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“Railways in China: the Formosan Government Railway.”¹

(Abstract.)

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THE Formosan Government Railway may be considered the first railway line constructed as Government work in Chinese territory, for public as well as private use. It was begun in 1887 under the personal direction of His Excellency Liu Ming Ch'uan, then Governor of the island of Formosa (called by the Chinese Taiwan), which lies about 460 miles north-east of Hong Kong (see *Fig. 1*). The island is about 240 statute miles in length; its greatest breadth is 86 miles, and its superficial area is about 15,000 square-miles; the larger portion is mountainous, with peaks exceeding 10,000 feet in height; but in the south, and towards the west coast, there are extensive and highly cultivated sea-bordered plains, sometimes nearly 40 miles in width. Uncivilized tribes of aborigines still occupy most of the mountainous districts.

Partially occupied by the Portuguese towards the end of the 16th century, and subsequently by the Spaniards, Formosa was seized by the Dutch about the year 1625, who in their turn were driven out by the Chinese in 1652. Little attention was, however, paid to the island until 1884, when, during the Franco-Chinese War in Tongking, the French threatened it, and sent an expeditionary force, which bombarded the northernmost seaport of Kelung. The Governor of the island defended his post with great energy; the French were repulsed at Hobé, and soon afterwards retired. The Governor not only applied himself to the fortification of the island with Armstrong guns and torpedoes, but also established lines of telegraph across the country; and connected it by submarine cables with the Pescadores Islands and with the mainland beyond; he also erected a steam saw-mill at Tuatutia, and opened a colliery near the Port of Kelung.

¹ A series of articles entitled “Formosa and its Railways,” will be found in “Engineering,” March 25, May 6 and 13, and June 3, 1892, and, it is stated, will be further continued.

In 1887, after peace had been concluded with the French, Formosa was for the first time constituted a separate Province of the Chinese Empire, and the Governor was ordered to remove the capital from the sea coast, and build a new city near the centre of the island; but Liu Ming Ch'uan, who had already expressed himself in favour of the introduction of railways into China, replied that, in order to carry out this order, as there were no

Fig. 1.

roads, he must be permitted to construct a railway from the new capital to the coast. The Imperial sanction having been obtained, the railway was begun in March, 1887, and, in the following year, was adopted as an Imperial undertaking, to be constructed by Chinese workmen, with the least possible assistance from foreign engineers.

The line was intended to traverse the island from the port of Kelung at the north-eastern extremity, *via* Tuatutia, to the new central capital near Changhua, and thence to Taiwanfu on the south-western coast. In deference to the strong national prejudice against "foreign barbarians," the Governor himself initiated the enterprise, and, accompanied by a German railway engineer, who happened to be in the island, directed the marking out of the first four miles of the line. He distributed companies of soldiers in temporary camps along the route, and assigned to their generals the task of directing the execution of the several sections of the work; some foreign assistants being engaged to peg out the line, but without any personal authority over the soldier-navvies.

For the sake of economy, a single line of 3 feet 6 inches gauge was adopted; 36 lbs. steel rails were used; the maximum gradient was 1 in 30, and curves of 5 chains minimum radius were permitted. From the commencement, the work has been carried on perseveringly, although with some interruptions and mishaps. A succession of foreigners, generally Englishmen, have acted in various capacities for periods of a few months, and at the time of writing (December, 1891), Mr. W. Watson, Assoc. M. Inst. C.E., holds the appointment of chief engineer, and Mr. H. Mitchell that of locomotive superintendent. The writer, who had taken up his residence in the island in 1887, to superintend the works in connection with the collieries at Kelung, became consulting engineer for the railway in 1888, a Chinese official being the manager. A section of 4 miles at the Kelung end was opened for traffic in November, 1888, another section of $5\frac{1}{4}$ miles, on the southern line, in January, 1890, and by October, 1891, trains were running regularly over 20 miles of the northern, and 12 miles of the southern, portion of the railway. With the exception of a few days, when one Chinese acted as a substitute, the engine-drivers have all been English.

