

Public Works (1898) Department.

RAILWAY BRANCH.

G.O., No. 1240. *Ly.*
DATED 10th Oct. 1898.

[Despatch Abstract.]

Barsi and Morvi light Dps.

According letter from the Colonial
Secretary forwarding a copy of the reports
by Mr. A. G. Perman, Traffic Supdt., Ceylon
Coast Dps. with regard to the —

Indexed.

THE BARSİ LIGHT RAILWAY.

Mr. A. G. PERMAN, Traffic Superintendent, Ceylon Government Railways, to the
Hon. the COLONIAL SECRETARY, Ceylon.

Bombay, July 7, 1898.

SIR,—I HAVE the honour to submit, as the first section of my report on the Barsi and the Morvi Light Railways, that in accordance with the instructions contained in your letter No. 494 of June 24 I have visited Barsi, and beg to forward the following for the information of His Excellency the Governor.

My instructions were—

- (1) To ascertain whether a 2 ft. 6 in. gauge railway will carry the traffic in sight on the proposed Kelani Valley line.
- (2) To learn the present traffic of the Barsi Railway, and to determine the maximum that could be carried on that line by increasing the number of trains.
- (3) As to whether a 2 ft. 6 in. gauge railway could be constructed in a superior way and so rendered capable of carrying a traffic exceeding the maximum possible on the Barsi Line.
- (4) To compare rates and charges for conveyance and maintenance, &c.

Description of Line.—The Barsi Line was opened for traffic on March 1, 1897, and traverses a country of a softly undulating character, in which, except for bridges at the waterways, there are absolutely no engineering difficulties. It is laid on the left-hand side of the public road, which, except for one cutting about 12 ft. deep and 500 yards long, is practically a surface road, gently rising and falling with the undulations of the country. This road was originally constructed and bridged with the intention of making it a railway, but the project was in abeyance for a number of years, during which it was largely used by carts.

The soil is black alluvial, for the most part having a substratum of moorum a few feet below the surface. Moorum is a scaly stone which scales in thicknesses of about $1\frac{1}{2}$ inch, and is readily converted into ballast and road material, but which I am told disintegrates in a comparatively short time, and is therefore not so good for ballast as broken granite.

Waterways.—There are seventy-three waterways, the principal of which is a masonry bridge of 11 spans of 40 ft. stone arches; the next is 7 spans of 30 ft. stone arches; and there are also one of 4 spans, one of 3 spans, and one of 2 spans of 25 ft. each. The remainder are culverts from 3 to 20 ft. each. All these were constructed when the road was made in 1870, and all the Barsi Company has had to do has been to strengthen the longer ones to carry their heavy engines. This they have done by carrying up the abutments and piers to three inches above the crowns of the arches and laying girders upon them.

Length.—The length is 21 miles 47 chains of main line and 3 miles 13 chains of sidings.

Curves.—The line is practically straight, there being only 2 miles 8 chains of curves in its whole length. The sharpest curves are 450 ft. radius and occur only twice, viz., on entering the terminal stations at either end. There are also one of 500 ft. and one of 1,000 ft., but the remainder are 5,000, 9,000, 11,000 ft., and upwards. None of the curves are checked. The minimum distance between curves is 2 chains. Siding turnouts are generally 325 ft. radius. Super-elevation commences at the tangent point and varies from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in., the latter being the maximum.

No extra fastenings are placed on the outside of the curves.

Gradients.—The steepest gradient is 1 in 88 for half a mile; there is also 1 in 90 for 46 chains (100 feet to the chain), but beyond these there is nothing worth mentioning under 1 in 100. I append a list of gradients:—

List of Gradients.

From Mileage	To Mileage.	Gradient.	From Mileage	To Mileage.	Gradient.
0	0.21	Level	4.41	4.62	1 in 300
0.21	0.45	1 in 109	4.62	5.43	1 in 100
0.45	0.57	Level	5.43	5.60	1 in 200
0.57	0.83	1 in 127	5.60	5.90	1 in 188
0.83	1.09	Level	5.90	6.28	1 in 111
1.09	1.20	1 in 129	6.28	6.60	1 in 1,133
1.20	1.44	1 in 121	6.60	7.00	1 in 140
1.44	1.63	1 in 240	7.00	7.46	1 in 90
1.63	1.78	1 in 89	7.46	7.76	Level
1.78	2.00	1 in 300	7.76	8.00	1 in 244
2.00	2.16	1 in 160	8.00	8.39	1 in 200
2.16	2.55	1 in 100	8.39	8.60	1 in 440
2.55	3.05	1 in 88	8.60	8.73	Level
3.05	3.18	1 in 107	8.73	8.92	1 in 666
3.18	3.31	1 in 233	8.92	9.24	1 in 154
3.31	3.46	Level	9.24	9.58	1 in 300
3.46	3.79	1 in 100	9.58	9.64	1 in 100
3.79	4.05	1 in 466	9.64	10.00	Level
4.05	4.24	1 in 286	10.00	10.26	1 in 188
4.24	4.41	1 in 164	10.26	10.64	1 in 166

List of Gradients—contd.

From Mileage	To Mileage.	Gradient.	From Mileage	To Mileage.	Gradient.
10-64	10-78	1 in 178	16-70	17-06	1 in 1,266
10-78	10-98	1 in 105	17-06	17-57	1 in 771
10-98	11-11	1 in 500	17-57	17-76	1 in 2,000
11-11	11-47	1 in 1,066	17-76	17-93	1 in 300
11-47	11-90	1 in 135	17-93	18-29	1 in 122
11-90	12-48	1 in 286	18-29	18-48	1 in 2,000
12-48	13-20	1 in 1,000	18-48	19-01	1 in 100
13-20	13-86	1 in 312	19-01	19-31	1 in 123
13-86	13-92	1 in 600	19-31	19-37	Level
13-92	14-31	1 in 300	19-37	19-58	1 in 440
14-31	14-58	1 in 560	19-58	19-77	Level
14-58	14-96	1 in 308	19-77	19-94	1 in 257
14-96	15-28	Level	19-94	20-17	1 in 266
15-28	15-39	1 in 240	20-17	20-35	1 in 2,000
15-39	15-83	1 in 115	20-35	20-83	1 in 357
15-83	15-90	1 in 800	20-83	21-02	1 in 286
15-90	16-30	1 in 124	21-02	21-13	1 in 120
16-30	16-45	1 in 267	21-13	21-23	1 in 143
16-45	16-57	Level	21-23	21-38	1 in 800
16-57	16-70	1 in 350	21-38	21-59	Level

List of Curves.

Mileage.	No. of Curve.	Right or Left.	Radius.	Mileage.	No. of Curve.	Right or Left.	Radius.
			Ft.				Ft.
0	1	Left	450	8½	11	Left	14,000
3¼	2	Right	600	9½	12	Right	5,000
3¾	3	Right	5,730	10	13	Left	5,730
5	4	Left	2,865	14½	14	do.	7,500
5½	5	Right	1,432	17½	15	do.	9,000
5¾	6	Left	3,820	20	16	Right	9,000
7½	7	Right	3,820	21	17	do.	3,110
7¾	8	Left	1,910	21	18	do.	500
8	9	do.	3,820	21½	19	Left	450
8¼	10	do.	2,200				

List of Girder Bridges.

Mileage.	Name of River.	Nature of Bridges.	Mileage.	Name of River.	Nature of Bridges.
0-56	...	2 spans of 10 ft. girder	9-79	... Ardah ...	7 spans of 30 ft. girder
1-47	...	1 " 10 "	15-85	... Khandvi ...	3 " 25 "
1-60	...	1 " 10 "	18-46	... Alipur ...	4 " 25 "
3-27	...	3 " 25-6 ft. skew	19-94	...	1 skew span of 18 ft.
5-45	...	1 " 20 ft. girder	20-75	... Lendy ...	2 spans of 25 ft. girder
8-14	... Sina ...	11 " 40 "	20-90	...	2 " 25 "
8-71	...	1 " 12 "			

Curves and Gradients combined.—Curves and grades combined occur in ten places and are as shown below :—

Length.	Radius of Curve.	Grade.	Length.	Radius of Curve.	Grade.
Ft.	Ft.		Ft.	Ft.	
240	600	1 in 100	544	3,820	...
300	5,730	"	500	2,200	...
648	2,865	"	130	1,910	...
535	1,432	"	230	5,730	...
215	500	120	715	450	...

Permanent Way.—The permanent way appears to be well laid and ballasted, and travelling upon it is very smooth and even.

The rails used are steel, and weigh 35 lb. to the yard. They are supplied in three lengths viz., 18, 21, and 24 ft., and there are cut rails 23 ft. 10½ in. for use on the inner side of curves where 24 ft. outer rails are laid. They are fixed together with plates 16 in. long and fastened thereto with four bolts spaced four inches apart (*vide* diagram of section, "Technical Paper" No. 58). A lighter section rail, 30 lb. to the yard, is used in sidings.

The sleepers are wrought steel trough-shaped plates, 5 ft. long, 8 in. wide at bottom, and 5 in. high. Ten are laid to each 24 ft. rail, or 2,200 per mile. They are spaced at 2 ft. 5 in. centres, except at the rail-joints, where they are 2 ft. There are two classes of these sleepers, one for use on the straights the other for curves, the latter permitting of a widening of the gauge up to ½ in. by the use of special keys. Each sleeper weighs 40 lb., and is provided with clips, into which the rail is fastened by two steel keys. Teak sleepers, 5 ft. by 10 in. by 5 in., spaced 2 ft. centres, are used at the points and crossings, and fastened with dog spikes in the usual way.

Formation widths are 12 ft. on banks and 10 ft. in cuttings, exclusive of side drains, which are 1 ft. wide at the bottom and 1 ft. deep, having a slope of 1½ to 1. The slopes of banks are 2 to 1 and those of cuttings 1½ to 1 in soft soil, but steeper in hard soil.

Ballast is principally of hard moorum (*vide* paragraph 2), which is laid to a depth of six inches below the sleeper, with a minimum of seven cubic feet to the foot run.

Fencing is not provided, except at bridges and cuttings; at such places a fence of old rail posts and wrought iron pipes, 1½ in. diameter, is put up, leaving a minimum road width of 12½ ft. Trespass

is very infrequent, but the engines are provided with a syren to warn people and drive cattle off the line. Because the line is not fenced the speed is restricted to twelve miles an hour.

Level Crossings.—Level crossings only occur at the Barsi town end of the line, and even there there are only minor roads. The approaches to the crossings are protected for about 30 ft. right and left on either side of the line by a post and chain fence. The posts are made of old rails spaced 6 ft. apart, and the chain runs through them. No gates are provided, but a removable length of chain is substituted. At each crossing a flagman is employed and he looks after the chain.

Stations.—There are five stations in all, viz., two terminal and three intermediate. They are situated between four and six miles apart, viz., at the 6th, 11½, 16½, and 21st miles, reckoning from the Barsi road end where the connection with the G. I. P. Railway is made. The 11½ mile station is the only crossing station, but there is a lay-bye at the 16½ mile station, where a short train could be shunted.

The platforms are six inches above rail level and are curbed with cut stone and gravelled. At the intermediate stations the platforms are 400 by 13, 650 by 16, and 400 by 13, respectively; but at the terminal stations, where the passengers and goods are dealt with separately, they are 100 ft. at Barsi road and 189 ft. at Barsi town.

At Barsi road there is no covered accommodation for passengers at present, the G. I. P. Railway waiting rooms being available, besides which a Barsi Line train is always waiting the main line connections. The 6th mile station being of small importance has no covered accommodation for either passengers or goods, but at the 11½ mile there is a third class waiting room without seats, 14 ft. 6 in. by 18 ft. 9 in. The 16½ mile station, in anticipation of a goods traffic, is provided with an open shed 100 ft. by 13 ft., and this being on the platform serves for all purposes at present.

At Barsi town there are closed waiting rooms for upper class passengers: one for gentlemen, 20 ft. by 12 ft., and one of the same dimensions for ladies. Both are divided, one-half of each being used as a retiring room. The third class waiting room is 24 by 23, without seats, and is open at the sides.

Horbury's patent latrines are provided at Barsi town, one for males and one for females, but I did not note any at the wayside stations.

For the interchange of goods at Barsi road there is an open transshipment shed 300 ft. long by 35 ft. wide on rail standards with galvanized iron roof, and through it runs one broad gauge line and one narrow gauge line with an intervening platform 10 ft. wide by (I think) 2 ft. 9 in. or 3 ft. high, accommodation which has been found quite sufficient for the work to be done.

At Barsi town there is an inwards goods shed of rubble masonry 144 ft. by 24 ft., with a platform of the same width, 300 ft. long, and a similar shed for outwards traffic, 240 ft. by 24 ft., and platform 356 ft. long. These platforms are 12 in. above rail level, the shed floors being about one foot higher.

There are no fixed cranes, but one travelling crane is kept at this station. There are no wagon-weighbridges on this line. Wagons are weighed at the G. I. P. station when necessary.

Residences.—Bungalows are provided for the principal officers at Barsi town, and each station master has accommodation in the station buildings.

Lines for the menial staff are of wattle-and-daub, roofed with deal boards from old packing cases. Signals.—Suitable signals and ground lights working with the points are provided at Barsi road, but at the station *en route* there are only discs working with the points, or, where there are no points, at the end of the platform.

Telegraph.—A line of telegraph connects all stations, and trains are worked on the telegraph line-clear system common to most Indian Railways.

Engine Sheds for four engines at Barsi town and for two engines at Barsi road have been provided, and at each place there are suitable coaling and watering arrangements and engine pits. There is a small repairing shop at Barsi town, but heavy repairs can only be done at the G. I. P. shops at Bombay.

Turntables are not provided, but there is a triangle at each end of the line for reversing the engines.

