Diamond jubilee of the Gotthard Railway

DIAMOND JUBILEE OF THE GOTTHARD RAILWAY.

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When the Gotthard line was opened throughout on June 1st, 1882, few people realised how important a rôle this Swiss railway route would play in Central European traffic. The first project for a Gotthard railway was submitted in 1852, by Herr Koller, a Swiss engineer, who was in charge of the Eidgen. Eisenbahn bureau (the railway department of the Swiss Government). In 1853 the first Gotthard Committee was set up in Lucerne to discuss the problem of a Gotthard railway in general, but no conclusions were reached.

With the construction of the Mont Cenis line (1857) in the west, and the prospects of a Brenner line in the east, interest in the Gotthard line flared up again, and on September 15th, 1860, the second Gotthard Committee was set up. This recommended Koller's proposal. As it was realised that such a gigantic project could not be carried out without the financial assistance of the interested neighbouring States (Germany and Italy), Switzerland approached the then kingdom of Sardinia, in Turin, and obtained an undertaking for financial assistance in 1861.

This brought the project a step further, and in July, 1861, a Swiss engineer, Herr W. Weltli, of Zürich, was commissioned to undertake a topographical survey of the route. The preliminary survey was completed in the very short time of a year, but then financial difficulties interrupted Weltli's work for about a year. In the meantime the so-called Gotthard Conference was founded, and decided at its meeting of August 7/8th, 1863, to appoint two experts, Herr A. V. Beckh and Herr R. Gerwig, to complete Weltli's survey. The maximum gradient was fixed at 26 per mille (1 in 38.4) with the exception of short stretches on the southern section, where it is 27 per mille (1 in 37), and the minimum radius of curves was fixed at 300 metres (280 metres in exceptional cases), or 14.9 chains and 13.9 chains respectively. The topographical conditions in the two valleys leading to the summit tunnel necessitated an artificial extension of the length of the line by spiral tunnels (near Wassen, Rodi-Fiesso, and Giornico stations) in order not to exceed the maximum gradient of 26 per mille.

The original project was based on the following train service; one fast train of 70 tonnes, 2 slow trains carrying a gross load of 170 tonnes, with a speed on the 26 per mille gradients of 22 kilometres per hour (13.67 m.p.h.) for the passenger and 12 k.p.h.) for the goods trains. On September 15th, 1869, the first international Gotthard Conference was held at Berne, the Governments of Switzerland, Germany and Italy taking part. The first project was revised, and the length of 257 kilometres (Lucerne-Chiasso, with the branches from Zug to Arth-Goldau and from Bellinzona to Locarno) was extended to 265 kilometres (164.66 miles) by including the line from Cadenazzo to the Swiss-Italian frontier at Pino. The necessary capital for building the line was estimated at 187,000,000 fr., of which 85,000,000 fr. were government subsidies (20,000,000 fr. from Switzerland, 45,000,000 fr. from Italy, and 20,000,000 fr. from Germany). A State treaty was signed on October 31st, 1871, and on November 1st, 1871, the Gotthard Railway Company was founded.

Detailed surveys of the projected line showed that the construction costs would exceed the original estimates by 120,000,000 fr. This nearly had very serious consequences for the whole project, but at a special meeting of the International Gotthard Conference on June 4th, 1877, it was decided to reduce the construction programme by the building of single track lines on the northern and southern approaches to the Gotthard Tunnel, although all the tunnels were to be built to take a second track, and by postponing construction of the feeder lines from Lucerne to Immensee and from Zug to Arth-Goldau, etc.

By this reduction of the building programme, the additional expenditure was decreased from 102,000,000 fr. to 40,000,000 fr., with additional government subsidies of 10,000,000 fr. from Germany and Italy respectively, and 8,000,000 fr. from Switzerland, while the remainder had to be raised by the Gotthard Railway Company. Finally, the construction costs for the southern part of the Gotthard line, from Bellinzona to Chiasso, again exceeded the estimates, and both Italy and Switzerland had to give another subsidy of 3,000,000 fr. each. Of a total of 119,000,000 fr. of government subsidies, Italy paid 58,000,000 fr., Switzerland 31,000,000 fr., and Germany 30,000,000 fr.

