4-2-1 Estimation of the Present OD

The OD is estimated separately for railways, buses and expresses, the total OD being simply the sum of the three.

(1) Railway OD

"The railway OD table between stations" made on the basis of the OD survey conducted by B.R.C. (cf. CHAPTER 3), is converted into "railway OD table between townships" using the station-township relationship table (cf. Table 4.2.1). The abovementioned station-township relationship table was prepared on the basis of field observations and interview with stationmasters and other B.R.C. personnel.

Table 4.2.1 Station-Township Relationship

Station	Township
1. Rangoon	Kyauktada (40%) Pabedan (40%) Mingalataungnyunt (10%) Botataung (5%) Pazundaung (3%) Latha (2%)
2. Pazundaung	Pazundaung (60%) Mingalataungnyunt (33%) Dawbon (7%)
3. Mahlwagon	Tamwe (90%) Mingalataungnyunt (10%)
4. Myithanyunt	Tamwe (100%)
5. Tamwe	Tamwe (80%) Yankin (10%) Thingangyun (10%)
6. Bauktaw	Yankin (50%) Thingangyun (50%)
7. Kanbe	South Okkalapa (75%) Yankin (25%)
8. Paryame	South Okkalapa (45%) Yankin (45%) Mayangon (10%)
9. Yegu	Mayangon (100%)
10. Tadagale	North Okkalapa (90%) Mayangon (10%)
11. Kyaukyedwin	North Okkalapa (90%) Mayangon (10%)
12. Paywetseikkon	North Okkalapa (90%) Mayangon (5%) Mingaladon (5%)
13. Okkalapa	North Okkalapa (90%) Mayangon (10%)
14. Burma Air Force	Mingaladon (70%) North Okkalapa (30%)
15. Mingaladon Cantt.	Mingaladon (100%)
16. Mingaladon Bazaar	Mingaladon (100%)
17. Kyaikkale	Mingaladon (100%)
18. Golf Course	Insein (100%)
19. Danyingon	Insein (100%)
20. Aungsan Myo	Insein (100%)
21. Hpawkan	Insein (100%)
22. Ywama	Insein (100%)

Station	Township
23. Insein	Insein (100%)
24. Gyogon	Insein (100%)
25. Thamaing	Mayangon (100%)
26. Okkyin	Hlaing (100%)
27. Thirimyaing	Hlaing (100%)
28. Kamayut	Hlaing (80%) Kamayut (20%)
29. Hletan	Kamayut (70%) Kemmendine (30%)
30. Hanthawaddy	Kemmendine (50%) Sanchaung (25%) Kamayat (25%)
31. Kemmendine	Sanchaung (60%) Kemmendine (40%)
32. Hume Road	Sanchaung (50%) Kemmendine (30%) Ahlone (20%)
33. Mission Road	Ahlone (80%) Dagon (20%)
34. Gymkhana	Ahlone (80%) Dagon (20%)
35. Prome Road	Lanmadaw (50%) Dagon (40%) Latha (10%)
36. Lanmadaw	Latha (50%) Dagon (30%) Lanmadaw (20%)
37. Pagoda Road	Pabedan (90%) Latha (5%) Dagon (5%)
38. Hninzigon	Thingangyun (100%)
39. Thingangyun	Thingangyun (100%)
40. Ngamoyeik	Thingangyun (100%)
41. Togyaunggale	Thingangyun (100%)
42. Ywathagyi	Hlegu (100%)

Source: Study estimates

(2) Bus and express OD

a. Estimation of production-attraction

Information on the number of passengers for each line was obtained through R.T.C. and R.D.B.C.C., and these numbers are allotted to each township while taking account of the number of bus stops, the characteristics of each township and the pattern of boarding and alighting.

b. Estimation of distribution (OD table)

The results of the field observations and interviews indicate that the pattern of boarding and alighting differs between the peak and off-peak hours. The number of passengers for each line is grouped into peak and off-peak groups using the peak hour rate which is estimated based on the results of R.D.B.C.C.

The production-attraction during the peak hours is distributed according to the present peak-time flow (i.e. mostly between the CBD and other areas).