Rolling Stock.—The rolling stock consists of—

4 engines	Carriages.
1 officers' saloon	
4 composite brakes	
2 lower class	
8 covered goods	Goods.
6 high-sided	
40 low-sided	
1 travelling crane	
10 ballast	

There are only two classes of carriage, upper and lower: the upper being upholstered and furnished in every respect equal to our first class varnished stock, the lower corresponding with our new bogie thirds. The composite brakes seat 6 upper class and 32 lower class passengers, leaving about 60 square feet for luggage, brake, and guard's accommodation. The lower class seats 64 third class passengers.

The goods wagons carry—

	Tons	cwt.
Covered goods	...	14 2
High-sided	...	14 13
Low-sided	...	15 18
Crane lifts	...	10 0

The whole of the stock was designed and built under the supervision of Mr. E. R. Calthrop, who is now Consulting Engineer to the Company and resident in London. The passenger portion

is expensively fitted, and although very comfortable it is unnecessarily lavish for a line with such a small mileage. The wagons are all of pressed steel with all the parts interchangeable, and the proportion of tare to load is about one-third. In a pamphlet written by Mr. Calthrop he has described them and all their advantages exhaustively, and I send a copy herewith to save repetition.

The cost of the stock was very high, as follows:—

		Price in Sterling delivered in London.	Price in Rupees at 1s. 3d. delivered in Bombay.
		£	Rs.
Locomotives	...	1,775	32,160
Officers' saloon	...	1,144	19,420
Composite brake	...	905	17,480
Lower class	...	722	15,380
Covered goods	...	144½	2,640
High-sided	...	152½	2,680
Low-sided	...	110½	2,040

Traffic—The usual train service is two trains each way per diem, and the usual formation is one composite brake and one lower class carriage, the remainder being goods wagons, as many as required, up to the limit of the load, which is 16 vehicles. The seating accommodation on each train is therefore for 6 upper class and 92 lower class passengers; but as one compartment to hold eight is generally reserved for mails, I have in any subsequent computation reckoned only 88 as the full complement of passengers.

For the first complete year's working, viz., from March, 1897, till February, 1898, inclusive, the following are the figures taken from the registers at Barsi town station headquarter office:—

Passengers, upper	...	826
Passengers, lower	...	58,620
Total	...	59,446
Goods, tons, forwarded	...	25,563
Goods, tons, received	...	19,792
Total	...	45,355

The earnings on this traffic were Rs. 20,579 for passengers and other coaching and Rs. 109,576 for the goods. The working expenses are, I am told, about 50 per cent. of the receipts, but as such accounts are kept by the G. I. P. Railway at Bombay, and as the Agent of the Company is absent in London, the figures were not accessible. I have, however, obtained them from the opening of the line till the end of December, 1897, and send you the abstract enclosed herewith.

There appears to be a falling off of the traffic in the first half of this year, as, on the same average, to the end of May (the latest date to which I was able to obtain particulars) the numbers should have been 24,575 passengers* and 29,221 tons goods,† but they were actually 18,020 passengers and 26,944 goods tons. This computation is only approximately correct, and the matter does not much concern the subject in hand.

The month of May, 1897, was the heaviest for goods, there being 4,200 tons forwarded and 2,466 tons received. The forwarded was equal to 80 tons per train,‡ two trains per diem, for 26 working days.

The goods traffic consists principally of raw cotton, grain, oil seeds, and salt. Oils, jute, and sugar take the next place, the remainder being miscellaneous. Of the 16,000 tons carried during the second half of the year 1897 there were:—

	Tons.
Grain	4,976
Cotton	2,625
Oil seeds	2,223
Salt	1,187
Oil	696
Sugar	551
Jute	323
Total	12,581

all easy traffic to handle and giving good weight for bulk.

With this information before us I think we can now proceed to the disposal of the questions at issue, *vide* page 1:—

Question No. 1.—Can a 2 ft. 6 in. gauge line carry the traffic in sight on the proposed Kelani Valley Railway Line, viz., 145,600 passengers and 40,000 tons of goods?

Answer.—The Barsi Line has within the year referred to carried 59,446 passengers, or 40 per cent. of the number expected by us, and 45,355 tons of goods, or 5,355 tons more than the estimated goods traffic. Its ordinary daily working accommodation for third class passengers is 88 per train on four trains a day, Sundays and week days, so that without any increase of the carriages actually run it could have conveyed 352 passengers per diem, or 128,480 in the year, equal to 88 per cent. of the Kelani Valley figures.

Question No. 2.—What is the maximum that could be carried on a 2 ft. 6 in. line similar to the Barsi Railway?

* Averaged on the whole year.

† Averaged on the five months to end of May.

‡ In considering the possibilities of the line, here is evidence of its being able to convey 80 tons goods per ordinary train by every train for a month; and if the traffic had kept up, it would have carried 50,000 tons of "forwarded" goods only, without counting the return loads.

Answer.—Without departing from its present ordinary train service of two trains each way per diem, the Barsi Railway could carry a total of 221,920 passengers by adding one third class carriage to each train, or 315,360 if two extra thirds were put on. With the one additional third first mentioned, the full engine load could be made up with 13 trucks of goods, each containing 13½ tons, or, with two extra thirds, 12 trucks with similar weights could be attached, making a train of 16 vehicles in each case, which would give an annual goods haulage of 217,700 tons, or 201,528, respectively, reckoning only 311 working days for goods of the year, *e.g.*, by the first composition of train we get, for passengers:—

One Bogie Composite.	Two Thirds.	Per Train.	Trains.	Per Diem.	Days.	Per Annum.						
24	+	128	=	152	×	4	=	608	×	365	=	221,920

for goods:—

Trucks.		Carrying.		Tons.		Trains.		Per Diem.		Days.		Per Annum.
13	×	13½	=	175	×	4	=	700	×	311	=	217,700

The gross load of each train would be 289 tons and 286 tons respectively, viz.:—

			Tons cwt.	Tons cwt.	Load.
					Tons cwt.
(1) 1 Composite brake load	...	...	...	2	0
2 Thirds, each with load	...	...	3 4	6	8
13 Goods, each with load	...	...	13 10	175	0
Plus Tares:					
3 Carriages at	...	...	13 4	39	12
7 Wagons at	...	...	5 18	41	6
6 Wagons at	...	...	4 2	24	12
					105 10
					288 18
(2) 1 Composite brakes	...	...	...	2	0
3 Thirds, each	...	...	3 4	9	12
12 Goods, each	...	...	13 10	162	0
Plus Tares:					
4 Carriages at	...	...	13 4	52	16
6 Wagons at	...	...	5 18	35	8
6 Wagons at	...	...	4 2	24	12
					112 16
					286 8

These loads are, I am assured, quite within the capacity of the Barsi engines for ordinary working over their line, though it very seldom happens that they can get such a load to convey by any one train. Recently, however, viz., on the 24th June, they managed to make up a train of 290 tons, particulars of which I annex:—

Statement showing Test Load taken by Engine No. 4 on June 24, 1898.

Ordinary Train 10 A.M. Time Table Times correctly kept.

Description.	No. on Vehicle.	Tare.	Load.*	Total.
		Tons cwt. qr.	Tons cwt. qr.	Tons cwt. qr.
Composite brake	...	...	...	...
Lower class	...	...	...	...
Low-sided	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
High-sided	...	...	...	...
Covered goods	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Do.	...	...	...	...
Total	...	92 5 0	197 15 0	290 0 0

* Passengers at 1 cwt. per adult.

Class of Wagons on Barsi Light Railway.

Description.	Tare.	Carrying Capacity.
	Tons cwt.	Tons cwt.
Low-sided	...	...
High-sided	...	...
Covered goods	...	...

In these calculations I have not counted upper class passengers, though 6 per train could be taken with the accommodation provided; therefore, 6 × 4 × 365 = 8,760, which could be added to the numbers I have given.

By putting in crossing sidings at the 6th and 11½ mile stations the train service could be trebled so that six trains could be run in each direction with ample time for all reasonable work between

the hours of 6 A.M. and 9 P.M., and assuming, as we have done all along, that each train worked to its fullest capacity it would be possible and practicable to move 946,080 passengers and 604,584 tons goods per annum. Six trains a day in each direction is not, however, the limit of possibilities on the Barsi Line, several more could perfectly well be added, but what I have shown to be practicable is sufficient to illustrate our case.

In all these computations I have taken the theoretical maximums and kept strictly to possibilities, so that in applying them to everyday practice the usual fluctuations of traffic, both passengers and goods, and the inequalities of the "flow" from either end, must be always kept in mind.

Question No. 3.—Could a 2 ft. 6 in. gauge railway be constructed to carry more than the Barsi Line is capable of doing?

Answer.—This question appears to me to be one that only competent Engineers can answer, but so far as I have been able to gather opinion, it is thought that the Barsi Line approaches the maximum possibilities of a 2 ft. 6 in. gauge railway, so far as construction and equipment are concerned.

The capacity of a line is only limited by the number of trains run upon it: thus, a single line of 50 miles with only one train in each direction per diem carrying 20 tons per train would only convey 20 by 2 by 365 = 14,600 tons per annum, but it is obvious that if by putting in crossing stations the number of trains is multiplied by 10, the possibilities of the line is increased in like ratio. The trains on any gauge railway can be increased *ad libitum* by increasing the crossing places until the line practically becomes a double line. The Barsi Line apparently takes, or is capable of taking, the greatest paying load *per train*, and therefore were it worked to its fullest capacity by increasing its train service to a practical maximum no other line of similar character could exceed its possibilities.

Question No. 4.—How do the rates and charges on the Barsi Line for conveyance and maintenance compare with those of the Ceylon Railways?

Answer.—The rates and charges for conveyance appear to me to be lighter than on the Ceylon Railways, but as I am sending this report from Bombay I have no means of making a comparison. I send, however, a rate book, and would suggest that the Railway Accountant be requested to furnish the desired information. Labour is much cheaper here, and a comparison of rates can hardly be of much value seeing that the charges necessary to a remunerative return must depend upon local conditions.

Maintenance of the permanent way costs about Rs. 49 per mile per month. Five gangs consisting of one kangany, one keyman, and six platelayers are employed, or about two men per mile. These are supervised by one Permanent Way Inspector and one Timekeeper. The rates of pay are Inspector Rs. 140, Timekeeper Rs. 20, kangany Rs. 10, and platelayers Rs. 7 per month.

The locomotive expenses for the half-year ending December, 1897, including superintendence, wages, fuel, water, stores, maintenance, and renewals, cost 12½ cents per engine mile run.

Upkeep, cleaning, oiling, and all other charges amounted to 2-6 cents per train mile. A complete list of the staff employed is annexed, the wages of each being given. Both the drivers are Eurasians, the only European being the Assistant Locomotive Superintendent:—

Statement showing Staff employed in Locomotive Department of Barsi Light Railway.

No.	Description.	Rate each.	Amount.
		Rs.	Rs.
1	Works Foreman	120	120
1	Locomotive clerk	20	20
1	Office boy	4	4
2	Drivers	100	200
1	Fireman	15	15
1	Do.	12	12
2	Oilers	10	20
1	Lighter	10	10
2	Shunters	30	60
9	Engine cleaners boys	4	36
8	Pumpers	9	72
4	Do.	7	28
1	Carriage examiner	35	35
1	Assistant carriage examiner	10	10
1	Packer	7	7
2	Carriage cleaners	7	14
1	Watchman	8	8
1	Engine cleaner	7	7
1	Fitter	50	50
1	Do.	45	45
1	Assistant fitter	25	25
1	Do.	15	15
1	Carpenter	30	30
1	Assistant carpenter	25	25
1	Carpenter boy	6	6
1	Boiler-maker	35	35
1	Assistant boiler-maker	22	22
1	Blacksmith	30	30
1	Coal muddam	15	15
1	Striker	8	8
1	Store cooly	8	8
9	Coolies	7	63
	Total		1,055

The traffic charges for supervision, wages, stores, lighting, telegraphs, advertising, stationery, tickets, &c., was equal to 16-2 cents per train mile for the half-year closed in December, 1897. I omitted to obtain a list of the staff employed, which I regret.

An abstract of receipts and expenditure on revenue account from the opening of the line to December 31, 1897, is sent herewith.

If I have correctly interpreted my instructions, it was intended that I should make such observations as I may consider would be useful in determining the question of gauge for the proposed Kelani Valley Line, and I should like to say that the first impression created in my mind on seeing a 2 ft. 6 in. gauge railway was its thoroughly business-like appearance. At first sight, except that the vehicles were closer to the ground than I have been accustomed to see them, the train looked almost as big and substantial as the broad gauge, and even after taking out dimensions I found there really was not a great difference after all. The carriages are quite as long and almost as wide as ours, and the interior space between the seats is the same as we have, in fact, the only difference is in the width, which is only one foot less than ours. The furnishing and conveniences are more lavish than I should recommend, but to a narrow gauge railway *per se* there can be no great objection on the score of its Lilliputian character, or the apparent instability of its trains.

Travelling upon the line was smooth and easy enough until the train began to exceed 12 miles an hour, and then a long fore and aft movement of the saloon set in, which, if continued for a long period, would be decidedly unpleasant. This motion was attributed to the flexibility of the springs, and at Barsi town a vehicle was lifted to show me the arrangement of the bogie. They are all spiral springs, Timmis's patent, and there are seven of them, three under the bolster and four over the journals. It is possible some rearrangement or hardening of these springs would prevent the disagreeable movement of the carriage, which I take to be a bar to all travelling in comfort over a booked speed of twelve miles an hour. A short trial speed trip was arranged to test what motion 20 miles an hour would set up, but there was no perceptible difference, so I conclude that the roll is not increased with an increase of speed over, say, fifteen miles an hour, but there is no doubt it exists whenever twelve miles an hour is exceeded.

