account of his experience of engineering work in Australasia during the past 55 years. Since leaving England in 1850 he has been engaged in the engineering work of a new country, at that time devoid of roads or bridges, and until the last few years inhabited by savage tribes. Being often for months under canvas, and working for long periods in primeval forest, his life has been necessarily one of isolation, the “Proceedings” of the Institution being almost his only source of information as to the advance of engineering knowledge and practice.

Landing in Lyttelton, the Author for a long time had a professional holiday, filling up his leisure chiefly with house-building and dairying, until he received Government instructions to set out a line across Banks’ Peninsula as the basis of a bridle-path and stock-driving road from sea to sea, to connect the harbours of Lyttelton and Akaroa. This required no engineering knowledge. It was simply a piece of bushman’s work; but it was very different from setting out a road up a leading valley. It meant running up a leading spur to its summit, and then following the watershed until another spur was reached, which would lead down to the sea-level. The only engineering difficulty was on reaching falling ground to know whether the direction taken would lead down one of the lateral valleys or merely to another saddle at a lower elevation; for the denseness of the undergrowth of the New Zealand bush and the impossibility of advancing even a couple of yards without cutting away the supplejack (a strong vine with which the whole of the bush is entangled) rendered it impossible to make any previous exploration. Commissariat difficulties necessitated limiting the number of the party

to four besides the Author, namely, three axemen and one man as cook and camp-keeper. The greater part of the track was more than 1000 feet above sea-level, and in the early stages of the work the use of pack-horses was impracticable. To provision the camps from either end of the line involved much labour and waste of time, and therefore the only stores procured in this way were flour and salt, tea and sugar. The party lived on birds, chiefly pigeons, which the Author shot in the morning as he went to work and hung up in the track, to be collected by the cook a couple of hours later. The flour was either made into cakes, baked in the embers, or into dumplings, boiled with the pigeons. No vegetables, meat, bread, butter, cheese, milk, beer or spirits were procurable, but nevertheless the party lived very well, and no complaint was heard, either as to the quality or the quantity of the food. The water-supply was the only real difficulty. It was not easy to find camp-sites sufficiently near the water and conveniently near the track; and in the winter frosts water could only be obtained by melting the scrapings of a scant snow-fall. Owing to the denseness of the bush, the work went on very slowly, and the cutting of the 18 miles of bush-track occupied many months; but when this was completed and the line to be permanently adopted was definitely settled, the rest was easy enough. The path through the bush was widened to a minimum breadth of 10 feet and cleared of stumps and fallen timber, and side-cuttings were made where required by the slope of the sidelong ground. This road, known as the Akaroa bridle-path, proved to be a great public convenience, especially when connecting-tracks had been cut from the lateral valleys. The denseness of the Akaroa bush affords a good example of the differences in survey-work induced by the climate and physical conditions of the countries in which such work is carried out. Many years later, on the works of the Geelong Water Supply, the Author had to transverse a contour-line defining the surface-level of an intended reservoir, in order to ascertain the area from which the timber had to be cleared, and, although the forest was thickly studded with well-grown timber, the absence of undergrowth enabled work to be done in a few hours which in the Akaroa bush would have occupied as many days. The cutting of the Akaroa bridle-path was the Author's introduction to tent-life, and the first of a long series of experiences, from which he learnt a few of those lessons which are an essential part of the education of an engineer, but which he is not taught either at school or at college. He should be a good shot and a good cook, and be able to make and mend his own tents if necessity arise. He must be able not only to swing an axe, but to carve the delicate curves of an axe-handle with no other tools than

a spoke-shave and a piece of broken glass for a scraper. Axe-handles, unless made of well-selected material, often come to grief, and the cutting of axe-handles is a useful amusement when sitting round the camp-fire in the evenings. This catalogue of qualifications might be extended *ad infinitum*, and it goes without saying that he should be able to ride and drive, and manage a boat; but he should also be able to shoe his pack-horses, repair their harness, and use the diamond-hitch in securing their loads, which, in the Author's opinion, is the best precaution against strain and sore backs. Again, accidents are sure to happen sooner or later, and it is well that the leader of a party should understand ambulance-work, and know how to set a broken limb and how to bandage a cut or a strain.