The distribution volume in off-peak hours is estimated by using a gravity model with independent variables of the production-attraction and the time-distance. The model is as follows.

$$P_{ij} = \alpha (G_i \; A_j)^{\beta} \cdot T_{ij}^{\gamma}$$

where, P_{ij}: Distribution volume from township i to township j

G_i: Production in township i

A_j: Attraction in township j

T_{ij}: Distance between township i and township j

Parameters α , β and γ are estimated by the method of least squares using the interim data of the study for the daily public transport trip rate which is presently being conducted by the Housing Department.

α = -5.34200

β = 1.02052

γ = -1.05908

(r = 0.85)

The estimated distribution volume for the peak and off-peak hours is modified using the Fratar Method on the basis of the estimated production-attraction, and then "the bus OD table between townships" is obtained.

Total OD Table is formulated by summing the three OD Tables, railways, buses and expresses. It is modified to be in accordance with the base data.

4-2-2 Forecast of Production-Attraction

(1) Present production-attraction by township

This is obtained from the present OD which is estimated in the section 4-2-1.

(2) Forecast production-attraction by township

This is determined by the following regression formula derived from the present number of passengers as mentioned in (1), the population and the number of employed in each township as of 1982.

This formula is as follows.

$$Y = 2.57456\ X_1 + 0.07887\ X_2 - 21.89728 \qquad (r = 0.97)$$

where, Y : No. of passengers (1,000 per day)

X_1 : the number of employed (1,000)

X_2 : population (1,000)

The forecast value for the future production-attraction for each township is obtained by substituting the forecast values for X_1 and X_2. *Assuming an annual population increase of 2%* for Rangoon City, the population of each township for 1990 is extrapolated from past trends of each. The number of employed for the year 1990 is forecast based on the interim projection provided by the Housing Department.

(3) Total demand forecast

The total demand for railways, buses and expresses is forecast in the two following stages since there was no time series data available for R.D.B.C.C. pick-ups.

a. First stage

A forecast using multiple regression analysis is first made for the total passengers for railways and buses (including the R.T.C. special bus service). This forecast is made by using the total passenger, population, the GDP, the per capita GDP and time trend data for the years between 1974 and 1982 (cf. Table 4.2.2). The results indicate that the correlation coefficient is largest when the passenger demand is determined by the population and the per capita GDP growth rate. The following formula is adopted.

$$Y = 3.26226X_1 + 20.04793X_2 - 376.65367 \qquad (r = 0.93)$$

where, Y : total number of passengers (1,000,000)

X_1 : population of Rangoon City (10,000)

X_2 : per capita GDP growth rate (%)

Substituting the forecast values for the population of Rangoon and the per capita GDP growth rate as described in Chapter 2, enables the future total passengers (excluding pick-ups) to be obtained.

Table 4.2.2 Data for Total Demand Forecast

	Unit	1974/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82	82/83
Passenger Carried Per Year In Rangoon City										
Railway	Million	22.8	21.7	10.8	11.8	20.5	23.3	27.9	30.4	31.7
R.T.C. Bus	Million	136.7	140.8	170.7	184.1	162.4	151.8	132.9	150.4	144.6
R.D.B.C.C. Bus	Million	136.6	169.8	220.3	245.7	274.4	303.6	312.7	289.5	299.9
Total	Million	296.1	332.3	401.8	441.6	457.3	478.7	473.5	470.3	476.2
Economic Indicators										
1 Population of Rangoon City	Thousand	2080	2117	2154	2193	2233	2275	2319	2364	2411
2 GDP	Million Kyats	11101	11562	12265	12996	13843	14562	15718	16716	17905
3 Per Capita GDP	Kyats	368	375	389	408	425	437	461	479	502
4 GDP Growth Rate	%	2.7	4.1	6.1	6	6.5	5.2	7.9	6.4	7.1
5 Per Capita GDP Growth Rate	%	0.5	1.9	3.7	4.9	4.2	2.0	5.5	3.9	4.7
6 LN* (Population of Rangoon City)		7.640	7.658	7.675	7.699	7.711	7.730	7.749	7.768	7.788
7 LN* (GDP)		9.315	9.355	9.415	9.472	9.536	9.586	9.663	9.724	9.793
8 LN* (Per Capita GDP)		5.908	5.927	5.964	6.011	6.052	6.080	6.133	6.172	6.219

Note: * means natural logarithm.
Source: C.S.O., B.R.C.

b. Second stage

The present number of passengers is known for the pick-ups and so the ratio between the pick-up passengers and the total passengers (excluding pick-up passengers) can be multiplied with the future total passengers (excluding pick-up passengers) to obtain the forecast value for the total passengers.