Of the capacity of the goods vehicles to do all we require I have no doubt, but whether pressed steel stock is absolutely the best is open to question. From a traffic point of view the principal objection to it is that in ordinary wear and tear the doors become buckled, and there is a constant difficulty in opening and shutting them. I carefully examined the Barsi stock and found traces of hammers or stones on nearly all the fastenings, showing where force had to be employed to get the doors into their places and the pins in and out. It is claimed for the brakes that they can be applied from either side, and that they exert equal pressure on all the wheels, but I cannot say I like them as I found them, and would prefer another pattern. Only a few of the wagons (covered) have ventilators; in iron stock every one should have thorough air circulation. The doors of covered wagons do not reach from top to bottom, there is a flap at the bottom to let down, the idea being, I assume, that they may be used for the conveyance of cattle; but in the event of such a contingency, portable flaps (loading boards) could very well be substituted, and all the doors should open from roof to floor as in the B. G. vehicles. Such of the covered trucks as are ventilated are said to be suitable for the conveyance of horses or cattle. I do not think they would answer such a purpose without alteration. They would be unbearably hot, unless run with the doors open on both sides, in which case there would be a loss of one-third of their load, besides which there are no footholds for the animals, and they would be likely to get down and not be able to get up again. On the South Indian Line they have covered wagons convertible into live stock trucks, which would answer the purpose better. The low-sided wagons have practically no sides at all, and although they might carry cotton and grain well roped and sheeted, they would not suit our tea traffic. One or two might be useful to us to load road vehicles on their own wheels or portable engines, but not for general traffic. The high-sided wagons would suit us much better, being suitable for both rice and tea if properly sheeted with good tarpaulins.

There are, I believe, engineering objections to this pressed steel stock, principally on the ground of the difficulty of repairing it. I am told that if the under frame, for instance, becomes damaged from accident or derailment, it is practically done for, it being almost impossible to straighten out bends or reduce heavy indentations; but this is a matter I must leave to engineers. The Barsi stock has been running now for fifteen months, and has so far, I am assured by the officers who work the railway, satisfactorily answered all requirements. It is the first time I understand that this kind of vehicle has been built, and doubtless it has its defects; but one great object, viz., the reduction of dead weight, has been obtained, and possibly experience and skill will remedy its shortcomings. The buffers, I think, might be improved by having one convex face and one flat one as we have on our stock, instead of two perfectly flat ones. Mr. Calthrop claims that when the buffers are screwed up they are perfectly rigid, the necessary lateral play being obtained by the introduction of "rocking dishes"; but as a matter of fact the buffer heads are constantly chafing when the train is in motion, and it seemed to me that to allow for and ease it would be advisable.

With these remarks I beg to conclude my report, not that I have said all there is to say on such an important matter, but because there will be found in the reports and pamphlets which accompany it many important details I have not touched upon, because I think them better expressed and more competently dealt with by the gentlemen who have written them. One further observation I may be permitted to make, and that is, that on page 7 of Technical Paper No. 58 reference is made to the heavy weight of the Barsi engines, and it is pointed out that the coupled wheels are so close together that although the weight per axle is less than on the engines they are being compared to, the maximum load on each sleeper is greater, though the area of the sleeper is less, and consequently "it seems probable that the maintenance will be high even though the speed be restricted." I wish to point out that the total load on the coupled wheels is 19 tons 14 cwt. (vide diagram 1, Technical Paper No. 58), and that the engines of the North-east Dundas Line, Tasmania, a 2 ft. gauge line, weigh 19 tons 15 cwt., and as they work over curves of 1½ chain radius, the weight cannot be more widely distributed than on the Barsi engines. It would therefore be helpful to know the weight of rails and character of sleepers and permanent way on that line if the adoption of the Barsi type engine should be contemplated.

In addition to the enclosures already mentioned, I send statements of the capital account of the Barsi Railway (kindly supplied by Major Hoskyns) and a report on the railway by Mr. C. E. Phipps, the Locomotive Superintendent of the Madras Railway. Three sheets of accounts showing the working costs of the engines complete the addenda.

I have, &c.,

A. G. PERMAN,
Traffic Superintendent, C. G. R.

SESSIONAL PAPERS, 1898.

Sundry Stores issued to Locomotive Department.

Month.	Oil.							Tallow.	Waste No. 1.	Waste No. 3.	Bath Bricks.	Flax.	Emery Paper.	Cair Yarn.	Wool, Worsted.
	Axle.	Castor.	Cylinder.	Cocoanut.	Kerosine.	Engine.	Engine-cleaning.								
1897.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	No.	lb.	Sheets.	lb.	lb.
March	93	62	15½	38½	31	—	—	3	15½	62	2	3	6	2	—
April	150	120	30	37½	15	—	—	2	30	48	3	4	12	4	—
May	155	124	31	—	15½	—	—	3	31	46½	2	4	—	4	—
June	150	—	30	—	15	120	37½	2	30	45	4	4	—	2	—
July	155	—	31	—	15	124	40	4	31	46½	4	4	—	2	—
August	160	—	32½	—	27¾	129	40¾	4	32½	48	4	4	—	2	—
September	114½	—	30	15	15	115¾	57¾	4	30	45	4	4	—	2	—
October	—	93	31	—	31	95	40	4	31	46½	4	4	—	2	—
November	—	98½	38½	7½	31	96	38	4	32	45	4	4	6	2	—
December	—	93	50	15	32	93	38½	4	31	46½	4	4	—	4	—
1898.	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
January	—	127¾	64	8	32	72¾	38½	4	33½	46½	4	4	—	4	—
February	—	168	56	7	32	—	36	4	28	70	4	4	—	4	—
March	—	186	63	8	32	—	38	4	31	62	4	4	—	4	—
April	—	189	67	2	32	—	38	4	31	62	4	4	—	4	—
May	—	186	63	—	32	—	38¾	4	31	62	4	4	4	4	—

Each month's consumption being that of two engines. There are four engines, but only two work at one time.

Coal Consumption.

Month.	Total Consumption.			No of Miles Run.	No of Trips.	Total Load, including Engine.	Average Load per Trip.	Consumption.			Wood for Lighting.
	Tons.	c.	qr. lb.					Per Mile.	Per Mile per Vehicle.	Per Ton.	
1897.				No.	No.	No of Vehicles.	No of Vehicles.	lb.	lb.	lb.	T. c. qr. lb.
March	34	12	2 20	2,052	50.5	767	7.6	30.4	4	—	—
April	46	9	1 4	2,660	60	1,140	9.5	39	4.1	—	—
May	44	13	2 22	2,852	66	1,222.5	9.2	35.2	3.7	—	—
June	39	11	1 6	2,790	60	837.5	7.1	31.6	4.3	—	—
July	39	11	1 7½	2,904	64	849.5	6.6	30.5	4.6	—	—
August	36	0	1 19½	3,058	65	747.5	5.7	26.4	4.6	—	—
September	34	1	1 1	2,729	60	670	5.6	27.9	5	—	—
October	34	3	2 4	2,810	62.5	657.5	5.2	27.2	5.2	—	3 17 2 0
November	33	2	0 7	2,861.5	61	744	6.1	25.9	4.2	43	3 15 0 0
December	41	0	1 19	3,066	63	1,022	8.1	29.9	3.7	—	3 17 2 0
1898.											
January	46	2	1 16	2,894	63	990	7.8	35.7	4.6	42	4 0 0 0
February	38	13	1 0	2,546	56	764	6.8	34	5	41	3 10 0 0
March	43	17	3 16	2,865.5	63	959	7.6	34.3	4.5	35	3 19 0 0
April	42	3	1 8	2,861	62	1,062.5	8.5	33	3.9	29	3 5 1 0
May	42	17	0 6	2,837	62.5	974.5	7.8	33.8	4.3	37	3 2 0 0

One trip equals 44 miles.

Statement showing the Total Mileage of each Engine since the Opening of the Line, including Shunting, &c.

Month.	Engine No. 1.	Engine No. 2.	Engine No. 3.	Engine No. 4.
1897.				
March	1,034	550	638	—
April	1,012	880	770	—
May	1,012	1,166	550	—
June	1,423	1,433	—	—
July	1,392	795	—	904
August	400	1,348	—	1,316
September	931	517	—	1,280
October	198	1,268	—	1,322
November	211	1,244	—	1,362
December	54	1,595	—	1,385
1898.				
January	680	419	816	1,022
February	789	—	1,255	502
March	903	—	1,080	838
April	176	552	286	1,467
May	755	818	562	700
Total	10,970	12,585	5,957	12,098

Shunting reckoned at the rate of 6 miles per hour.

THE MORVI LIGHT RAILWAY.

Mr. A. G. PERMAN, Traffic Superintendent, Ceylon Government Railways, to the Hon. the COLONIAL SECRETARY, Ceylon. Morvi, July 18, 1898.

SIR,—FURTHER to my report of the 7th instant, despatched from Bombay, I have the honour to state that I have now inspected the Morvi lines and submit the following for the information of His Excellency the Governor.

The Morvi Railway belongs to His Highness the Thakur Sahib of Morvi, and was constructed at his expense, except that the requisite land was conveyed free to him where the line passes through other States. It connects Wadhwan on the B. B. C. I. Railway with the Jetalpur Railway at Rajkot, and continues on to Morvi by a separate line from Vankaneer Junction.

It is managed by European officers, but the whole of the staff is native. *Date of Construction.*—The line was commenced in 1885 and was opened for traffic from Wadhwan to Morvi on March 24, 1887, a distance of 68½ miles. A branch line from Vankaneer at the 52nd mile to Rajkot, 25¼ miles, was completed on January 1, 1890, and this was carried across the Aji river on August 6, 1894, completing the system and making a running line of 94½ miles.

Cost per Mile.—The cost per mile, exclusive of rolling stock, was: (1) Main line, Rs. 18,564; (2) Branch, Rs. 26,899.

Description of Country.—The country through which the Morvi line runs is very similar to that at Barsi, and except for some heavier work on the Rajkot branch there were no engineering difficulties. The first 24 miles on leaving Wadhwan is laid on the cart road, occupying a maximum width of 8 ft. 6 in. and leaving a minimum of 18 ft. for cart traffic; it afterwards passes through cultivated lands with easy curves and long straights (here and there aligning with the cart road) till the termini are reached.

Curves.—The line throughout is practically straight, the only curves worth mentioning being one of 230 ft. radius for about 5 chains immediately on leaving Wadhwan station. There are some of 400 ft., but most are 500 ft. and upwards, as will be seen from the list attached.

Gradients.—For a flat country like India the grades are fairly heavy, the line being practically laid on the surface, so that it is one series of undulations. The maximum gradient is 1 in 134 for 780 ft., but this is closely approached by others under 200 ft. as follows:—

1 in 140 for 900 and for 980 ft.
1 in 150 for 300, 2,500, 2,100, and 800 ft.
1 in 160 for 680 and 3,080 ft.
1 in 167 for 1,180 ft.
1 in 170 for 1,600 ft.
1 in 175 for 4,880, 2,880, 1,400, 1,380, 1,000, 900, and 700 ft.
1 in 180 for 1,400 ft.
1 in 185 for 1,750 ft.
1 in 190 for 2,680 ft.

Of 1 in 200 there are 4½ miles on fairly long banks, as, one of 1½ mile, and others 3,500, 2,800, 2,400, 2,000, 1,700, 1,600, and 1,500 ft., while of 1 in 300 there are 21 miles, all but 400 ft. The longest stretch on this grade is 1¼ mile, there being others of 10,560 ft., 4,580 ft., and less. The gradient list is annexed.

Curves and Gradients combined.—There are no curves and gradients combined, nor reverse curves worth detailing.

Bridges.—The principal bridges are: (1) four girder bridges of seven spans of 35 ft. clear each. The girders are rolled beams of 21½ by 7½ by 1¼ in. section weighing 112 lb. per foot run, and are supported on sandstone piers and abutments; (2) one of fifteen spans of 50 ft. masonry arches, and two of seven spans of 30 ft. arches. None of these existed on the cart road, and all are fairly charged to construction.

Permanent Way.—The permanent way is comparatively lightly ballasted, the engineers being of the opinion that a springy road is more suited to the heavy traffic that passes over the exceptionally light rails (19 lb.) that were originally laid throughout, and which still carry the traffic over 25 miles. The motion of the train is smooth and even, and travelling at 18 or 20 miles an hour quite comfortable.

Rails.—The rails used are steel, 19 lb., 29 lb., and 41½ lb. to the yard, and all are 24 ft. long of the sections shown on annexure. The whole line was originally laid with the 19 lb. rails, but as traffic necessitated the use of heavier engines heavier rails have in some places been substituted, so that only 25 miles of these light rails remain, and these are being replaced. At first 29-lb. rails took the place of the lighter ones, and 51 miles of this weight were put down, but of late years (1896) the 41½ lb. (metre gauge section) have been used over 18 miles of the Rajkot branch in view of the probable conversion of the line to the metre gauge. The 29-lb. rails were found quite sufficient for the weights to be carried (the heaviest engine weighs 15 tons in full working order), and the metre gauge rails would never have been used but for the anticipated conversion. I should here state that the conversion is in no way due to the incapacity of the line to do its work, but entirely because it already connects with a metre gauge line at one end and will do so at the other when the short length of broad gauge line between Virungaum and Wadhwan is converted to metre gauge, and thus give a through connection between the southern lines (Kattywar) and the great Rajputana-Malwa system.

Fishplates.—The 29-lb. rails are fished together with 6-holed plates weighing 6½ lb. each; the 19 lb. and 41½ lb. with four-holed plates of 3½ and 9½ lb. weight respectively.

Sleepers.—For the 19-lb. rails cast steel sleepers weighing 11 lb. each are used. These are 3 ft. 6 in. long, 4½ inches wide at bottom, 1½ inch deep, and ½ thick, and these have been down for twelve years with very good results, the percentage of breakages even with the 15-ton engines running over them being absolutely nil. (It should be however mentioned that on most of the sharp curves 29-lb. rails and suitable sleepers were substituted when the bigger engines were brought into use.) They are spaced 2 ft. 6 in. apart, 10 being used to each sleeper, those near the rail joints being a little closer. The rails are secured by the outer flange being placed under a clip rivetted to the sleeper, the inner flange being fastened by a movable clip bolted to the sleeper.

Under the 29-lb. rails cast steel trough-shaped sleepers weighing 33 lb. are placed. These are 4 ft. 6 in. long, 8 in. wide under rail at bottom (6 in. across centre), and 3 in. deep, 9 being used to each 24-foot rail, which is placed in double clips and keyed, a widening of the gauge to suit curves being obtained by placing the key on the inner or the outer side of the rail flange as the case may be.