In November, 1854, the Author received an appointment as Provincial Engineer, and amongst other works the execution of which was entrusted to him in this capacity were the Lyttelton and Christchurch Railway, with a tunnel through the Port Hills, and the West Coast Road across the New Zealand Alps, through the Otira Gorge and the valley of the Teremakau to the sea at Hokitika. The importance of the Christchurch Railway lay in the fact that the tunnel through the Port Hills was the only direct communication for wheeled traffic between the port and the plains, whilst that of the Otira Gorge road lay in its being the only means of reaching the western goldfields. Owing to the height of the summit, the Moorhouse tunnel had to be driven entirely from the two ends, and the hardness of the lava-streams and of the intersecting dykes caused the execution of the work to extend over many years. It is difficult for anyone who has not had personal experience of work of this kind to imagine the severe mental tension produced by years of hopeful anticipation clouded over by dark forebodings of possible failure which it involves, or the immense relief experienced, when the drives are at last connected, on seeing the two sets of plumb-lines hanging in perfect unison. The Author refers to this for the purpose of enforcing the necessity, in work of this kind, of sparing no expense or trouble in the accurate determination of the centre-line, and of securing from interference the leading marks erected for this purpose.

On account of the rush to the western goldfields and the difficulty of getting there, great public interest was excited by the proposals for the construction of the West Coast Road. Before the final adoption of the selected route, in conjunction with his eldest son, Mr. George Dobson, subsequently murdered at the diggings in 1866, the Author took barometer-readings over the dividing range, wherever there was any possible chance of making a road, and the

calculation of the heights above sea-level from these observations enabled him to illustrate his report to the Government with valuable maps of the district and sections of all the saddles, as well as lithographic views, prepared from pencil-sketches of leading portions of the proposed route. There was a great deal of comment and criticism on the subject of the work; but the publication of this report was a full justification of the adoption of the Otira Gorge route selected by the Author. These circumstances are mentioned for the purpose of pointing out that it is well for a young engineer, engaged in work of this kind, to take every opportunity of graphically illustrating his reports, as a means of inspiring the confidence of his employers in the ability of their engineer. The mere exhibition of a field-book, illustrated with good pencil-sketches of the scenery through which the survey has been taken, is often of great value towards accomplishing this end, and notwithstanding the use that may be made of a camera, it is very desirable that the engineer should endeavour to attain proficiency in rapid landscape-sketching.

Besides the Christchurch Railroad and the West Coast Road a great deal of work came under the Author's charge, which, although of less public importance, was extremely interesting from a professional point of view. For example, on the South Road below Timaru, for a distance of 4 miles, a belt of swamp extended from the shore-line to the foot of the Downs, which were intersected by deep creeks, so that the only practicable road was along the beach, where travellers, if caught by the tide with their horses, were liable to be drowned in the sea or overwhelmed in the swamp. Now that the creeks have been bridged, and the swamp drained by cutting permanent outlets for the flood-water, it is difficult to realize the former condition of this part of the country; and the visitor who is being driven along the foot of the Downs on a broad, well-metalled road, does not hesitate to express his complacent criticism of the folly of the engineer in winding round the spurs, when to all appearance the road might have been carried for miles in a straight line—a plan which, half-a-century ago, would have been too difficult and costly for adoption. Again, on the North Road the engineering of a practicable line through the limestone country of the Weka Pass was an interesting piece of work, the upheaval and folding of the stratification forming a very instructive geological study, especially in connection with the formation of the valleys and the consequent direction to be given to the roads of the district. The Author would urge all engineering students, when engaged in survey-work, to make full use of the opportunities thus afforded for geological study, not only in connection with the work upon which they are

then actually engaged, but as a means of enlarging their education and fitting them for future engineering experiences.