(4) Modification of production-attraction by township

The production-attraction for each township and forecast in (2) is modified to correspond to the total demand forecast in (3), since the data base for this study must be in compliance with the most authoritative statistics.

Since the railway OD table is based on the number of the tickets sold, season ticket passengers are included in this modification.

4-2-3 Forecast Future Distribution

The production-attraction volume forecast in the section 4-2-2 for each township, is distributed using the Fratar Method, to the future OD table on the basis of the present OD table estimated in the section 4-2-1.

4-2-4 Forecast of Modal Split

(1) Present share calculation for each mode

The share held by each mode for each zone pair is calculated using the resulting OD tables for each mode since the distribution volumes for each mode has already been estimated.

(2) Formulation of modal split model

Factors relevant in the preference of the transportation mode include the distance to be travelled, the time required, the cost, convenience, safety, degree of comfort and the dependability, etc. The gravity model is used to explain the share held by each of the modes as regards the time and cost.

$$S_{nij} = \frac{1}{T_{nij}{}^{\alpha} C_{nij}} \bigg/ \sum_{n=1}^{3} \left(\frac{1}{T_{nij}{}^{\alpha} C_{nij}}\right)$$

where, S_{nij}: share of mode "n" between zones i and j

T_{nij}: time of mode "n" between zones i and j (time: total of access time, waiting time, on-board time and transfer time)

C_{nij}: cost of mode "n" between zones i and j

α : Parameter

A value for α of 2.3 having the minimum error is adopted for use, after parameter α of the gravity model is estimated using the present shares for each traffic mode and the assumed preferential factors operating at present.

The present numerical values of these preferential factors are set for each zone pair based on the following definitions and calculation methods.

a. Time

(a) Access time

This is the time required to travel the distance between the starting point to the point of boarding, and from the point of alighting to the eventual destination.

- In the case of railways, this time is set at between 10 and 30 minutes on the basis of the field observations and interviews.
- In the case of buses and expresses, this time is set as 5 minutes, on the basis of the distribution of bus stops and from interviews.

(b) On-board time

This is the time required for the use of the traffic system between the objective stations (zones), and is calculated by dividing the distance between the zones by the speed of the mode itself. The distances for buses and expresses are estimated by setting the representative bus stops for each zone, and by measuring around the route maps. The present speeds for the modes are set as follows, using materials of B.R.C., R.T.C. and R.D.B.C.C.

B.R.C.	Circular Line	19.7 km/hour
	Suburban Line	23.3 km/hour
	Circular + Suburban	20.8 km/hour
Bus		19 km/hour
Express		23 km/hour

(c) Waiting time

This is the time spent waiting at the boarding point and is calculated as follows, with the psychological factor included.

$$W_n = (H_n / D_n) / 2$$

where, W_n: waiting time on n-mode

H_n: headway time of n-mode

This is calculated for each section and direction in the case of railways, and is supposed to be 5 minutes for both buses and expresses.

D_n: dependability rate of n-mode

This is estimated as 92% for railways on the basis of the recent rate for cancellations and delays of more than 30 minutes. The R.T.C. data for accidents caused during operation is used to obtain the estimate of 95% for buses and expresses.

(d) Transfer time

This is the time spent by passengers at the station when they are transferring either to or from the Circular and Suburban Lines.

b. Cost

The fares for each mode are taken as the costs. This is based on the table for fares between townships made by the station-township relation table in the case of railways.
In the case of buses, the fare is calculated by dividing the distance between townships by the unit distance fare. There is a uniform fare of one Kyat for the expresses.

The values set by the above definitions and methods are shown in Table 4.2.3 for the three main zones.