Where the 41½-lb. rails are laid, creosoted pine sleepers of the standard metre gauge dimensions are used, and they are dog-spiked with spikes 4½ in. long by ¾ in. square. In many places on the line the land is salt, and in such places teak sleepers are used.

Ballast.—Ballast is finely broken moorum (decayed trap stone) and sand. This produces a springy and somewhat yielding road, which is found better for this light railway than ordinary broken granite. It is laid to a depth of 6 inches under the rail, or three cubic feet per foot run.

General.—Super-elevation of 1½ in. to 230 ft. curves and downwards is given, and rises from and runs well out into the flat; 75 ft. for 1½ in. cant and proportionately for less is the rule.

Double fastenings on the outsides of curves are not used, but on the 230 ft. radius holding-down bolts are employed at every third sleeper.

Turnouts are 1 in 7 to 1 in 10, the minimum being 1 in 7 at leading in points. Switches are 5 ft. to 10 ft. according to the turnout.

Teakwood sleepers are used under points and crossings.

Level Crossings.—There are only one or two level crossings. These are at Wadhwan, and a flagman is in charge. The line does not cross the cart road at any point, and where agricultural roads traverse the railway only check rails are provided.

Fences and Gates.—There are no fences or gates throughout the line. In the town of Wadhwan a bell on the engine is rung to warn people of the approach of the train, but no other precaution for the safety of foot passengers and road traffic is taken. Within the town limits the speed does not exceed 10 or 12 miles an hour.

Stations.—There are ten stations, and all except Morvi are of the cheapest construction, being of rubble masonry, tiled with locally-made tiles. Most of them are about 10 ft. wide, but they vary from 50 to 75 ft. long. Their general disposition is shown by the diagrams below:—

Morvi.

14 ft.	Telegraph.	Open space for Passengers, covered.	Station Master's Office.	Open space for Upper Class.	Printing Office.
	12 ft.	30 ft.	12 ft.	12 ft.	10 ft.

Vankaneer Junction.

10 ft.	Open space, Third Class.	Station Master's Office.	Telegraph Office.	Open space for Upper Class.	Waiting Room.
	20 ft.	12 ft.	10 ft.	10 ft.	10 ft.

General Roadside.

10 ft.	Waiting Room.	Open space without Seats.	Station Master's Office.
	14 ft.	20 ft.	14 ft.

The "open" spaces are only open in front, the back and sides being closed in and all being roofed.

Morvi station is the most pretentious building, being of cut stone with ornamental pillars and corrugated iron roof with ridge tiles and finials.

Platforms.—There are no platforms of any description whatever, not even a boundary curbing, and passengers alight wherever the train stops.

Goods Sheds.—At Wadhwan, where traffic is exchanged with the B. B. and C. I. Railway, there is a goods shed 50 ft. by 20 ft. of corrugated iron with curved roof, a masonry goods office 30 ft. by 12 ft., a transshipment platform (uncovered) 125 ft. by 15 ft., and a loading bank 30 ft. long sloping up from ground level to 2 ft. 6 in. high.

Except for a small shed at Rajkot these are the only goods buildings on the line.

It should, however, be remembered that this is a very dry country, and that traffic in the rainy season is almost nil. The rainfall is only 22 in.

Crossing Stations.—All the stations are crossing stations, and there are also four intermediate crossing loops, so that trains can pass each other at ten places, or equal to one for every nine miles of railway.

Signals.—Semaphore signals of the usual type are placed at Vankaneer Junction and at Morvi, but at all other places only a disc by day and a lamp by night, operated by the pointsman, are used.

Telegraphs.—There is a telegraph instrument with a call bell at every station, and the train service is worked on the Line-clear Ticket System usual in India.

Conservancy.—Latrines are provided only at Vankaneer Junction.

Locomotion.—The rolling stock consists of: 8 engines, viz., 5 passenger and 3 goods; 49 carriages and brake vans; and 2 horse boxes, namely:—

	Bogie.	Ordinary.
Saloons	2	1
Composite, first and second	4	—
Second class	—	3
Composite, second and mail	14	17
Third class	1	—
Composite, second, third, and mail	1	3
Brake vans	—	—

and 112 goods vehicles, namely:—

Covered goods	10	10
Lowsided open	57	35

Type drawings of each class of engine and vehicle accompany this report.*

Description and Construction of Carriages.—Three classes of passengers—first, second, and third—are carried, the same as in Ceylon; and in every train a carriage (third class) is wholly set apart for women.

Table A gives a detailed description of each vehicle, its weight, carrying capacity, cost, and builder; and is annexed to the type drawings referred to.*

Corrugated iron is largely used in the construction of both carriages and wagons. The body framing is of teak covered outside with corrugated or sheet iron, and lined inside with match boarding (wagons are not lined). The carriage roofs are of wood† with corrugated iron covering above them, allowing a 2-in. air space. All first and second class carriages have retiring accommodation; and there is a retiring space in the women's third class carriages. The first dation and lavatories, and the roofs are panelled with Lincrusta class carriages are nicely upholstered with maroon morocco, and the roofs are panelled with Lincrusta walton. The second class are similarly furnished, except that Indian leather is used for the cushions and that the roofs are painted. The third class are of the ordinary painted and varnished type. Altogether the stock is very suited to its requirements, and is much the same as I should recommend for use on the Kelani Valley line. I cannot say that corrugated iron outsides strikes one as extremely beautiful for carriages, but I am told that when they are nicely painted and varnished they look very well. Of course the iron is used to reduce weight, but perhaps we may be able to keep to our own standard without a great sacrifice in this respect.

The bogie carriages are 28 ft. and 30 ft. long inside buffers, and are 6 ft. 6 in. wide inside standards, their weight being 7 tons 6 cwt. and 6 tons 7 cwt. and 5 tons 12 cwt. each in their respective classes, or about 4½ cwt. per foot run as compared with 6½ cwt. on the Barsi line. I mention the Barsi stock because presently I shall have occasion to refer to it.

Lighting Carriages.—Although the drawings show no lamp covers, the ordinary roof lamp is used, boiled castor oil being substituted for cocoanut oil. It is however the intention of the management to do away with roof lamps (in the third class at least) and to replace them with lanterns in the ends of the carriages and light them with good quality candles in spring candle-holders. It is thought that these will give a better light and will not be so expensive in renewals as the ordinary roof lamp, the globes of which are constantly breaking and cost Rs. 6 or Rs. 7 to replace. Besides these considerations it is anticipated that less trouble will be experienced in keeping the roofs watertight, an important factor in the comfort of passengers in the monsoon rains. I recommend the idea to favourable consideration for adoption in the new Kelani Valley stock.

Wagons.—The wagons are built as lightly as possible consistent with the loads to be carried, but the tares are very high compared with their nominal loads: thus, covered bogie weigh 4 tons 1 cwt. and carry 5 tons 9 cwt., or 75 per cent. dead weight; four-wheeled covered wagons weigh 2 tons 10 cwt. and carry 4 tons, or 60 per cent. dead weight; but I am assured that the same wagons if placed on stronger bogies would carry 75 per cent. more paying load.

Brakes.—Only the engines and brake vans are fitted with brakes, and it is said that with such light stock brakes have not been found to be necessary.

Local Construction.—All the stock except the first equipment has been built at Morvi, and it is claimed that the vehicles are stronger and cheaper than those imported. Even engines are being constructed here; several fire boxes and two complete boilers having been made, so that only wheels, cylinders, and spiral springs are obtained from England.

Engines.—I have not gone into details with regard to engines because their construction and suitability for the work required of them is entirely a matter for the Locomotive Engineer, but I have obtained as much information about them as possible and annex it hereto.

I may however mention that the passenger engines draw a load of 60 tons at an average speed of 20 miles an hour, that is, a train of equal to 15 four-wheelers with 300 passengers, allowing 1 cwt. per passenger, and that the load is restricted in order that the speed may be maintained during the high winds that prevail here. The goods engines haul a load of 120 tons at an average speed of 12 miles per hour over the gradients referred to.

Turntables are provided at Wadhwan, Rajkot, and Morvi; and there is a triangle for turning engines at Vankaneer. The necessary arrangements for watering and coaling and examination are made at the three first-mentioned stations.

Traffic.—The passenger traffic is principally third class, the proportion of first and second class passengers being only 3 per cent.

The goods traffic is stone, grain, cotton, oil-seeds, timber, coal, and salt. The number of passengers carried in 1897 was 311,016, the tonnage for the same period 35,322.

For the first half of 1898 the figures are 125,903 passengers and 19,705 tons goods.

* Not reproduced.

† Pine is used for roofs, seats, and fittings of all descriptions, as well as floors.

The progressive traffic for the last ten years is given below :—

Year.			Mean Mileage worked.	Traffic.				Total.	
				Coaching.		Goods.			Sundries, including Telegraphs.
				No. of Passengers	Amount.	Tons.	Amount.		
				Rs.		Rs.	Rs.	Rs.	
1887	...	...	64.73	125,286	87,154	7,681	41,117	1,136	129,407
1888	...	...	68	131,718	91,897	11,764	66,264	3,926	162,087
1889	...	...	68	157,183	109,033	10,623	64,236	4,052	177,321
1890	...	...	94	204,742	175,101	20,356	110,697	9,429	295,227
1891	...	...	94	224,428	192,976	22,208	111,580	4,862	309,418
1892	...	...	94	228,008	194,990	24,210	106,642	7,539	309,171
1893	...	...	94	269,314	217,169	24,198	100,829	4,820	322,818
1894	...	...	94.36	284,521	214,869	21,984	98,950	6,529	320,348
1895	...	...	94.36	309,113	236,919	28,725	125,077	7,976	369,972
1896	...	...	94.36	337,365	253,048	35,499	125,502	8,333	386,883
1897	...	...	94.36	311,016	250,023	35,322	130,109	47,351	427,483

The largest goods traffic carried in any one week of the present year was for the week ending May 14, when 890 tons were transported in almost exact proportion of forwarded and received. This is 125 tons per diem, 7 days to the week, and is equivalent to 43,280 tons per annum.

Five hundred and eighty tons of this was transhipped to the broad gauge at Wadhwan or to the metre gauge at Rajkot at a cost of cents 8.16 per ton (Rs. 3 per 1,000 mds.).

Bulky articles are principally carried on low-sided trucks, and recently a launch 60 ft. long by 10 ft. wide was safely conveyed from one end of the line to the other. A mill boiler 30 ft. by 8 ft. and a fly wheel 14 ft. diameter have also been successfully transported. Half-pressed cotton is stacked up on these trucks to a height of 10 ft. above the wagon floor and carried quite safely.

Labour Force.—The goods loading and unloading is all performed by the railway staff, extra hands being taken on when required.

I will now proceed to answer the questions entrusted to me.

Question 1.—Can a 2 ft. 6 in. gauge railway carry the traffic in sight on the proposed Kelani Valley line, viz., 145,600 passengers and 40,000 tons goods?

Answer.—In 1896 the Morvi Railway carried 337,365 passengers, or more than 130 per cent. over what we expect, and 35,500 tons of goods, or 90 per cent. of the total we estimate.

Question 2.—What is the maximum that could be carried over a 2 ft. 6 in. gauge line similar to the Morvi Railway?

Answer.—The ordinary train service now is two trains each way per diem. These could be increased to five each way per diem without any extra sidings, and this could be done within the present working hours if the first train started at 5 A.M. instead of 7 A.M. On the assumption that five trains are run, the passenger traffic could be doubled and the goods trebled. By a slight adjustment of the present service it would be possible to put in a sixth train, which is about the maximum practicable service, without extra crossing stations. Assuming now that the ordinary composition of the trains is adhered to, and that the service is two passenger trains and four goods trains each way per diem, we get the following as the maximum capacity of the Morvi Railway within the limits I have mentioned :—

Passenger Train No. 1 :—		First.	Second.	Third.
1 Bogie composite	...	12	...	8
1 Second class	...	...	...	14
1 Composite mail	...	...	...	19
3 Bogie thirds (46 each)	...	...	...	138
1 Four-wheel third	...	...	...	21
1 Brake van	...	...	...	...
		...	...	178

Passenger Train No. 2 :—		First.	Second.	Third.
1 Bogie composite	...	12	...	8
3 Bogie thirds	...	...	...	138
6 Four-wheel thirds (21 each)	...	...	...	126
1 Brake van	...	...	...	...
		...	...	264

	Passengers.	Trains.	Days.	
Passenger Train No. 1	178	×	2	×
Passenger Train No. 2	264	×	2	×

Total Passengers ... 322,660

Goods Trains.—The gross load is 120 tons, of which 50 per cent. is dead weight, so that 60 tons per train is its paying weight (load 60 tons × 8 trains × 365 days = 176,400 aggregate tons per annum); but I should not omit to mention that at cotton crop, when full loads of cotton can be obtained, it is possible, indeed the ordinary practice, to run trains in which the relation of load to tare is nearly 3 to 1. Thus, high-sided weighing 1 ton 12 cwt. each carry 3 tons 14 cwt., or bogie low-sided weighing 3 tons each carry 7 tons, or 57 per cent. pay loads.

THE MORVI LIGHT RAILWAY.

Question 3.—Could a 2 ft. 6 in. gauge railway be constructed in a superior manner to carry more than the Morvi line is capable of doing?

Answer.—Yes, as is shown in my report on the Barsi Line.

Question 4.—How do the rates and charges on the Morvi Line for (1) conveyance and (2) maintenance compare with those of the Ceylon Railway?

Answer.—I am at this distance unable to make the comparisons, but I send a rate and fare book that will enable the Railway Accountant to do so. I also attach abstracts showing the expenses for the maintenance of each Department, viz. :—

Abstract A for Ways, Works, and Stations
Do. B for Locomotive Expenses
Do. C for Carriage and Wagon Expenses
Do. D for Traffic Charges

and with each an account of the staff employed, their rates of pay, and, where possible, the cost of materials.