The doubling of the northern and southern approaches to the Gotthard tunnel was carried out during 1888-1893, while double-track operation in the Gotthard tunnel was commenced in 1884. The feeder lines from Lucerne to Immensee and from Zug to Arth-Goldau were built from 1895 to 1897, and on May 1st, 1909, when the Gotthard railway was taken over by the Swiss Federal Railways, the capital of the company was about 300,000,000 fr.

The total length of the Gotthard line from Immensee to Chiasso is 205 kilometres (127 miles). The difference in altitude on the northern section is 716 metres (2,349 ft.) and on the southern section 922 metres (3,025 ft.), on the mountain sections from Erstfeld to the summit in the Gotthard tunnel and from Biasca to the summit in the Gotthard tunnel respectively. Between Bellinzona and Chiasso the line rises again to the Mont Cenere Pass, with differences in altitude of 242 and 234 metres (794 ft. and 768 ft.) respectively. Between Immensee and Chiasso there are 80 tunnels and galleries, the longest of which is the 9.3-mile-long Gotthard tunnel; 1,234 bridges and viaducts with a length of 6,471 metres (4 miles), while the total length of the tunnels is 46,356 metres (28⅝ miles).

Before the electrification the principal types of steam locomotives used on the Gotthard line were the following: The first type of steam locomotive, put into service in 1882, was an 0-6-0 twin locomotive with a weight in working order of 68 tonnes, an adhesive weight of 44 tonnes, and a maximum speed of 55 km.p.h. This locomotive hauled a fast train of 110 tonnes with a speed of 24 km.p.h., a slow passenger train of 120 km.p.h., and a goods train of 140 tonnes with a speed of 15 km.p.h., over a 26 per mille gradient. In 1891 a new four-cylinder compound tank locomotive of the 0-6-6-0 wheel arrangement was put into service for goods trains. Its weight in working order was 87 tonnes. It could haul goods trains of 200 tonnes on a 26 per mille gradient with a speed of 15 km.p.h., while its maximum speed was 45 km.p.h.

In 1894 a new type of passenger locomotive was introduced on the Gotthard line. It was a three and,

later, four cylinder compound 4-6-0 locomotive. The weight in working order was 100 tonnes, the adhesive weight 46 tonnes, and maximum speed, of 90 km.p.h. On a gradient of 26 per mille it hauled fast trains of 120 tonnes at 40 km.p.h., and slow trains of 140 tonnes at 35 km.p.h.

In 1913 the Swiss Federal Railways put into service a 2-10-0 four-cylinder compound goods locomotive, weight in working order 128 tonnes, adhesive weight 76 tonnes, maxixum speed 65 km.p.h. This type of locomotive can haul goods trains of 305 tonnes at speeds of 25 km.p.h. on a gradient of 26 per mille. While most of the older types of steam locomotives were either scrapped or sold when the Gotthard line was electrified, the 2-10-0 locomotives are still in existence, and are being kept in reserve in case of emergency. They are also used on the remaining steam-operated lines of the Swiss Federal Railways.

Increased traffic and difficult operating conditions for steam traction were the main reasons why the Swiss Federal Railways decided to electrify the Gotthard line from Erstfeld to Bellinzona before the last war. Construction work was delayed by the war, but electric traction was put into service in December, 1920. The 15,000 volt, $16\frac{2}{3}$ cycle a.c. system with overhead feed is used. Energy is generated in the railway-owned power stations of Amsteg and Ritom and supplied to substations, which, in turn, feed the contact line.

The old electric passenger locomotives of the Gotthard line were of the Be 4/6 and the Be 4/7 class, with an adhesive weight of 70/80 tonnes. They were later replaced by the standard Swiss electric passenger locomotive class Ae 4/7. For gods traffic the Ce 6/8 class was used. This locomotive has a total length over buffers of 19.40 metres, a weight in working order of 128 tonnes, an adhesive weight of 104 tonnes, a maximum speed of 75 km.p.h., and can haul goods trains of 430 tonnes at a speed of 35 km.p.h. on a gradient of 26 per mille.