Table 4.2.3 Present Competitive Condition for Main Zone Pair

(Unit: Minute ( ); %)

	Insein - Kyauktada			N. Okkalapa - Kyauktada			Thingangyun - Kyauktada		
	Railway	Bus	Express	Railway	Bus	Express	Railway	Bus	Express
Access Time	20.0 (23.6)	10.0 (16.3)	10.0 (18.9)	25.0 (26.1)	10.0 (15.9)	10.0 (18.5)	20.0 (29.2)	10.0 (20.9)	10.0 (23.9)
On Board Time	44.2 (52.2)	48.9 (79.5)	40.4 (76.2)	46.6 (48.7)	50.1 (79.9)	41.4 (76.7)	22.2 (32.4)	35.3 (73.7)	29.2 (69.9)
Waiting Time	20.4 (24.1)	2.6 (4.2)	2.6 (4.9)	24.1 (25.2)	2.6 (4.1)	2.6 (4.8)	26.4 (38.5)	2.6 (5.4)	2.6 (6.2)
Transfer Time	0	0	0	0	0	0	0	0	0
Total Time	84.6 (100.0)	61.5 (100.0)	53.0 (100.0)	95.7 (100.0)	62.7 (100.0)	54.0 (100.0)	68.6 (100.0)	47.9 (100.0)	41.8 (100.0)
Fare (Pyas)	70	40	100	60	40	100	40	30	100

Source: Study estimates

(3) Forecast of traffic volume by mode

In the case of "With the Project", the future share for each mode is obtained by substituting the improved values of competitive factors into the model as follows. The conditions are not assumed to change for the buses and expresses which compete with the railways (A simulation with altered conditions will be performed later, as described in the section 4-3-4). The costs (fares) are not assumed to change for the railways, buses and expresses in future.

Table 4.2.4 Competitive Factor Improvements for the "With the Project" Case

		Present	Future with the Project (1990)
Scheduled Speed	Circular Line	19.7 km/hour	23.0 km/hour
	Suburban Line	23.3 km/hour	30.8 km/hour
	Circular + Suburban	20.8 km/hour	25.3 km/hour
Dependability		92%	95%
Headway Ratio		100	70

Source: Study estimates

Notes : 1. For the Circular Line between Rangoon and Insein, 90% of the scheduled speed is applied, because the distances between stations are relatively short.

2. The access time and the fares are not assumed to change.

The time of railway with the project set as above, is shown in Table 4.2.5 for the main zone pairs.

Table 4.2.5 Competitive Condition for Main Zone Pairs for the "With the Project" Case (1990)

	Insein - Kyauktada			N. Okkalapa - Kyauktada			Thingangyun - Kyauktada		
	Railway with the Project	Bus	Express	Railway with the Project	Bus	Express	Railway with the Project	Bus	Express
Access Time	20.0 (0)	10.0	10.0	25.0 (0)	10.0	10.0	20.0 (0)	10.0	10.0
On Board Time	41.7 (2.5)	48.9	40.4	39.9 (6.7)	50.1	41.4	19.0 (3.2)	35.3	29.2
Waiting Time	13.8 (6.6)	2.6	2.6	16.3 (7.8)	2.6	2.6	17.9 (8.5)	2.6	2.6
Total Time	75.5 (9.1)	61.5	53.0	81.2 (14.5)	62.7	54.0	56.9 (11.7)	47.9	41.8

Source: Study estimates
Note: ( ): improvement from the present

In the case of "Without the Project", the present shares of traffic are left unchanged, on the assumption that the present competitive factors are constant.

Road congestion, arising from an increase in the number of vehicles including private cars, will effect on the competitive factor. This effect is not however taken into account because its difference between "With the Project" and "Without the Project" would be small and because its long-term projection is quite difficult and may bias the justifiable demand forecast.

Here, the future OD table is forecast for each mode by multiplying the estimated future share with the future total OD.

(4) Long-term forecast within project life

The total demand is forecast to increase over the full 30 years. Train diagram improvements with the train headway ratio set at 60% for the year 2000, and 50% for the year 2010, are planned to correspond to the increasing railway share. It is assumed that the operation conditions for buses and expresses will not change.

In the case of "Without the Project", the present share of traffic will be left unchanged for the 30 years.

4-3 Results of Demand Forecast

4-3-1 Total Demand Forecast

The forecast results are shown in Table 4.3.1. As can be seen from the table, the daily number of passengers in 1990 is 2,179 thousand, which is 1.36 times the 1982 level, and represents a 4% annual increase. Since it is assumed that the population will increase by 2%, this 4% increase consists of the 2% population increase as well as a 2% increase in the daily public transport trip rate resulting from the economic growth induced. (The daily public transport trip rate for 1982 and 1990 are 0.66 and 0.78 respectively).