The engineers have throughout laboured under the disadvantage of having no control over the work. For a long time no plans were made, the Governor desiring merely to have a longitudinal section upon which the centre heights of embankments and cuttings should be indicated; and the petty officers in charge of the gangs of soldiers were careless about working to the engineers' pegs, which were continually taken away for firewood. When complaints were addressed to the Governor, representing the bad work resulting from this, he would give his orders of redress through his generals, and the generals usually showed themselves more disposed to support their own officers, than to correct them on

account of "foreigners'" complaints; so that the engineers had frequently to set out the line several times over.

The headquarters of the railway are at Tuatutia, and the construction was begun at that point, first in the direction of Kelung, and later towards the south (see *Fig. 2*). Tuatutia stands in the midst of a plain, and the first 7 miles of the line towards Kelung run over nearly level ground, through irrigated rice-land, which required the provision of many culverts and small wooden bridges. The landowners frequently objected to their rice-fields being cut in two; and the Chinese officers would twist the rails from side to side to please them, and, in spite of the level ground, contrived to introduce an unnecessary number of curves into the line.

From Tuatutia to Saitingka (11 miles) the railway was completed and opened for traffic in the spring of 1889. After that, a long delay was occasioned by a cutting at Katongka, half a mile further on, through a low spur rising abruptly out of the valley and covered with tea plantations, which absorb water like a sponge. It could have been tunnelled easily, but the Governor would not allow that, and, in order to pass through the crest of the ridge with a cutting about 60 feet deep, ordered that the line should be carried up to it by embankments on each side of the ridge. This cutting was begun early in 1888. The greater part of the excavation consisted of clay, which softened under rain, and slipped, cracked, or flowed during heavy downfalls. Moreover, the general in command failed to realise that so deep a cutting would require considerable width for its sloping sides, and much of the spoil was thrown on to ground which had afterwards to be itself cut away. And so it resulted that, as fast as spoil was taken out, more stuff slipped into the cutting, whilst the upper part became a quagmire.

In May, 1889, the engineer recommended an alternative route round the spur, and, on that being rejected, suggested plans for drawing off the water, or the construction of a covered way which should be lined and covered with stone and brick, step by step, as it was made; but his advice was not acted upon. At length, there was so much sickness among the soldiers that native labourers had to be employed, and, finally, in November, 1889, the cutting had to be abandoned, and the diversion previously recommended round, instead of through, the spur was adopted; this increased the length of the line by about half-a-mile; and was completed early in 1890.

Continuing in the direction of Kelung, an iron bridge 100 feet in length, another rather troublesome cutting, two embankments 30 feet and 40 feet high respectively, two small wooden bridges

and two other bridges over the Kelung river, bring the line to a ridge which divides the so-called Kelung River Valley from the sea. Here, with much difficulty, the engineer succeeded in obtaining approval for the construction of a tunnel 286 yards in length instead of an open cutting which would have been nearly 200 feet deep.

This work was commenced early in 1887 with open cuttings on each side of the ridge. The foreign engineers were only allowed to mark out the required direction of the line and state the depth of cutting at each peg, and the work was carried on by the Chinese in their own way under the direction of their generals and officers. The strata passed through consisted of shales, sandstones and clays of different degrees of hardness, permeability, &c., and lying at a high inclination. The rainfall of the locality usually exceeds 130 inches per annum, but few or no precautions were taken to prevent surface drainage from finding its way into the cutting; and, before the tunnel proper was reached, a huge mass of rock and earth slid bodily into the excavation on the northern side, followed by a similar, though less extensive, slip on the south side. Thereupon the Chinese officials urgently pressed the Governor to give up the idea of a tunnel, and to make an open cutting for the whole distance through the hill. He adhered, however, to a tunnel, but ordered a new line to be laid out to the west of the previous site, with a slight curve near the middle of it; and they began again.