Annexed, too, is an analysis of the working results, passengers and goods, for the half-year ended December 31, 1897 :—

Abstract A.

Maintenance of Ways, Works, and Stations.

Rs.	A.	P.		Rs.	A.	P.
I.—General Superintendence :—						
1,305	1	0	(1) Engineer's salary	1,793	0	9
73	0	0	(2) Allowances of ditto, including travelling	310	0	0
1,414	0	0	(3) Subordinate superintendence	1,462	13	3
9	7	0	(4) Allowances of ditto, including travelling	13	3	0
—	—	—	(5) Overtime allowances	1,065	7	3
1,042	5	3	(6) Office expenses	—	—	—
II.—Maintenance and Renewal of Permanent Way :—						
12,309	0	11	(1) Wages	12,390	14	7
1,466	6	10	(2) Materials	2,879	6	5
III.—Repairs of Bridges, &c., Wages and Materials :—						
399	9	5	(1) Bridges and tunnels	191	9	0
13	1	0	(2) Miscellaneous, including earthwork, roads, fencing, &c....	22	8	0
IV.—Repairs of Stations and Buildings, Wages and Materials :—						
1,043	0	1	(1) Repairs of buildings of every description, including station yards and signals, but excepting quarters of the staff	1,483	9	8
V.—Maintenance by Contract						
90	0	0	VI.—New Minor Works	366	7	6
VII.—Unclassified Expenditure :—						
—	—	—	(1) Plantations	9	6	0
5	3	2	(2) Tools and plant	201	12	1
173	11	1	(3) Loss on stores, &c.	389	13	0
866	0	6	(4) Carriage of revenue stores	22,579	14	6
20,199	7	11	Credit for works done in the Engineering workshop for other departments during the half-year		11	13
29	3	3	Total		22,568	0
20,170	4	8			0	11

Departmentally.

Mean Mileage maintained by Revenue :—		Miles.
94.36	...	94.36
4	...	4
98.36	...	98.36
Rs. 205.06	Cost per mile of track including sidings	Rs. 229.44

Strength of Staff.

Office.		Cost per Month.
		Rs. A. P.
Head clerk and two clerks, 5 peons (2 office and 3 personal)		130 0 0
Subordinates.		
2 Permanent Way Inspectors at Rs. 35 to Rs. 31		245 0 0
1 Sub-Inspector at Rs. 23		
8 Timekeepers at Rs. 15 to Rs. 21		
Total		375 0 0

Maintenance Staff.

28 Permanent Way muckadams, average daily pay per each 7 annas 3 pies	380	0	0
154 Permanent Way gangmen, average daily pay per each 4 annas 3 pies	1,232	0	0
Gate-men and bridge guards, average daily pay per each 3 annas 9 pies	99	0	0
8 Lorry-men, average daily pay per each 4 annas 8 pies	72	0	0
Total	1,783	0	0

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Workshop.		Rs.	A.	P.
1 Mistry (daily 1 anna 6 pies, including batta) ...	...	41	4	0
3 Carpenters with assistants, average daily pay 15 annas and 4 annas 3 pies ...	...	114	0	0
2 Smiths with hammermen and 2 bellowsmen, average daily pay 15 annas 6 pies, 5 annas 6 pies, and 5 annas ...	...	120	0	0
1 Screw-cutter 10 annas; water woman 3 annas; mason with assistant Re. 1 and 4 annas 3 pies ...	...	38	0	0
Total ...	...	313	4	0
Grand Total per Month ...	...	2,471	4	0

Two gangs consisting of 1 mucedam and 8 gangmen cost Rs. 80 each.
Eight gangs consisting of 1 mucedam and 6 gangmen cost Rs. 63 each.
Eighteen gangs consisting of 1 mucedam and 5 gangmen cost Rs. 55 each.
Length of each gang varies from 3 miles to 3½ miles.

Abstract B.

Locomotive Expenses.

Rs.	A.	P.	I.—General Superintendence :—	Rs.	A.	P.
1,480	0	0	(1) Salaries of Superintendent and Assistants ...	1,508	10	6
218	4	0	(2) Allowances of ditto, including travelling ...	204	12	0
480	0	0	(3) Subordinate superintendence ...	480	0	0
66	4	0	(4) Allowances of ditto, including travelling ...	65	5	0
—	—	—	(5) Overtime allowances ...	—	—	—
378	12	0	(6) Office expenses ...	395	14	0
II.—Running Expenses (Wages connected with the working of Locomotive Engines) :—						
2,460	9	9	(1) Wages of drivers and firemen ...	2,705	11	6
924	5	1	(2) Overtime allowances ...	—	—	—
376	2	4	(3) All labour connected with fuelling, cleaning, and looking after engines in yards ...	1,168	4	0
—	—	—	(4) Contingent expenses, including clothing ...	224	10	11
III.—Fuel :—						
17,753	3	5	690 tons (1) Coal, Cardiff, 859 tons ...	22,847	2	0
645	9	7	IV.—Water (including wages and stores) ...	599	3	8
923	5	7	V.—Oil, tallow, and other stores (expended on engines in work) ...	1,284	0	0
VI.—Maintenance and Renewal of Locomotive Engines and Machinery :—						
3,523	15	11	(1) Wages ...	1,326	9	2
10,226	3	8	(2) Overtime allowances ...	3,720	11	3
—	—	—	(3) Materials ...	—	—	—
VII.—New minor works ...						
VIII.—Payments made to other Lines ...						
IX.—Unclassified Expenditure :—						
45	6	11	(1) Tools and plant ...	2	2	0
9	10	0	(2) Carriage of revenue stores :—	Rs.	A.	P.
0	8	0	(1) Coal ...	165	5	0
47	13	9	(2) Other revenue stores ...	11	13	0
39,469	4	2	(3) Loss on stores, &c. ...	177	2	0
—	—	—	...	36,710	11	0
39,469	4	2	Credit for works done in the Locomotive workshop for other departments during the half-year ...	138	7	9
—	—	—	...	36,572	3	3

Locomotive Department.—Expenditure List for the Half-year ended December 31, 1897.

Details.	Amount.	In Annas per Train Mile.	In Annas per Engine Mile.
General Superintendence :—	Rs. A. P.	84,670	88,478
Salary of Superintendent ...	1,508 10 6	29	28
Batta of Superintendent ...	204 12 0	04	04
Salary of Foreman ...	480 0 0	09	08
Batta of Foreman ...	65 5 0	01	01
Office expenses ...	395 14 0	07	07
Total ...	2,654 9 6	50	48

THE MORVI LIGHT RAILWAY.

Details.	Amount.	In Annas per Train Mile.	In Annas per Engine Mile.
Running Expense :—	Rs. A. P.	84,670	88,478
Salaries of drivers and firemen ...	2,705 11 6	51	50
All labour connected with fuelling, cleaning, &c. ...	1,168 4 0	22	21
Contingent expenses ...	224 10 11	04	04
Total ...	4,098 10 5	77	75
Coal 21·7 lb. per engine mile ...	22,847 2 0	4·32	4·13°
Water ...	599 3 8	12	11
Oil, tallow, and other stores ...	1,284 9 0	24	23
Maintenance and Renewals :—	Rs. A. P.	84,670	88,478
Wages, including overtime ...	1,188 2 0	22	21
Materials ...	3,720 11 3	70	68
Tools and plant ...	2 2 0	—	—
Total ...	4,910 15 5	92	89
New minor works ...	177 2 0	03	03
Grand Total ...	36,572 3 3	6·9	6·62

* Cost Rs. 26 9 annas 6 pies per ton.

Abstract C.

Carriage and Wagon Expenses.

Rs.	A.	P.	I.—General Superintendence :—	Rs.	A.	P.
500	0	0	(1) Salaries of Superintendent and Assistants ...	668	5	4
106	8	0	(2) Allowances do. ...	115	8	0
240	0	0	(3) Subordinate superintendence ...	240	0	0
32	8	0	(4) Allowances do. ...	33	12	0
—	—	—	(5) Overtime allowances ...	—	—	—
302	14	8	(6) Office expenses ...	420	0	0
II.—Repairs and Renewals of Vehicles and Machinery :—						
(a) Coaching Vehicles.						
1,292	8	7	(1) Wages ...	519	13	2
2,753	0	10	(2) Overtime ...	929	14	3
—	—	—	(3) Materials ...	—	—	—
(b) Goods Vehicles.						
55	9	0	(1) Wages ...	23	13	6
154	11	6	(2) Overtime ...	10	6	7
—	—	—	(3) Materials ...	—	—	—
III.—Cleaning Carriages and Wagons and Oiling :—						
652	15	4	(1) Labour, including wages of oilers, carriage cleaners, and examiners ...	883	1	10
236	2	7	(2) Stores, including oil, grease, and other stores for consumption on running vehicles ...	343	1	5
IV.—New Minor Works ...						
V.—Unclassified Expenditure :—						
—	—	—	(1) Tools and plant ...	—	—	—
—	—	—	(2) Loss on stores ...	—	—	—
6,326	14	6	Credit for works done in the workshop for other departments during the half-year ...	4,177	14	6
—	—	—	...	69	3	10
6,326	14	6	...	4,108	10	8

Carriage Department.—Expenditure List for the Half-year ended December 31, 1897.

Details.	Amount.	In Annas per Train Mile.
General Superintendence :—	Rs. A. P.	
Salary of Superintendent, with allowance ...	783 13 4	15
Salary of Foreman, do. ...	273 12 0	05
Office expenses ...	420 0 0	08
Total ...	1,477 9 4	28
Repairs and Renewals of Vehicles :—	Rs. A. P.	
Wages for repairing vehicles ...	543 10 8	10
Materials ...	919 7 8	17
Total ...	1,463 2 4	27

Details.	Amount.	In Annas per Train Mile.
Oiling, Cleaning Vehicles :—		
Wages of carriage examiner and others	Rs. A. P.	
Stores	883 1 10	16
	443 1 5	07
Total	1,226 3 3	23
New Minor Works :—		
Less credit office charges	69 3 10	01
Grand Total	4,108 10 8	77

Abstract D.

Traffic Expenses.

Rs.	A.	P.	(a) General Superintendence :	Rs.	A.	P.
1,262	0	0	(1) Traffic Manager, Assistant Traffic Manager, District Superintendents, and Traffic Canners	1,920	8	10
1,693	14	4	(2) Office establishment	1,694	11	6
141	5	0	(3) Travelling allowances	124	8	0
42	6	6	(4) Contingencies	17	8	0
7,374	13	7	(b) Station Staff :	7,991	6	6
			(1) Station Masters, clerks, porters, pointsmen, gatekeepers of level crossings, signalmen, station servants, &c.			
1,108	4	4	(c) Train Staff :	1,068	13	10
398	9	11	(1) Guards and assistant guards	427	13	3
			(2) Overtime allowances			
1,281	15	10	II.—Fuel, Lighting, Water, and General Stores—			
656	11	4	(1) Fire, light, water, and general stores for carriages, stations, offices, &c.	1,548	1	1
72	6	6	(2) Wagon covers, ropes, &c.	2,783	10	0
271	13	0	(3) Office and station fittings and furniture	61	13	4
2,362	5	2	III.—Clothing	527	4	3
3,361	3	0	IV.—Printing, stationery, and tickets	2,150	10	9
68	4	0	V.—Charges for delivery and collection of goods	2,618	4	5
			VI.—Miscellaneous expenses	106	8	0
			VII.—Payments to other Lines			
1,040	9	8	VIII.—Unclassified Expenditure—	597	0	8
46	2	7	(1) Tools and plant			
			(2) Loss on stores, &c.			
21,182	12	9		23,638	10	5

Revised List of Station Staff on and from January 20, 1898.

Designation.			Name.		Salary.		Designation.			Name.		Salary.	
					Rs. A.							Rs. A.	
WADHWAN.													
S. M.	...	Nialchand Trikamji	...	25	0								
C. Clerk	...	Gopal Shivaram	...	22	8								
Signaller	...	Khetsi Panachand	...	15	0								
Do.	...	Thakersi Morarji	...	15	0								
Checker	...	Nanji Karson	...	16	0								
T. Checker	...	Nanoo Ramaned	...	10	0								
Tranship Clerk	...	Raghavaji Ghella	...	14	0								
Checker	...	Ganpat Narayne	...	10	0								
Do.	...	Remashanker Ambavidas	...	10	0								
MULI.													
S. M.	...	Jivram Lalji	...	20	0								
Signaller	...	Ranchod Narbheram	...	15	0								
DOLIA.													
S. M.	...	Shivshanker Hirji	...	20	0								
THAN ROAD.													
S. M.	...	Prabhashanker Lalji	...	20	0								
Signaller	...	Shivshanker Umashanker	...	15	0								
VANKANEER JUNCTION.													
S. M.	...	Kallianji Harjivan	...	36	0								
C. Clerk	...	Gordhan Pragji	...	11	0								
Signaller	...	Kameshvar Rugnash	...	15	0								
Do.	...	Panachand Trikamji	...	16	0								
Checker	...	Panachand Devchand	...	10	0								
T. Checker	...	Mohan Jeyshanker	...	12	8								
C. Clerk	...	Umishanker Ghella	...	12	0								
SINDHAVADAR.													
S. M.	...	Prabhashanker Ramnand	...	20	0								
KHORANA.													
S. M.	...	Jivram Harjivan	...	20	0								
RAJKOT.													
S. M.	...	Mansooklal Tarachand	...	40	0								
Junior Clerk	...	Nanchand Govindji	...	25	0								
C. Clerk	...	Amerchand Abhechand	...	16	0								
Signaller	...	Daya Manalji	...	16	0								
Do.	...	Kripashanker Dayaram	...	15	0								
Checker	...	Manilal Vanarsi	...	15	0								
T. Checker	...	Mamshanke Abhechand	...	10	0								
MORVI.													
S. M.	...	Kripashanker Zunza	...	25	8								
C. Clerk	...	Ghella Mulchand	...	15	0								
Signaller	...	Hemchand Kusalchand	...	15	8								
Do.	...	Sadashiv Narayan	...	15	0								
Checker	...	Keshavlal Popat	...	10	0								
Goods Clerk	...	Gokal Thakersi	...	16	8								
RELIEVING STAFF.													
S. M.	...	Kallianrai Himatram	...	25	0								
Signaller	...	Pranshanker Ranjai	...	16	0								
Checker	...	Shamji Savchand	...	10	0								
GUARDS.*													
I.	...	Kallianji Makanji	...	22	0								
II.	...	St. Anna D'Cunna	...	22	0								
III.	...	Venilal Mugatram	...	21	0								
IV.	...	Vasram Dayabhai	...	19	8								
V.	...	Nandlal Naranji	...	17	0								
VI.	...	Govindram Devji	...	16	8								
BRAKESMEN.†													
I.	...	Bhawan Nathoo	...	12	0								
II.	...	Chakoo Amersi	...	12	0								
III.	...	Abhechand Talaksi	...	10	8								
IV.	...	Devji Kanji	...	10	8								
V.	...	Nanchand Bhanji	...	10	8								
VI.	...	Maganlal Ambaram	...	10	0								
VII.	...	Laxmishanker Purshotam	...	10	0								

* Allowance at the rate of 5 annas per 100 miles.