When compared to the average growth rate of 6.1% (cf. Table 4.2.2) for the demand from 1974 to 1982, the estimated value of 4% can be said to be a conservative estimate.

Table 4.3.1 Total Passenger Volume Forecast

	Population (10,000)	GDP/Capita Growth Rate (%)	Passengers Per Year (1,000,000)	Passengers Per Year incl. Pick-up (1,000,000)	Passengers Per Day incl. Pick-up (1,000)	Passengers incl. Pick-up Index	Passengers incl. Pick-up Growth Rate
1982	241.1	4.7	476.2	582.9	1,597	1.00	
1983	245.9	3.5	495.9	607.0	1,663	1.04	4.1%
1984	250.9	3.5	512.0	626.7	1,717	1.08	3.3%
1985	255.9	3.5	528.4	646.8	1,772	1.11	3.2%
1986	261.1	4.6	567.3	694.4	1,902	1.19	7.3%
1987	266.3	4.6	584.4	715.3	1,960	1.23	3.0%
1988	271.7	4.6	601.8	736.7	2,018	1.26	3.0%
1989	277.1	4.6	619.7	758.5	2,078	1.30	3.0%
1990	282.7	5.2	649.9	795.5	2,179	1.36	4.9%
1991	288.4	5.2	668.4	818.2	2,242	1.40	2.9%
1992	294.2	5.2	687.3	841.3	2,305	1.44	2.8%
1993	300.1	5.2	706.6	864.9	2,370	1.48	2.8%
1994	306.1	5.2	726.3	889.0	2,436	1.53	2.8%
1995	312.3	5.2	746.4	913.6	2,503	1.57	2.8%
1996	318.6	5.2	766.8	938.7	2,572	1.61	2.7%
1997	325.0	5.2	787.7	964.2	2,642	1.65	2.7%
1998	331.5	5.2	809.0	990.3	2,713	1.70	2.7%
1999	338.2	5.2	830.8	1,016.9	2,786	1.74	2.7%
2000	345.0	5.2	852.9	1,044.1	2,860	1.79	2.7%
2001	351.9	5.2	875.6	1,071.7	2,936	1.84	2.7%
2002	359.0	5.2	898.6	1,100.0	3,014	1.89	2.6%
2003	366.2	5.2	922.2	1,128.8	3,093	1.94	2.6%
2004	373.5	5.2	946.2	1,158.2	3,173	1.99	2.6%
2005	381.0	5.2	970.7	1,188.2	3,255	2.04	2.6%
2006	388.7	5.2	995.7	1,218.8	3,339	2.09	2.6%
2007	396.5	5.2	1,021.1	1,250.0	3,425	2.14	2.6%
2008	404.5	5.2	1,047.1	1,281.8	3,512	2.20	2.5%
2009	412.6	5.2	1,073.7	1,314.2	3,601	2.25	2.5%
2010	420.9	5.2	1,100.7	1,347.4	3,691	2.31	2.5%
2011	429.4	5.2	1,128.3	1,381.1	3,784	2.37	2.5%
2012	438.0	5.2	1,156.5	1,415.6	3,878	2.43	2.5%
2013	446.8	5.2	1,185.2	1,450.8	3,975	2.49	2.5%
2014	455.8	5.2	1,214.5	1,486.6	4,073	2.55	2.5%
2015	465.0	5.2	1,244.4	1,523.2	4,173	2.61	2.5%
2016	474.3	5.2	1,274.9	1,560.5	4,275	2.68	2.5%
2017	483.8	5.2	1,306.0	1,598.6	4,380	2.74	2.4%
2018	493.6	5.2	1,337.7	1,637.4	4,486	2.81	2.4%
2019	503.5	5.2	1,370.1	1,677.0	4,595	2.88	2.4%
2020	513.6	5.2	1,403.1	1,717.5	4,705	2.95	2.4%

Source: Study estimates

4-3-2 Forecast of Total OD Table

The forecast results are shown in Table 4.3.2. The 1990 production-attraction is extracted from the OD table and compared with the present values shown in Table 4.3.3. It can be seen in the table that the relative importance of the CBD has decreased while that for the areas of Kamayut, Hlaing, Insein and North Okkalapa has increased. This is because the forecast is performed with consideration given to the effect of the policy of decentralizing both population and urban functions into these presently suburban areas.