Shortly after the completion of the railroad to Christchurch, in November, 1868, the Author left New Zealand for Australia, where he soon received an appointment as *locum tenens* for the late Mr. William Elsdon, the engineer for the Melbourne suburban railways, who was then going to England on sick-leave. The principal work carried out by the Author during his tenure of this appointment was the removal and rebuilding of the bridge over the Yarra at the Melbourne station. This was a timber bow suspension-bridge of a little over 90 feet span, the laminated arches of which had become dangerously rotten. It was replaced by a bridge in three spans, in which the sleepers rested on undertrussed beams of hardwood. The success of this construction was evidenced by the fact that the horizontal hand-rail erected at the side of the bridge remained perfectly level, without the slightest deflection during subsequent years of traffic. The conditions under which this work was done were somewhat peculiar; diversion of the traffic was impossible, its suspension even for a short period was not to be thought of, and the only time when it was possible to break the continuity of the rails was between eleven o'clock on Saturday night and ten o'clock on Sunday morning. The only alteration in the arrangement of the traffic was that the bathers' train on Sunday morning started from outside the station. On Mr. Elsdon's return, after two years' absence, the Author's engagement in Melbourne terminated.

During the next 5 years the Author was engaged in the completion of the works of the Geelong water-supply under Mr. George Gordon as Engineer-in-chief. The failure of the great earthen dam of the Stoney Creek reservoir rendered necessary the execution of extensive repairs and many additions to the original design of the works. All this was fully described in a Paper¹ by the Author, read at the Institution in 1879; but a few remarks may here be made on the dam of the lower reservoir, the behaviour of which gives rise to important questions, which may well be the subject of future Papers by members engaged on work of similar character. The dam is of concrete and is curved in plan; and as the hills on each side prevented the formation of a lateral by-wash, the top of the dam is dished to direct the flood-water towards its centre. The work was carried out under the Author's supervision, and for several years after it was opened for use it showed no sign of settlement or

¹ "The Geelong Water-Supply, Victoria, Australia." Minutes of Proceedings Inst. C.E., vol. lvi, p. 94.

leakage. In later years, however, a vertical hair-crack has appeared in the outer face, from top to bottom, plainly marked by a damp margin on each side. It can scarcely be said to be a leakage; but there is a slight oozing of moisture at the lower part of the wall. There is no sign whatever of vertical settlement, or of horizontal movement of the wall on either side of the fissure, and the Author is at a loss to account for its occurrence. It is presumed that the crack extends throughout the whole thickness of the wall, but this cannot be ascertained with certainty. The immense pressure of the water on the inside of the wall and the curvature of its plan no doubt keep the wall pressed against the abutments of this horizontal arch in perfect safety; and this leads the Author to approve of building dam-walls on a curved line, where they are bounded by hills only a few hundred feet apart. Mr. C. J. R. Williams, M. Inst. C.E., the Harbour Engineer at Christchurch, who has lately come from government service in Queensland, has told the Author that he is always prepared to find trouble in the use of concrete. It would be interesting to learn the opinions of other members of the Institution as to the choice of concrete or stonework in the construction of large dams, and also on the subject of straight and curved dams.

In completing the works of the Malmesbury reservoir, the Author was confronted with a new and somewhat difficult problem, the manner of solving which may here be described with advantage. The paving of the by-wash had been delayed, although the reservoir was kept filled with water nearly up to the level of the top of the dam, and a heavy flood caused the scour of a broad and deep gully, the extension of which for a few chains would have almost wrecked the reservoir. Without further delay the by-wash was paved with heavy blocks of masonry, and a concrete wall was thrown across the gully to prevent its further extension. This wall was curved in plan and its summit formed a vertical curve corresponding with the curve of the cross-section of the paved by-wash. The top of the wall, forming the bed of the coping, was horizontal in a direction radial to the curve of the plan, whilst the joints of the coping-stones were radial to the vertical curve of the top of the wall. After the building of the wall had been completed, it would have been easy to mark upon the top of the wall the position of each of the coping-stones, and to obtain by actual measurement the angles of the beds and joints, by which to cut templates to be sent to the quarry. But to obtain these templates simply from examination of the drawings was difficult and almost impossible. The following expedient was therefore adopted:—On an adjoining piece