† Allowance at the rate of 2 annas per 100 miles.

Pointsman, Porters, and others, Rs. 7 to Rs. 9 per mensem.	Rs.	A.	P.
Rates for relieving, acting, &c., allowances for men drawing less than Rs. 10	0	2	0
Do. do. do. 10 to 14	0	3	0
Do. do. do. 15 to 19	0	4	0
Do. do. do. 20 to 30	0	5	0
Do. do. do. 31 to 40	0	6	0
Do. do. do. 41 to 60	0	8	0
Do. do. do. 61 to 80	0	12	0
Do. do. do. 81 to 100	1	0	0

For every additional Rs. 25, or fraction of Rs. 25, 4 annas more, subject to minimum of Rs. 5.

Analysis of the Working Results for the Half-year ended December 31, 1897.

(a) Passenger Traffic.	Miles	94
Average length open :—		
1 Receipts from coaching traffic	Rs.	134,375
2 Passenger train miles run	No.	60,762
3 Average passenger train mile receipt...	Rs.	2-21
4 Number of passengers carried one mile	No.	7,219,433
5 Average sum received for carrying a passenger one mile	Ans.	0-27
6 Average number of passengers in a train at any one time	No.	119
7 Average number of passenger trains per diem each way, supposing each train to traverse the whole line open	No.	1-76
8 Average number of passengers passing over each mile of line daily (both ways)	No.	417
9 Total working expenses for both goods and passengers, deducting from them telegraph, special, and miscellaneous receipts and demurrage on goods	Rs.	61,909
10 Average cost of running a train mile, passenger and goods miles assumed to cost the same	Rs.	0-73
11 Average cost of carrying a passenger one mile	Ans.	0-10
(b) Goods Traffic.	Miles	94
Average length open :—		
1 Receipts from goods traffic exclusive of demurrage on goods	Rs.	47,517
2 Goods train miles run	No.	23,908
3 Average goods train mile receipts	Rs.	1-99
4 Tons of goods carried one mile	Tons	718,316-30
5 Average sum received for carrying one ton one mile	Ans.	1-06
6 Average number of tons in a goods train at any one time	Tons	30-05
7 Average number of goods trains per diem each way, supposing each train to run over the whole line open	No.	0-69
8 Average number of tons of goods passing over each mile of line daily (both ways)	Tons	41-53
9 Total working expenses for both goods and passengers, deducting from them telegraph, special, and miscellaneous receipts and demurrage on goods	Rs.	61,909
10 Average cost per train mile, goods and passenger miles assumed to cost the same	Rs.	0-73
11 Average cost of carrying a ton of goods one mile	Ans.	0-39

Table of Standard Dimensions to be generally observed on Railways in India.

General.	Gauge.	Gauge.
Formation, Single Line—	2 ft. 6 in.	2 ft. 0 in.
(1) Minimum width in embankments	10 ft.	9 ft.
(2) Minimum width in cuttings exclusive of side drains	10 ft.	9 ft.
Curves.	24°	28°
(3) Maximum angle of curvature on main line	Radius = 238 ft.	204 ft.
NOTE.—In open country, 1,432 ft. is recommended.		
Ballast.		
(4) Minimum width of ballast at level of foot of rail	6 ft.	5 ft.
(5) Minimum depth below sleeper	6 in.	6 in.
Sleepers.		
Minimum dimensions for timber cross sleepers—		
(6) Length	5 ft.	4 ft.
(7) Breadth	6 in.	6 in.
(8) Depth	4 in.	4 in.
(9) Number per mile under light rails	2,000	2,000
Rails.		
(10) Minimum weight per yard	30 lb.	30 lb.
Spacing of tracks, station yards—		
(11) Minimum distance centre to centre	12 ft.	12 ft.
Locomotives and Rolling stock—		
Weight on a pair of Wheels.		
(12) Maximum for locomotives	6 tons	6 tons
(13) Maximum for goods and coaching stock	4 tons	4 tons
Wheel Base.		
(14) Maximum rigid wheel base for passenger and goods vehicle	12 ft.	10 ft.
Moving Dimensions.		
(15) Maximum width over all	7 ft. 6 in.	6 ft.
(16) Maximum height above rail	10 ft.	9 ft.
Accommodation.		
(17) Minimum width of seat per passenger	19½ in.	19½ in.
(18) Minimum floor area per passenger	3½ sq. ft.	3½ sq. ft.
(19) Minimum cubic capacity per passenger	22 c. ft.	27 c. ft.

Having described the Morvi Railway and given an account of its traffic and working, it only remains for me to offer a few remarks in conclusion, which I do after very careful consideration.

- (1) There is not, in my opinion, the slightest doubt as to the capacity of a 2 ft. 6 in. gauge railway to carry all the traffic of the proposed Kelani Valley line, present and prospective.
- (2) That a speed of 18 to 20 miles an hour for passenger trains and 15 miles an hour for goods trains can be safely run upon a 2 ft. 6 in. line.
- (3) That 2 ft. 6 in. trains, carriages, wagons, and engines are substantial and business-like.
- (4) That vehicles of a sufficient cubical capacity to meet our requirements can be constructed with a light tare to carry a good paying load.
- (5) That there is a considerable difference between a light railway of 2 ft. 6 in. gauge and a heavy railway on a narrow gauge, 2 ft. 6 in. or otherwise.
- (6) That the Barsi line is a heavy one and the Morvi a light one.
- (7) That between the two will probably be found the economic mean.

I should therefore recommend for the Kelani Valley line—

- (1) 30-lb. rails and 40-lb. sleepers.
- (2) Engines not exceeding 4 tons per axle.
- (3) Rolling stock not exceeding $2\frac{1}{2}$ or 3 tons per axle.
- (4) That all bridges, banks, and works be designed to meet such a load.
- (5) That all vehicles, both passenger and goods, be of the same lengths and widths, and that type bogies (without the swinging links) for the whole.
- (6) That the standard dimensions be 30 ft. 6 in. by 6 ft. 6 in. by 6 ft. 6 in. inside standard.
- (7) That the interior arrangements of the carriages be very much of the Morvi line type.
- (8) That the body framing and doors of all covered goods wagons be of wood with corrugated iron sides and roofs. The wooden doors will obviate the difficulty experienced with the fastenings of all wholly iron vehicles.
- (9) That several of the covered trucks be constructed so as to be convertible into live stock wagons, as is the practice on narrow-gauge lines, to save the building of cattle trucks.
- (10) That the economic conveyance of tea is the principal factor in the profitable working of the proposed railway, that being the largest traffic having bulk rather than weight.
- (11) That the wagon dimensions I have given will enable the best load, viz., 120 to 125 full chests of tea, of average 120 lb. each (say 6 tons) to be carried upon the $2\frac{1}{2}$ ton axle load I have recommended in (3).
- (12) That rice in the usual consignments of 90 bags could be conveyed in such wagons and be just within the maximum weight, so that with the two largest items of our traffic we should get the best results.
- (13) That in not following the Barsi equation of loads per axle on both engines and rolling stock, I have thought that a fully-loaded Barsi train of say 16 vehicles would be equivalent to a train of 17 engines, which may not be found economic in practice, however well it may look on paper, as such a load would in ordinary working be very hard on the road.
- (14) I recommend for consideration the use of a light engine over the flatter grades and curves on the first 35 miles of the proposed railway (a heavier engine being employed on the more difficult portion) the construction being lighter in proportion.
- (15) I invite attention to the use of rolled beams for girder bridges which I am told is sound in principle and cheap in practice, and that they are being adopted in broad-gauge constructions.
- (16) I had occasion to mark, in my Barsi report, on the buffers in use on that line. I have found here what appears to me to be a much superior buffer (White and Burke's patent), of which I will bring complete drawings and explain its advantages personally.
- (17) There are many minor details to be referred to, but I leave them till I shall have an opportunity of speaking about them, and with these remarks I close my report.

The greatest courtesy and assistance has been shown and rendered to me by Mr. C. P. White, the Resident Engineer of this Railway, and to him I am indebted for much of the material of this report. He has been on the line since its commencement, and at my request has written a memorandum, which I send herewith, which contains many valuable observations suggested by his long experience. Mr. W. H. White, the Manager, was unfortunately away until yesterday, but I have had the advantage of consulting with him on various points in this report, and now make my acknowledgments. I met with the readiest assistance from the Consulting Engineers at Madras and Bombay, and everything has been done to enable me to lay before you a clear account of the two lines I am instructed to report upon.

In my report on the Barsi line I should have acknowledged the courtesy and assistance of the Acting Manager, Mr. F. Parker, who helped me in every way to obtain the information I required.

A. P. PERMAN,
Traffic Superintendent.

NOTES on Light Railways by Mr. C. P. WHITE.

Narrow gauge, but heavy, railways should not be confounded with light narrow gauge railways. (Narrow gauge stock can be constructed to carry 40 tons in a 2 ft. 6 in.-base, such as is done in large workshops.) The benefits of a light railway consist in light permanent way, narrow banks, and inexpensive bridges, and light stock that can easily be shifted and shunted by manual labour, and slow speeds which permit of complicated precautionary measures and rules against accident being done away with. No platforms are necessary, and all buildings should be constructed as cheaply as possible, gateways, &c., being quite unnecessary. Line should not be fenced. If the country permits of it, the line to follow the surface of the country as much as possible, unnecessary bridging thereby being avoided, "dips" often meeting the case just as efficiently as a bridge or culvert. Though such a line may at times be under water, the delays to traffic will not be great, and damages to tracks by their non-existence avoided.

As earnings increase curves may be eased and grades reduced (as has been done on this line).

Light rails and steel sleepers should not be stiffly packed. On this line 19 lb. rails and 11 lb. steel sleepers have been run over by 14-ton engines at a working speed of 12 miles an hour for years without damage to either. This is due to the ballast being of moorum (decayed trap) or sand. If broken stone ballast of a depth to 6 in. to 9 in. under the sleepers had been used, the sleepers would have buckled and rails suffered.

On a 29 lb. rail with 33 lb. trough steel sleepers, a speed of 30 miles an hour has been attained without undue oscillation or danger, and a time table speed of 18 miles an hour between stations is worked to.

Rolled steel beams as girders have been successfully used. Engines and stock of medium hauling and carrying capacity are recommended, as otherwise they would probably usually work to less than half their power.

In the same manner a certain percentage of 4-wheeled stock is recommended. Wagons for picking up small roadside station loads and carriages to give "reserved accommodation," and for attaching to overcrowded trains.

Care should be taken to run the "cant" of curves well out into the straight to avoid lurching to high loads (such as unpressed cotton).

Stock with a 9 ft. wheel base has worked successfully round a 230 ft. radius curve for years, but nothing under 500 ft. for such a wheel base is recommended (outside station limits).

For smooth running carriages up to 6 ft. 6 in. inside width are recommended; widths over this have not run as smoothly. With sufficient crossing stations the traffic that can be handled is almost unlimited, and goods of any description can be carried—a launch 60 ft. by 10 ft., a mill boiler 30 ft. by 8 ft., and fly wheel 14 ft. diameter having been carried attached to an ordinary goods train; in fact, bulky articles such as would not pass under the top boom bracings of 5 ft. 6 in. gauge girder bridges could safely be carried, and have been carried.

If I were called upon to give an opinion as to the most satisfactory sort of permanent way and rolling stock to carry the traffic such as this line is at present doing, and to meet a fair increase over say five years, I would recommend a 30 lb. flat-footed steel rail, 33 lb. trough steel sleepers or creosoted pine, and six-holed fishplates.

Passenger engines, 4 wheel coupled, with leading bogie truck—diameter of coupled wheels 3 ft. 3 in., weight on driving axle about 5 tons, stiff wheel base about 6 ft. 3 in., 6 wheeled tender with water capacity for 40 miles or over.

Such engine to run a rake of passenger coaches at a through speed of 15 to 16 miles an hour. Mixed trains and goods engine, 6 wheel coupled engine, with leading bogie truck—diameter of coupled wheels 2 ft. 9 in., weight on driving axle about 5 tons, on others about $4\frac{1}{2}$, stiff wheel base about 8 ft. 6 in. Such engines to run mixed trains at a through speed of 12 miles an hour and goods trains 9 to 10 miles an hour.

As the drivers and firemen on small gauge railways are invariably lowly paid men, and the fire boxes small, something over the ordinary calculated size is recommended.

Carriages.—Third class bogie, 30 to 35 ft. long, 6 ft. 6 in. inside width, sufficient to seat four passengers (anything over this is waste space).

Carriages.—Four-wheeled, 16 ft. long, with a stiff wheel base of 8 ft. to 8 ft. 6 in. These carriages to be built of Channel iron or pressed steel (Fox's) frames, say one-third each, and wooden framing and corrugated iron sides and roof to all.

Wagons.—Bogie low-sided, about 25 ft. long, carrying 7 to 9 tons; tare say 2 to 3 tons (half-pressed steel, half ordinary Channel frames). Some wooden, some iron flooring; sides to be not more than 6 in. high and sloping outwards.