Table 4.3.2 Future Total OD Table between Townships (1990)

(Unit: Person)

		1. PZG	2. BTTG	3. KYKT	4. PBD	5. LTH	6. LAW	7. SEKN	8. DGN	9. ALN	10. KMDN	11. SNCG	12. KYT	13. HLNG	14. ISN
1.	Pazundaung	743	338	337	294	192	146	7	1278	2451	928	1757	3033	2139	3583
2.	Botataung	347	6462	1352	1232	685	622	129	2237	6936	5452	1811	4098	971	1394
3.	Kyauktada	357	1341	10468	6450	2279	1329	152	8607	6069	1847	2755	6328	5651	8142
4.	Pabedan	310	1223	6401	10656	6199	2749	346	10790	8051	4065	3365	8281	8982	11412
5.	Latha	188	691	2291	6239	5635	5415	271	8999	7466	2456	2942	7058	7024	9665
6.	Lanmadaw	145	634	1347	2786	5439	4968	150	4610	6498	2710	2016	4523	5223	7024
7.	Seikkan	7	130	154	349	270	148	68	440	676	279	100	360	328	410
8.	Dagon	1304	2279	8828	10989	9083	4629	447	15791	238	67	1101	1604	2320	1598
9.	Ahlone	2550	7062	6253	8265	7689	6723	694	249	10726	1204	278	594	2509	2014
10.	Kemmendine	997	5661	1899	4187	2520	2775	288	35	1179	8583	2268	2634	1517	1116
11.	Sanchaung	1874	1907	2864	3490	3041	2073	104	1082	245	2300	8665	3373	2028	1662
12.	Kamayut	3175	4274	6395	8331	7142	4581	365	1588	555	2591	3277	48770	11611	6866
13.	Hlaing	2061	941	5552	8963	6832	5197	314	2625	2852	2040	2612	12121	43487	18458
14.	Insein	3659	1372	8069	10511	9569	7008	405	1549	1770	1069	1599	6770	19425	67682
15.	Mingaladon	255	41	1604	2810	2266	1168	112	272	212	72	152	298	860	2331
16.	N. Okkalapa	590	267	10470	12380	10133	5275	496	467	322	57	124	248	461	2763
17.	Mayangon	1541	941	12136	14593	12448	7178	560	1566	1832	476	916	3705	6774	8503
18.	S. Okkalapa	291	2301	11412	10092	5628	4312	187	292	114	18	25	26	92	398
19.	Yankin	83	320	3869	3559	2527	1370	80	163	82	7	10	334	585	668
20.	Thingangyun	2809	9825	12133	12189	9601	5962	1328	469	561	102	175	90	335	311
21.	Tamwe	558	4775	8251	6512	5086	4173	385	164	178	426	634	1487	1527	1533
22.	Bahan	729	3135	7081	6846	4851	1780	220	626	162	1205	2151	2533	1379	1270
23.	Mingalataung	2975	10644	17366	14409	10430	8865	934	364	270	742	1003	1875	1138	861
24.	Dawbon	1134	1148	2536	2298	2047	3103	218	6	61	17	4	15	80	60
25.	Thaketa	4934	5834	14102	14349	10732	17095	1240	0	176	89	0	0	0	0
26.	Dallah	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.	Seikkyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.	Hlegu	6	3	25	24	1	0	0	0	0	0	0	0	0	0
	TOTAL	33622	73549	163191	182803	142324	108644	9501	64271	59681	38803	39739	120159	126448	159726

Table 4.3.2 - continued

(Unit: Person)