of tolerably level ground the curve of half the length of the wall was set out, and at short distances apart pieces of scantling were erected and set to the intended batter of the wall. On these scantlings were marked the heights of the vertical curve of the top of the wall, to serve as a guide in nailing to them a light batten, which thus formed a working model of the top edge of the wall, from which the templates could be obtained almost as readily as from the completed wall itself. This plan proved perfectly successful, and the coping was afterwards placed upon the wall without the blocks requiring the slightest alteration. This problem illustrates the necessity for a practical acquaintance with the geometry of lines, surfaces and solids, as a part of the education of a Resident Engineer, who without this knowledge would be unable to give intelligent direction to the operations of a contractor, whose work it may be his duty to approve or condemn.

On the Author's return from Australia to New Zealand in 1876, when he entered into partnership with his son, Mr. Arthur Dudley Dobson, he found that great political changes had taken place since the time when he was appointed Provincial Engineer for Canterbury. The government of the country by provincial councils, each with a superintendent and executive, had come to an end. All legislative power was vested in the general Government, established at Wellington, with a House of Representatives, Legislative Council, Premier, and a Ministerial Executive. The provinces remained as geographical districts, with a certain amount of local administration of the Government departments, whilst public works were under the management of Road Boards, County Councils, and Municipalities, with, however, this great change, that the land fund, instead of coming directly to the Road Boards, went to the general Government at Wellington, and the funds for public works had to be raised by local rates assisted by Government grants. The effect of this to the Author's firm was that, whilst enjoying the freedom and independence of private practice, their sources of employment were many and the works entrusted to them were of a very varied nature. They made many extensive surveys, both public and private, and laid out new roads through pastoral country and many miles of water-races. These races required that the levels should be carefully contoured, in order to ensure uniformity of gradient and to avoid scouring-action, whilst the tunnels and sluices of the intake-works had to be skilfully designed and carefully executed. They also built many timber bridges, some of great length. The last of these was one of thirty-five 20-foot spans over the River Selwyn. The piles, capsills, and floor-beams were of iron-bark, imported from Australia,

whilst the flooring was of New Zealand heart of black birch. In addition, they carried out two important railway surveys for the Government.

The first of these was a length of 25 miles between Kaikoura and the River Waiau, on the line of the East Coast Railway now under construction between Waipara and Blenheim. This was the roughest bit of survey-work that the Author has ever undertaken; some miles were along a rugged, broken coast-line, where the survey-party were often liable to be caught by the tide. Inland portions of the route were inaccessible to pack-horses, and in a roadless country the distribution of 25 miles of heavy survey-pegs was a difficult matter. The Amuri district is broken up by deep, precipitous ravines, and the bush is of the usual dense character of the New Zealand forest. The provisioning of the camps was often difficult, and the severity of the weather made the work very trying, the survey-party often having their clothes frozen on their limbs after wading through the numerous streams. As in many places direct measurement would have been impracticable without ladders and scaffolding, the Author made use of tachemetry by means of the theodolite. Two different methods were adopted, namely, that of observing the intercept on the level-staff subtended by a given angle, and that of observing the angle subtended by a rod 4 feet 6 inches in length held up by one of the survey-hands. In these surveys frequent use was made of the aneroid barometer in filling up sectional details between two bench-marks, fixed either by ordinary levelling or by triangulation. Every set of observations was begun and closed by reference to a bench-mark; thus, if the height of the bench-mark at which work was commenced was 734 feet, the normal tabular reading of which was 29.17 whilst the actual reading was 28.99, the difference, 0.18, would be added as an index-error to the subsequent readings. If on arriving at the second bench-mark the index-error was greater or less, which often happened, as the barometer is seldom stationary, the difference was distributed to form a second revision of the barometer-readings, the time at which the readings were taken having been carefully recorded. The use of the aneroid barometer was found very helpful in running trial-sections. In order to run levels through the forest with the spirit-level it is necessary to cut lines to get a sight of the level-staff; but a barometer-reading can be obtained anywhere, although it may be necessary to crawl through the scrub on one's hands and knees.