The highest train weights over the mountain sections of the Gotthard line are 600 tonnes for passenger and 1,400 tonnes for goods trains. Their haulage requires an adhesive weight of 150/160 and 310/320 tonnes respectively (maximum axle load 20 tonnes). In order to economise engine crews, the Swiss Federal Railways put into service in 1932 two double locomotives of the Ae 8/14 class with a total length over buffers of 34 metres, a weight in working order of 245 tonnes, an adhesive weight of 157/168 tonnes, and maximum speed of 100 km.p.h. which can haul passenger trains of 600 tonnes at a speed of 62 km.p.h. and goods trains of 750 tonnes at a speed of 50 km.p.h. on gradients of 26 per mille. Both these locomotives have an hourly output of 8,800 h.p.

In 1939 a new type of Ae 8/14 double locomotive was put into service with an hourly output of 12,000 h.p. and a maximum speed of 110 km.p.h. The one-hour rating corresponds to a tractive effort of about 88,000 lb. at a speed of 47 km.p.h., with a maximum tractive effort of about 110,000 lb. The weight in working order is 244 tonnes, the adhesive weight 160 tonnes. In order to use the high tractive effort effectively when starting, the adhesive weight is increased from 160 tonnes to 172 tonnes by transferring weight from the middle carrying axles by means of a compressed air weight-reducer. This new locomotive is fitted with regenerative braking, as are nearly all new Swiss electric locomotives. Also in 1939 six new electric locomotives of the Ae 4/6 class were ordered, each with an hourly output of 5,700 h.p. and a maximum speed of 125 km.p.h.

The table reproduced shows the increase in traffic from 1882 to 1908, the last year before the line was taken over by the Swiss Federal Railways :

Year	*Passenger*	*Freight*
Estimate in 1865 ...	180,000 ...	270,000 tonnes
1883 ...	1,056,000 ...	470,000 ,,
1908 ...	3,860,000 ...	1,615,000 ,,

Between 1882 and 1938 the train weights increased by 500 per cent. and the speed by 100 per cent. While in 1882 the shortest journey time between Lucerne and Chiasso was 7 hr. 25 min., the quickest train did the journey in 1932 in 3hr. 38 min.

The Gotthard line is the trunk route for German-Italian coal traffic since the outbreak of this war, although the Lötschberg and Mont Cenis lines in the west and the Brenner and Semmering lines in the east have their share of this traffic, which varies according to traffic conditions. The German-Italian coal traffic over the Gotthard line can be analysed as under. The southbound coal trains reach Arth-Goldau on the Gotthard line either from Basle via Aarau and Rothkreuz — as the Lucerne-Immensee approach line is chiefly reserved for passenger and internal Swiss goods traffic — or from Schaffhausen viâ Zurich. After crossing the Gotthard the coal trains split again at Bellinzona, part of them going to Chiasso and the other part going to Luino over the single-track steam-operated Bellinzona-Luino section.

Between Arth-Goldau and Bellinzona is only one $7\frac{1}{2}$-mile long single-track section along the Lake of Lucerne which forms a serious bottle-neck, but it was reported that part of this singletrack section will be opened for double-track working in July next. The normal number of goods trains over the Gotthard is 15 a day in each direction, with a gross weight of 1,200 tonnes per train. Owing to the layout of stations a goods train has, on the average, 100 axles or 50 wagons. The average German coal wagon can carry a net load of 15 tonnes — lately increased to 18.5 tonnes — which gives a net load of about 925 tonnes per train. Assuming that only old 15-tonne wagons are used — in fact, it is reported that some of the German coal trains are composed of the new 20 tonne wagons, which can be overloaded up to 22 tonnes — the net tonnage which could normally be carried would be 15 x 925=13,875 tonnes per day each way.

Assuming a wartime increase in the number of goods trains run from 15 to 24 per day each way, and, further, assuming that about one-third, or eight trains, are used for internal Swiss traffic or other German traffic than coal, we may conclude therefore that 16 trains of 50 wagons each could be used for the German-Italian coal traffic, which would give a net tonnage of 14,800 tonnes per day each way. Assuming a figure of 14,800 tonnes of coal per day to be carried on 300 days of the year — thus allowing a margin for interruptions, repairs, and cessation of work on Sundays, the total tonnage of coal that could be transported over the Gotthard, without causing an undue strain on the Swiss railwaymen anl locomotives, is 14,000 x 300=4,400,000 tonnes a year. This is a rather conservative estimate, but it shows the available capacity of the Gotthard route.