	15. MGDN	16. N.OK	17. MYGN	18. S.OK	19. YKN	20. THNG	21. TMWE	22. BAHN	23. MGTG	24. DWBN	25. TKT	26. DALA	27. SKY	28. HLGU	Total
1. Pazundaung	269	852	1544	307	101	2872	554	681	3180	1131	4897	0	0	9	33622
2. Botataung	49	251	932	2334	323	9901	4821	3147	11039	1160	5860	0	0	3	73549
3. Kyauktada	1662	10098	12025	11479	3897	12806	8278	7054	17512	2545	14037	0	0	22	163191
4. Pabedan	2967	11953	14422	10171	3585	12459	6524	6822	14466	2306	14277	0	0	21	182802
5. Latha	2299	9940	12574	5726	2568	9508	5136	4861	10537	2066	10769	0	0	1	142324
6. Lanmadaw	1181	5206	7175	4409	1399	5879	4225	1785	8975	3140	17199	0	0	0	108643
7. Seikkan	113	486	567	191	82	1325	389	221	944	220	1244	0	0	0	9501
8. Dagon	290	530	1316	319	177	201	157	643	356	4	0	0	0	0	64271
9. Ahlone	113	310	1157	119	89	239	163	168	266	64	183	0	0	0	59681
10. Kemmendine	61	50	513	11	5	29	427	1224	714	18	93	0	0	0	38803
11. Sanchaung	143	120	862	17	8	40	652	2206	978	5	0	0	0	0	39739
12. Kamayut	275	226	3955	22	342	71	1473	2522	1738	15	0	0	0	0	120159
13. Hlaing	833	505	5978	126	570	300	1564	1325	1121	70	0	0	0	0	126448
14. Insein	1970	2591	9529	375	664	333	1545	1259	918	85	0	0	0	1	159726
15. Mingaladon	34257	4800	1762	655	302	507	563	0	407	70	0	0	0	0	55776
16. N. Okkalapa	4627	51569	3870	962	689	639	1205	396	729	117	0	0	0	0	108855
17. Mayangon	1522	3690	41487	390	639	348	910	820	707	72	0	0	0	0	123754
18. S. Okkalapa	1040	1072	492	27342	1592	1478	1133	768	1279	28	0	0	0	0	71409
19. Yankin	407	783	677	1601	2373	69	544	635	463	10	0	0	0	0	21218
20. Thingangyun	585	837	433	1510	74	34608	1814	98	2529	235	0	0	0	216	98829
21. Tamwe	601	1434	925	1183	583	1795	14114	2396	5644	23	0	0	0	8	64394
22. Bahan	0	393	834	795	650	100	2403	22870	2630	0	0	0	0	0	64641
23. Mingalataung	439	963	651	1333	491	2862	5771	2742	45205	238	525	0	0	18	133112
24. Dawbon	74	197	76	33	15	247	23	0	236	881	944	0	0	2	15454
25. Thaketa	0	0	0	0	0	0	0	0	527	949	29158	0	0	0	99185
26. Dallah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27. Seikkyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28. Hlegu	0	0	0	0	0	214	8	0	16	1	0	0	0	0	300
TOTAL	55775	108855	123754	71409	21218	98830	64394	64642	133112	15454	99185	0	0	300	2179390

Source: Study estimates

Table 4.3.3 Production-Attraction Forecast

(Unit: Person)

		P/A : 1982 Per Day		P/A : 1990 Per Day		1990-1982 (%)
1	Pazundaung	30,416	1.9%	33,622	1.5%	-0.4%
2	Botataung	67,789	4.2%	73,549	3.4%	-0.9%
3	Kyauktada	150,048	9.4%	163,191	7.5%	-1.9%
4	Pabedan	167,238	10.5%	182,802	8.4%	-2.1%
5	Latha	131,720	8.2%	142,324	6.5%	-1.7%
6	Lanmadaw	99,377	6.2%	108,643	5.0%	-1.2%
7	Seikkan	8,975	0.6%	9,501	0.4%	-0.1%
	1-7 TOTAL	655,563	41.1%	713,632	32.7%	-8.3%
8	Dagon	40,391	2.5%	64,271	2.9%	0.4%
9	Ahlone	37,020	2.3%	59,681	2.7%	0.4%
10	Kemmendine	54,909	3.4%	38,803	1.8%	-1.7%
11	Sanchaung	41,365	2.6%	39,739	1.8%	-0.8%
12	Kamayut	45,141	2.8%	120,159	5.5%	2.7%
13	Hlaing	35,976	2.3%	126,448	5.8%	3.5%
14	Insein	38,143	2.4%	159,726	7.3%	4.9%
15	Mingaladon	26,845	1.7%	55,776	2.6%	0.9%
16	N. Okkalapa	50,356	3.2%	108,855	5.0%	1.8%
17	Mayangon	33,440	2.1%	123,754	5.7%	3.6%
18	S. Okkalapa	89,657	5.6%	71,409	3.3%	-2.3%
19	Yankin	53,491	3.3%	21,218	1.0%	-2.4%
20	Thingangyun	50,885	3.2%	98,829	4.5%	1.3%
21	Tamwe	93,275	5.8%	64,394	3.0%	-2.9%
22	Bahan	86,381	5.4%	64,641	3.0%	-2.4%
23	Mingala T.N.	97,579	6.1%	133,112	6.1%	0.0%
24	Dawbon	8,982	0.6%	15,454	0.7%	0.1%
25	Thaketa	57,383	3.6%	99,185	4.6%	1.0%
26	Dallah	0	0.0%	0	0.0%	0.0%
27	Seikkyi	0	0.0%	0	0.0%	0.0%
28	Hlegu	199	0.0%	300	0.0%	0.0%
	TOTAL	1,596,980	100.0%	2,179,390	100.0%	0.0%