This time the general in command fixed the level of the heading at the northern end 14 feet too high, which occasioned a good deal of trouble when the two ends of the tunnel met; while the soldiers had advanced but a short distance into the heading at the southern end, when the roof fell in, so that the floor of the excavation lay open to the sky. The tunnel-makers attempted to remove the fallen material without timbering the sides of the excavation; and, as they deposited the earth which they removed close to the edge of the excavation, the rain soon brought all down again into the hole.

It was strongly represented to the Governor by the engineers that this would not do, and they advised (December, 1888) that a small timber-protected heading should be carried through the *débris*, so as to get into the tunnel again as soon as possible, and that a brick-lined tunnel should be simultaneously constructed round the heading. The Governor approved of this course, but the general in charge objected to the expense of timber props, and persevered with the removal of the fallen stuff, which was

ultimately accomplished. At weak points of the roof of the tunnel a brick lining was put in the arch, the sides being of stone, and wooden props were adopted for less insecure parts; these were intended to be only temporary, but they have remained in position up to the present time.

From the northern end of the tunnel, the line runs down to the sea, and terminates on a wharf about $1\frac{1}{4}$ mile distant. This portion of the work has been badly executed, for much of the cutting which had previously been done was rendered useless by the change in the tunnel; and, after the engineer had pegged out a new line to the wharf, he was called away to the southern line, and during his absence the pegs were so much disregarded that the railway was built with curves of less than 3 chains in radius, and gradients on them of 1 in 16. When, at length, the Governor was persuaded to give his attention to this, the line was marked out once more, but the engineer was desired to make the most he could of such work as had been done in his absence; so that the line remains unsatisfactory at the very point where it should have had the greatest attention bestowed upon it. The wharf is constructed in a good position for shelter to boats, but the harbour has at this point a depth of only 3 feet at low-water; and, either the line must be extended into the harbour, or much dredging must be done to make the wharf available for steamers.

The line from Tuatutia southwards, starts from a point at about half-a-mile from the town in the direction of Kelung; and trains for the south back out from Tuatutia to the junction, whence they start forward to the bridge over the Tamani river, where there is another station. This bridge is 1,498 feet long, of which 1,465 feet are built of timber in forty-six spans; and at the end is a passage for the junks, 33 feet clear of everything, with an iron swinging span centred on a masonry-pier, and abutting on the shore. From this bridge, the line runs for nearly 7 miles over ground which is almost level, through fields of sugar-cane, hemp, oranges, betel-nuts, palms, sweet potatoes, ground-nuts, and rice. The ascent from the plain to the neighbouring tableland is made in 3 miles, of which $2\frac{1}{4}$ miles are on a maximum gradient of 1 in 30, the summit cutting being 70 feet deep, after which there follow 26 miles of undulating ground. The work in progress extends to about 50 miles from Tuatutia, and at about 50 miles beyond this point is the proposed site of the new city.

Latterly, much of the work has been done by native contractors, the ordinary labourers earning $7\frac{1}{2}d.$ per day, and masons or carpenters between $10\frac{1}{2}d.$ and $13\frac{1}{2}d.$ per day. The ordinary cost of

earthwork is 3*d.* per cubic yard, but in very easy ground the price does not exceed 1½*d.*, while in hard stuff or in high banks it reaches 6*d.* per cubic yard. The railway is much used by the people, and is being worked by the Chinese, as it was constructed, with as little foreign assistance as possible. The tariff for goods is high, the charge for light goods being 6·4*d.* and 8*d.* per ton per mile, and for coal 1·9*d.*; but passengers are conveyed from Kelung to Tuatutia, a distance of 20 miles, for 1*s.* Special saloon carriages are provided for the Governor and the high officials, the other passengers being divided into two classes.

It is much to be regretted that the energetic Governor has recently been forced by ill-health to resign his post, for it is not at all certain that his successor will be equally disposed to continue the construction of the railway; although it appears, since the above account of the works was written, that he will consent to the completion of the portion already actually commenced.