Wagons high-sided 4-wheeled, 12 to 13 ft. long, carrying say five tons; tare $1\frac{1}{2}$ to 2 tons, wheel base 8 ft. Wagons covered, bogie, 25 ft. long, carrying say 6 to 8 tons; tare $2\frac{1}{2}$ to $3\frac{1}{2}$ tons.

Wagons covered, 4-wheeled, 12 to 13 ft. long, carrying 4 tons; tare 2 to $2\frac{1}{2}$ tons. The gross load per axle on wagons is not recommended to be up to the weight on axle of engine driving wheels as being detrimental to the permanent way and road maintenance.

If anything more than the above permanent way and stock with sufficient crossing stations can move is required, then a wider gauge railway is recommended in preference to increasing axle loads and engine hauling power, with its following necessities of increased strength to girders and maintenance, &c., and non-increase of speed.

The greater the number of trains running the better the public are served. Such being accepted, in a poor country where one heavy train could lift all the traffic, the public would not be as well served as by two light trains, both as to speed and convenience; for the heavy train would have to run as a mixed train and would therefore have to stop at all stations both for attaching and detaching wagons and for passenger traffic.

C. P. WHITE.

Morvi, July 15, 1898.

P.S.—The above notes refer to the Morvi Railway, 96 miles long, running through poor country over fairly stiff grades.

Answers by Mr. Burke, Locomotive Engineer, to my Questions.

I.—Seven engines are at work and one generally under repairs in slack season, but during busy season the whole stock are at work.

II.—The workshops are as under:—Machine-fitting and boiler-making in one block of building. Moulding coppersmith, tinsmith, and blacksmith are accommodated in a lean-to attached to main building.

We have a detached shed for painting. Machinery.—We have a limited number, such as lathes, shaping, drilling, punching, and shearing, rolls, band saw, circular saw, and one pulverizing and one mixing machine for paint.

The number of hands we have at present, including leading mechanics, are 58. This number is far too large for our revenue work. We are at present doing State and outside work, and no sooner these are finished we contemplate making a reduction, which will bring us down to about 40 in all. At present we pay Rs. 30 and 13 annas per diem. This divided by 58 men gives an average of 8 annas 6 pies per head per diem. The maximum paid to fitter is 14 annas 6 pies per diem. The minimum paid to painter boy for rubbing and washing down paint is 2 annas per diem. Leading mechanics who, although in charge of work, are expected to work as ordinary mechanics. The maximum pay is Rs. 42 and the minimum is Rs. 36 per month.

We have had to import a boiler-maker from one of the big Railways, and owing to the responsibility of the work he is paid Rs. 62 per month.

With reference to works of any kind, whether engines, carriages, wagons, State or outside, I attend to all orders myself. All the mechanics in the workshop are the men of the State, who have been directly trained under me with the exception of a few, i.e., three in the boiler department and one in the fitting shop are outsiders.

III.—Description of Fuel.—We use Cardiff, Powell, Dufferin coal delivered at our depot at Wadhwan. The cost per ton is Rs. 31, but owing to several transshipments before it arrives at our depot we get a very heavy shortage, as much as from 5 to 6 per cent. The Locomotive Department signs for the full quantity, and at the end of the year the shortage has to be written off, and the whole amount is paid over the year's working, which increases the amount per ton more than what I have shown.

Last year we experimented with Indian, Japanese, and Australian. We found this description of coal did not suit our engines, as the steaming qualities of these coals require a larger area of fire grate than our little engines have, so hence this class of coal did not suit us. We had to get back to English.

We use the Vacuum Company's axle, cylinder, and engine-cleaning oils. We found that these oils reduce our consumption considerably. Tallow is not used on this Railway. Axle oil, 4 lb. per 100 engine miles, costs 6 annas 8 pies; cylinder oil, 1 lb. per 100 engine miles, costs 2 annas 9 pies; engine cleaning oil, 3 lb. per 100 engine miles, costs 8 pies; waste, 4 lb. per 100 engine miles, costs 10 pies; flax, .09 lb. per 100 engine miles, costs 6 pies; wood, 30 lb. per 100 engine miles, costs 3 annas; lamp oil, 3 lb. per 100 engine miles, costs 11 pies.

IV.—*Cost of Water and Consumption.*—Cost of water per 100 train miles = 10 annas; consumption of water per train mile = 18 gallons with our heaviest trains. We erect two tanks of 5 ft. cube at the end of each watering station. The water is taken direct from the tank by hose pipe.

V.—*Description of Cranes, &c.*—We have no cranes. We have two weigh-bridges at Wankaneer Junction at present, and these are in charge of Traffic.

VI.—*Load of Trains.*

Mail	...	...	...	15 vehicles
Mixed	...	...	...	24½ do.
Goods	...	...	...	24½ do.

Speed of Trains between Stations.

Mail	...	...	...	22 miles an hour
Mixed	...	...	...	14 do.
Goods	...	...	...	11 do.

Trains on the Wadhwan-Dolia section run to 12 miles an hour.

VII.—*List of Running Staff.*

	Rs.	A.	P.
Drivers, 6	1	8	0 average per diem
Firemen, 6	0	8	6 do.
Turners	0	11	0 per diem
Engine-lighters, 3	0	6	0 do.
Cleaners, 8	4	to 5	annas per diem
Car examiner, 1	1	0	0 per diem
Oilers, 4	0	6	6 average per diem

VIII.—With reference to other information that you ask me for, we have found that to do all our own work, as far as practicable, is the most economical way to work a little line like this. I have endeavoured to do everything that is possible. Besides being economical, it schools the men in their business. We have built all our rolling stock with the exception of a few that were first got out when the line was being constructed, and we find that we can make them stronger and more suitable to the requirements of the line, and also cheaper than if we got these from England.

With reference to our locomotives, we make our own fire-boxes, tube plates, &c. Besides this, we have built two complete locomotive boilers and other portable boilers for the State. We have now adopted the system of getting nothing from England but wheels, cylinders, and volute and spiral springs. All other works for either Locomotive or Carriage Department are done here. We have found that the use of corrugated iron on the sides of carriages and wagons have been a great saving to us. Formerly we used the sheet iron, which used to eat away from bottom, and had to be renewed about every third or fourth year, whereas the corrugated iron which we introduced about nine years ago appears to give entire satisfaction; and we run the vehicles in an unpainted state, which is a great benefit, for it saves painting until we were fortunate enough to find a deposit of oxide of iron in the Morvi District, which has given very satisfactory results, and is a cheaper paint and lasts as long as the English, and in fact it appears to be more lasting if mixed as it should be.

With reference to oils used in the Carriage Department, we use the heavy axle oil supplied by the Vacuum Oil Company, and we find this a very suitable lubricant, and the consumption is very small, and runs to as low as on the average throughout the year of .022 oz. per 100 bearing miles, or in money to .0022 annas.

We were using cast steel wheels under our wagons and carriages, besides wrought iron wheels with steel tyres. We found that the former cracked in the arms and the latter more badly in flanges. I have now adopted the cast chilled wheels, which is nothing but cast iron having a chilled face on tread, and from the last eleven years' experience I find that this is the wheel to suit a line like this. I have now extended this class of wheels to the bogies of our engines, and also under tenders, and gives very satisfactory results after four years' experience.

Locomotive Department.—Monthly Particulars connected with Engine No. 3 for the Month of June, 1898.

Daily average in miles	...	...	22.1
Light, shunting, and detention	...	...	47.5
Monthly mileage	...	...	711
Yearly mileage	...	...	—
Total mileage for the whole life of engine	...	...	198,994
Quantity of coal in cwt.	...	...	107
Quantity of wood in cwt.	...	...	2.1
Quantity of coal used in lb. per engine mile	...	...	17.2
Quantity of coal used in lb. per train mile	...	...	18.4
Cotton waste in lb. used during month for cleaning, &c.	...	...	2.25
Flax and other stores used during month	...	...	Rs. 3.4
Oil axle in lb. per 100 miles	...	...	3
Oil cylinder in lb. per 100 miles	...	...	9
Oil for lamps, &c., for 100 miles	...	...	4
Average working expenses per train mile in annas	...	...	4.9
Average working expenses per engine mile in annas	...	...	4.6
Coal saved over the quantity allowed in cwt.	...	...	—
Cost for monthly repairs	...	...	Rs. 6.6
Drivers' and firemen's wages	...	...	Rs. 24.0
Coal bonus earned	...	...	—
Date of examination of fire-box stays, &c.	...	...	26
Dates of examination of safety valves	...	...	15

Locomotive Department.—Statement Showing Mileage of Engines.

Number of Engine.	Monthly Average Mileage.	Yearly Average Mileage.	Whole life of Boiler.
3	1,507	18,090	198,994
4	1,473	17,675	194,443
5	1,248	14,976	109,784
6	2,118	25,425	237,282
7	2,294	27,524	256,893
8	2,010	24,124	225,168
9	2,604	31,251	143,235
10	2,656	31,870	146,057

THE MORVI LIGHT RAILWAY.

Locomotive and Carriage Department.—Fuel and Oil Return for the Month of June, 1898.

No. of Engine.	Name of Driver.	Train Miles run.	Detention Miles run.	Shunting Miles run.	Light or assisting Miles run.	Total Miles run.	Coal in lb. per Mile.	Axle Oil in lb. per Mile.	Cocoa Oil in lb. per Mile.	Cylinder Oil in lb. per Mile.	Waste in lb. per Mile.
3	Gunnesh, Surdarkhan, and Mulju	663½	15	32½	—	710½	17.2	.003	.004	.009	.003
4	Puthan Khooshalkhan	1,856½	60	128½	32	2,077½	14.4	.004	.004	.008	.003
5	Ravat Jetha	1,632	72½	81½	66	1,852	19.4	.003	.004	.007	.004
6	Jubarkhan, G.	2,255	69½	98½	68	2,491½	16.7	.004	.004	.009	.004
7	Abdul Reman	2,568½	107½	87½	32	2,795½	19.2	.004	.004	.009	.004
8	Bhaijee Nuthoo	2,136½	91½	80	166	2,473½	20.2	.004	.004	.009	.004
9	Jubarkhan and Surdarkhan	1,890	55½	51½	—	1,997	19.8	.043	.001	.012	.004
10	Mahomed Adum	2,881½	81½	156½	68	3,186½	16.0	.004	.001	.009	.004
	Total	15,883	553½	716½	432	17,584½	142.9	.303	.026	.072	.030
						Average Miles run.	Average in lb. per Mile.	Average in lb. per Mile.	Average in lb. per Mile.	Average in lb. per Mile.	Average in lb. per Mile.
						2,197	17.84	.038	.0033	.009	.0038

List of Gradients from Wadhwan to Morvi.

From M. F.	To M. F.	Length M. F.	Gradients.	Miles.
0 1000	0 1000	0 1000	Level	—
0 1500	0 1500	0 500	1 in 500	—
0 3600	0 3600	0 2100	Level	—
0 4380	0 4380	0 780	1 in 134	—
0 4380	0 5100	0 720	Level	—
0 5100	1 1000	0 1180	1 in 167	1
1 1000	1 3200	0 2200	1 in 500	—
1 3200	1 4200	0 1000	1 in 200	—
1 4200	2 4200	1 0	1 in 880	2
2 4200	2 4800	0 600	1 in 800	—
2 4800	3 2200	0 2680	1 in 500	3
3 2200	3 4900	0 2700	1 in 250	—
3 4900	4 500	0 880	1 in 325	4
4 500	4 2200	0 1700	1 in 200	—
4 2200	4 3800	0 1600	1 in 900	—
4 3800	5 0	0 1430	1 in 420	5
5 0	5 1900	0 1900	1 in 3800	—
5 1900	5 3300	0 1400	1 in 700	—
5 3300	6 0	0 1980	1 in 1980	6
6 0	6 2400	0 2400	1 in 300	—
6 2400	7 900	0 2780	1 in 800	7
7 900	7 2100	0 1200	1 in 350	—
7 2100	8 0	0 3180	1 in 800	8
8 0	8 2100	0 2100	1 in 400	—
8 2100	8 4500	0 2400	1 in 650	—
8 4500	9 1600	0 2380	Level	9
9 1600	10 0	0 3680	1 in 450	10
10 0	10 2500	0 2500	1 in 500	—
10 2500	10 4400	0 1900	1 in 1200	—
10 4400	11 800	0 1680	1 in 240	11
11 800	11 2400	0 1600	1 in 200	—
11 2400	11 4500	0 2100	1 in 210	—
11 4500	12 1500	0 2280	1 in 450	12
12 1500	12 2900	0 1400	Level	—
12 2900	13 1000	0 3300	1 in 1200	13
13 1000	13 2500	0 1500	1 in 375	—
13 2500	14 2600	0 1000	1 in 175	—
14 2600	14 4100	0 4380	1 in 650	14
14 4100	15 0	0 1500	1 in 900	—
15 0	15 900	0 1180	Level	15
15 900	15 1500	0 900	Level	—
15 1500	15 3600	0 600	1 in 780	—
15 3600	15 5000	0 2100	Level	—
15 5000	16 300	0 1000	1 in 4000	—
16 300	16 1900	0 400	1 in 240	—
16 1900	16 4500	0 580	1 in 400	16
16 4500	17 1600	0 1600	1 in 250	—
17 1600	17 2100	0 900	1 in 140	—
17 2100	17 3700	0 2800	1 in 275	—
17 3700	17 4000	0 1700	1 in 710	17
17 4000	18 900	0 2380	1 in 260	—
18 900		0 500	Level	—
		0 1200	1 in 500	—
		0 400	Level	—
		0 300	1 in 300	—
		0 1000	1 in 320	18
		0 1180		