The second of the two surveys referred to was over a length of 70 miles, between Waikari and Lake Brunner, forming one of the

routes proposed for the Midland Railway. This route was not ultimately approved of, that adopted being the one now under execution and partly completed, surveyed by the late Mr. C. Napier Bell, M. Inst. C.E., by way of the Otira Gorge, with a tunnel 6 miles in length under a summit-level of a little over 3,000 feet. The line surveyed by the Author lay along the valleys of the Hurunui and Teremakau Rivers, with a summit-level of considerably more than 3,000 feet, and, with the exception of a few miles of open country near Waikari, was entirely through river-bed and the usual dense New Zealand forest. But there were no engineering difficulties to be surmounted in the execution of the survey. The survey-party numbered twenty in all, with six horses, and there were no commissariat or climatic difficulties to contend with. The survey commenced at a trigonometrical station on the Canterbury Plains, where a true meridian was obtained from the reading of the registered bearing of another trigonometrical station in the secondary triangulation. The centre-line was staked out with branded pegs, 5 chains apart, on each side of which the topographical work was built up by ordinary survey methods. The work was plotted on separate sheets, imperial size, each sheet including a mile of survey, which was plotted to a scale of 3 chains to the inch, and on each sheet were ruled a meridian and an east-and-west line, on which were figured the distances west and north of the initial trigonometrical station. This enabled the work of each sheet to be transferred without the slightest difficulty to the Government maps. The work in the field was conducted by Mr. Arthur Dobson, and the mapping was done by the Author in the Christchurch office.

The Author is glad to learn from Sir Guilford Molesworth's Presidential address that interest is again being taken in railway gauges. He started railways in Canterbury in 1859 on the 5-foot 3-inch gauge, on which the lines were constructed for some distance beyond Christchurch. Then, on proceeding to Australia, he had the pleasure of managing the Melbourne suburban railways on the same gauge, with a heavy traffic in goods and passengers; and on his return to New Zealand in 1876 it was a bitter disappointment to find that the railway system of New Zealand was crippled by the adoption of the narrow gauge. He does not think that any of the advocates of a reduction of the standard gauge at all realize the evils of the narrow-gauge system. Apart from lightness of construction, the economy to be gained by reducing the distance between the rails is a very trifling factor in constructive cost. Diminution of train-speed necessitates increase of the number of hands employed, and of the quantity of rolling-stock required; for example, an increase of

the train-speed from 15 to 30 miles an hour practically enables double the work to be done with the same staff and rolling-stock. And increase in the capacity of wagons means a great diminution in the length of the trains. Thus, if 200 tons of coal have to be taken in 10-ton trucks, twenty trucks will be required, whereas with 6-ton trucks the work cannot be done with less than thirty-three trucks, the 10-ton truck being very little longer than that carrying only 6 tons. On a level country, where the roads are all crossed on the level, the excessive length of the trains often leads to serious delay and inconvenience, especially at the large stations, crossed at each end by public roads. It is quite common for trains of forty trucks to run through the Lyttelton tunnel, and this number is often exceeded. The carrying-capacity of a single narrow-gauge line is very limited. The railways of Canterbury comprise more than 2,000 miles of line with a very heavy traffic in coal, firewood, timber, grain, sheep, wool, and frozen mutton, and serious difficulties are encountered for want of sufficient facilities for the crossing of trains moving in opposite directions. Increase in train-speed is promised; but, as the maximum accelerated rate will not exceed 25 miles an hour, the improvement will not amount to much, and it is impossible to reflect without bitterness upon the fact that, had the gauge been retained on which the construction of railways was first commenced in Canterbury, the express trains would be running at not less than 50 miles an hour, with all the advantages derivable from rapidity of transit.

A point of some importance in the New Zealand railway time-tables is that the height above the sea of the rail-level at every station is recorded. It is impossible to exaggerate the value of this extensive system of levels, all referred to one common datum, in surveys for drainage-operations or works of water-supply.