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From M. F.	To M. F.	Length. M. F.	Gradients.	Miles.
18 900	18 4900	0 4000	1 in 220	19
18 4900	19 300	0 680	1 in 1000	19
19 300	19 1800	0 1500	1 in 200	20
19 1800	20 0	0 3480	1 in 280	20
20 0	20 1000	0 1000	1 in 280	20
20 1000	20 1300	0 300	1 in 150	21
20 1300	20 1900	0 600	Level	21
20 1900	20 3800	0 1900	1 in 280	21
20 3800	21 1800	0 3280	1 in 1150	21
21 1800	21 3800	0 2000	Level	22
21 3800	22 4200	0 400	1 in 200	22
22 4200	22 2200	0 3280	1 in 1000	22
22 2200	22 4300	0 2100	1 in 1000	23
22 4300	23 1800	0 2780	1 in 700	23
23 1800	23 3800	0 2000	1 in 290	24
23 3800	24 1100	0 2580	1 in 1300	24
24 1100	24 2400	0 1300	1 in 450	25
24 2400	24 3300	0 900	1 in 250	25
24 3300	24 3900	0 600	Level	25
25 0	25 900	0 1380	1 in 175	25
25 900	25 3000	0 900	1 in 175	26
25 3000	26 1600	0 2100	1 in 600	26
26 1600	26 4400	0 3880	1 in 1200	26
26 4400	28 300	0 2800	1 in 330	28
28 300	28 2600	1 1180	1 in 260	28
28 2600	29 600	0 2300	1 in 400	29
29 600	29 2300	0 3280	1 in 2000	29
29 2300	29 5000	0 1700	1 in 550	30
29 5000	30 200	0 2700	1 in 300	30
30 200	30 1700	0 480	1 in 120	30
30 1700	30 2800	0 1500	1 in 250	31
30 2800	30 3700	0 1100	1 in 550	31
30 3700	30 4600	0 900	1 in 900	31
30 4600	31 2700	0 900	1 in 240	31
31 2700	31 3200	0 3380	1 in 600	31
31 3200	31 5200	0 500	Level	32
31 5200	32 1800	0 2000	1 in 200	32
32 1800	33 4000	0 1880	1 in 170	33
33 4000	34 4300	1 1800	1 in 200	33
34 4300	35 0	1 380	1 in 310	34
35 0	35 1300	0 980	1 in 650	35
35 1300	35 4100	0 1300	1 in 450	35
35 4100	36 700	0 2800	1 in 200	36
36 700	36 2100	0 1880	1 in 650	36
36 2100	36 3500	0 1400	1 in 700	37
36 3500	36 4700	0 1400	1 in 600	37
36 4700	37 400	0 1200	1 in 275	37
37 400	37 1600	0 980	1 in 150	37
37 1600	37 4200	0 1200	1 in 420	37
37 4200	37 5100	0 2600	1 in 235	38
37 5100	38 400	0 900	Level	38
38 400	38 4800	0 580	1 in 200	38
38 4800	39 2000	0 4400	1 in 350	39
39 2000	39 3200	0 2480	1 in 400	39
39 3200	40 0	0 1200	1 in 200	40
40 0	40 800	0 2080	1 in 400	40
40 800	40 2800	0 800	1 in 300	41
40 2800	41 3400	0 2000	1 in 2000	41
41 3400	41 4300	1 1600	1 in 500	41
41 4300	42 2500	0 900	1 in 400	42
42 2500	42 3900	0 3480	1 in 275	42
42 3900	43 1000	0 1400	1 in 2000	43
43 1000	43 3500	0 2480	1 in 700	43
43 3500	44 100	0 2500	1 in 150	44
44 100	44 3300	0 1880	1 in 2500	44
44 3300	45 0	0 3200	1 in 250	45
45 0	45 2100	0 1980	1 in 340	45
45 2100	45 3500	0 2100	1 in 150	46
45 3500	46 500	0 1400	1 in 1000	46
46 500	46 3700	0 2280	1 in 500	46
46 3700	46 5280	0 3200	1 in 270	47
46 5280	47 2600	0 1580	1 in 300	47
47 2600	47 3600	0 2680	1 in 190	47
47 3600	48 200	0 1000	1 in 275	48
48 200	48 1700	0 1880	1 in 600	48
48 1700	49 2500	0 1500	Level	49
49 2500	50 0	1 800	1 in 750	49
50 0	50 1800	0 2780	1 in 450	50
50 1800	50 3200	0 1800	1 in 345	50
50 3200	51 700	0 1400	1 in 250	51
51 700	51 1800	0 2780	1 in 550	51
51 1800	51 3600	0 1100	1 in 500	51
51 3600	52 200	0 1800	1 in 250	52
52 200	52 2700	0 1880	1 in 700	52
52 2700	53 700	0 2500	1 in 550	53
53 700	53 2300	0 1000	1 in 800	53
53 2300	53 4700	0 1280	Level	53
		0 1600	1 in 400	
		0 2400	1 in 200	

THE MORVI LIGHT RAILWAY.

From M. F.	To M. F.	Length. M. F.	Gradients.	Miles.
53 4700	54 1300	0 1880	1 in 225	54
54 1300	55 0	0 3980	1 in 425	55
55 0	55 1700	0 1700	1 in 425	55
55 1700	55 2700	0 1000	1 in 1000	56
55 2700	56 5200	0 2500	1 in 330	56
56 5200	57 1000	1 0	1 in 550	57
57 1000	57 4600	0 1080	1 in 900	57
57 4600	58 300	0 3600	1 in 345	58
58 300	58 1100	0 300	Level	58
58 1100	59 1600	0 680	1 in 160	59
59 1600	59 3000	0 800	1 in 450	59
59 3000	60 0	1 500	1 in 650	60
60 0	60 2000	0 1400	Level	60
60 2000	61 500	0 400	1 in 725	61
61 500	61 2500	0 1880	1 in 600	61
61 2500	62 200	0 2000	Level	62
62 200	62 1300	0 600	1 in 1200	62
62 1300	62 3000	0 3180	1 in 100	63
62 3000	63 3100	0 2000	1 in 2000	63
63 3100	64 500	0 600	1 in 300	64
64 500	65 0	0 1100	1 in 300	64
65 0	65 1700	0 1280	1 in 450	65
65 1700	66 4800	0 900	Level	65
66 4800	67 3500	0 1700	1 in 400	66
67 3500	68 4300	0 800	1 in 550	66
		0 900	1 in 300	66
		0 1800	1 in 1200	66
		0 4080	1 in 1400	66
		0 800	1 in 500	66
		0 3980	1 in 210	66
		0 1200	1 in 600	66

List of Gradients from Vankaneer to Rajkot.

From M. F.	To M. F.	Length. M. F.	Gradients.	Miles.
51 2800	52 0	0 2480	Level	52
52 0	52 1600	0 1600	1 in 500	52
52 1600	52 2600	0 1000	Level	53
52 2600	53 500	0 2200	1 in 350	53
53 500	53 1200	0 980	1 in 140	53
53 1200	54 1200	0 700	Level	54
54 1200	54 2200	0 400	1 in 400	54
54 2200	55 2200	0 4880	1 in 175	54
55 2200	56 0	0 1000	1 in 300	55
56 0	56 2200	0 600	1 in 200	55
56 2200	57 300	0 1600	1 in 170	56
57 300	58 4000	0 3080	1 in 160	56
58 4000	59 2200	0 3080	1 in 275	56
59 2200	60 700	0 2200	1 in 220	57
60 700	61 0	0 600	1 in 200	57
61 0	62 0	0 2100	1 in 1000	57
62 0	63 0	0 680	1 in 550	58
63 0	64 0	0 1700	1 in 185	58
64 0	65 0	0 2000	1 in 250	58
65 0	66 0	0 2880	1 in 175	59
66 0	67 0	0 2300	1 in 800	59
67 0	68 0	0 3580	1 in 900	60
68 0	69 0	0 2200	1 in 400	60
69 0	70 0	0 1580	1 in 215	61
70 0	71 0	0 4580	1 in 230	61
71 0	72 0	0 10560	1 in 240	63
72 0	73 0	0 10960	1 in 400	65
73 0	74 0	0 1600	1 in 230	66
74 0	75 0	0 3280	1 in 220	66
75 0	76 0	0 3280	1 in 360	66
76 0	77 0	0 3280	1 in 200	66
77 0	78 0	0 3280	1 in 240	66
78 0	79 0	0 3280	1 in 900	66
79 0	80 0	0 3280	1 in 180	66
80 0	81 0	0 3280	Level	66
81 0	82 0	0 3280	1 in 260	66
82 0	83 0	0 3280	1 in 290	66
83 0	84 0	0 3280	Level	66
84 0	85 0	0 3280	1 in 500	66
85 0	86 0	0 3280	1 in 1500	66
86 0	87 0	0 3280	1 in 750	66
87 0	88 0	0 3280	1 in 320	66
88 0	89 0	0 3280	1 in 175	66
89 0	90 0	0 3280	1 in 260	66
90 0	91 0	0 3280	1 in 310	66

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From	To	Length.	Gradients.	Miles.
M. F.	M. F.	M. F.		
74 0	74 1171	—	1 in 400	—
74 1171	74 2300	—	Level	—
74 2300	75 700	—	1 in 550	—
75 700	75 1400	0 700	1 in 175	—
75 1400	76 1500	0 5380	1 in 400	—
76 1500	76 3700	0 2200	Level	—

Statement showing Mileages between which Curves under 1,000 ft. radius occur on the Morvi Railway—Wadhwan to Dolia Section—24 miles.

In Miles.	No. of Curves.	Radius.	Length in Ft.	In Miles.	No. of Curves.	Radius.	Length in Ft.
0 to 1	1	550	160	17 to 18	1	750	200
Do.	1	230	450	Do.	1	650	290
1 to 2	1	450	900	18 to 19	1	700	300
Do.	1	750	200	Do.	1	600	285
6 to 7	1	550	400	21 to 22	1	400	300
9 to 10	1	580	165	22 to 23	1	600	350
12 to 13	1	450	280	23 to 24	1	500	475
Do.	1	550	200	Do.	1	400	250
13 to 14	1	500	225	Do.	1	400	250
Do.	1	550	400	Do.	1	650	150
16 to 17	1	550	400				
Do.	1	650	250				
Do.	1	850	250				
17 to 18	1	450	360				

$$7,490 \text{ ft.} \div 5,280 = 1.41 \text{ mile.}$$

List of Curves from Wadhwan to Dolia Section, 24 miles.

Radius of Curves.	No. of Curves.
230 ft.	1
400 to 500 ft.	8
550 to 600 ft.	8
650 to 700 ft.	4
750 to 850 ft.	3
Total Curves	24

Total Length, 1.41 mile.

Statement showing Mileages between which Curves under 1,000 ft. radius occur on the Morvi Railway—Dolia to Wankaneer Section—27.75 miles.

In Miles.	No. of Curves.	Radius.	Length in Ft.	In Miles.	No. of Curves.	Radius.	Length in Ft.
24 to 25	1	800	350	43 to 44	1	650	200
Do.	1	700	300	44 to 45	1	750	100
Do.	1	750	550	45 to 46	1	600	175
25 to 26	1	450	450	Do.	1	375	200
31 to 32	1	450	1,050	47 to 48	1	500	200
35 to 36	1	450	350	48 to 49	1	800	200
38 to 39	1	550	200	50 to 51	1	750	300
40 to 41	1	600	300				
41 to 42	1	600	400				
Do.	1	700	150				

$$5,475 \div 5,280 = 1.03 \text{ mile.}$$

List of Curves from Dolia to Wankaneer Section—27.75 miles.

Radius of Curves.	No. of Curves.
375 ft.	1
450 to 500 ft.	4
550 to 600 ft.	4
650 to 700 ft.	3
750 to 800	5
Total Curves	17

1.03 mile.

Statement showing Mileages between which Curves under 1,000 ft. radius occur on the Morvi Railway—Wankaneer to Morvi Section—17.75 miles.

In Miles.	No. of Curves.	Radius.	Length in Ft.
58 to 59	1	850	200
59 to 60	1	550	300
64 to 65	1	800	490
	3		

$$990 \div 5,280 = .18 \text{ mile.}$$

THE MORVI LIGHT RAILWAY.

List of Curves from Wankaneer to Morvi Section, 17.75 miles.

Radius of Curves.	No. of Curves.
550 ft.	1
800 to 850 ft.	2
Total Curves	3
Total Length	.18 mile.

Statement showing Mileages between which Curves under 1,000 ft. radius occur on the Morvi Railway, Wankaneer to Rajkot Branch Section.

In Miles.	No. of Curves.	Radius.
0 to 1	1	600
0 to 1	1	650
0 to 1	1	800
1 to 2	1	800
3 to 4	1	800
4 to 5	1	600
4 to 5	1	500
5 to 6	1	800
22 to 23	1	600
22 to 23	9	

List of Curves from Wankaneer to Rajkot Section, 25.25 miles.

Radius of Curves.	No. of Curves.
500 ft.	1
600 to 650	4
800 ft.	4
Total Curves	9
Total Length	.62 mile.

P. H. Ry c^{no} 1151

Colonial Secretary's Office,

Colombo, 24 September, 1898.

Recd 3.10.98



No. _____

Sir,

I am desired by His Excellency the Governor to forward to you, for the information of your Government, a copy of the Reports by Mr. A.G. Perman with regard to the Barsi and Morvi Light Railways and to inform you that the Government has selected the 2 feet 6 inch gauge for the Kelani Valley Railway.

I am, Sir,

Your Obedient Servant,

J. P. C. J. J.

for Colonial Secretary.

The Hon'ble,

The Chief Secretary to Government

Fort St. George,

Madras.

31
P. H. Ry c^{no} 1151/98

C. No. 1151
3.10.98

SUBJECT.

HIS EXCELLENCY THE GOVERNOR.

~~THE HONBLE SIR HENRY BLISS, K.C.I.E.~~

~~THE HONBLE MR. A. T. ARUNDEL, I.C.S.~~

Mr. Perman's report on the
Barri and Morvi light
railways.

FOR ORDERS.

H.S. may like to see this.

The summary of Mr. Perman's conclusion is that
it found it July 18.

7/18

7/10/98

Bf No. 1240. Dy dated 10/10/98

Received.

7/18

10/10/98

H.S. 10.98. 12/10/1919