Source: Study estimates

4-3-3 Forecast of Railway Demand

(1) Demand forecast by mode for the "With the Project and "Without the Project" cases

The forecast results are as shown in Table 4.3.4. In the case of "With the Project", the railway demand is 233 thousand passengers per day in 1990, representing 2.7 times the 1982 passenger number, and a doubled share of 10.7%.

In the "Without the project" case, the railway demand is 118 thousand passengers per day in 1990 (1.4 times the present).

The difference between the "With" and "Without" cases amounts to 116 thousand passengers in 1990.

This difference is the demand which is diverted from buses and expresses. Although the size of this demand is nearly the same as the size of the railway demand without the project it only represents 5.6% of the total demand of buses and expresses.

After electrification, diagram improvements will be made in 2000 and 2010 and so the railway demand for the "With" case will be 323 thousand passengers per day in 2000, 436 thousand in 2010 and 555 thousand in 2020.

The estimation for the demand volume for the "Without" case is made on the assumption that the share after 1990 will not change.

Table 4.3.4 Demand Forecast by Mode for the "With the Project" and "Without the Project" Cases

	1982	1990	2000	2010	2020
Population (10,000)	241.1	282.7	345.0	420.9	513.6
GDP/Capita (Real Terms) Growth Rate (%)	4.7	5.2	5.2	5.2	5.2
Passenger Volume/Year (1,000,000)	582.9	795.5	1,044.1	1,347.4	1,717.5
Passenger Volume/Day (1,000)	1,597	2,179	2,860	3,691	4,705
Index/1982	1.000	1.365	1.791	2.311	2.946
(WITH CASE)					
Railway (%)	5.4	10.7	11.3	11.8	11.8
Bus (%)	72.7	68.6	68.2	67.8	67.8
Express (%)	21.8	20.7	20.5	20.4	20.4
Railway (/Day:1,000)	86	233	323	436	555
Bus (/Day:1,000)	1,161	1,495	1,951	2,503	3,190
Express (/Day:1,000)	348	451	586	753	960
Index:Railway (/1982)	1.000	2.704	3.748	5.051	6.438
(WITHOUT CASE)					
Railway (%)	5.4	5.4	5.4	5.4	5.4
Bus (%)	72.7	72.7	72.7	72.7	72.7
Express (%)	21.8	21.8	21.8	21.8	21.8
Railway (/Day:1,000)	86	118	154	199	254
Bus (/Day:1,000)	1,161	1,584	2,080	2,684	3,421
Express (/Day:1,000)	348	475	624	805	1,026
Index:Railway (/1982)	1.000	1.365	1.791	2.311	2.946
Difference:With-Without Railway (/Day:1,000)		115	169	237	301

Source: Study estimates

(2) Cross section volume between stations for "With the Project" case

Table 4.3.5 shows the forecast results of the sections for which the maximum cross section volumes are recorded. The section from Kamayut to Hletan shows the highest traffic volume for all sections along the Circular and Suburban Lines, and is expected to expand to up to 4,145 passengers/hour in 1990.

Table 4.3.5 Forecasted Cross Section Volumes between Stations of Maximum Traffic Volume for the "With the Project" Case (in morning peak hours)

(Unit: Person per hour)

Section	1982	1990	2000	2010	2020
Circular Line West Side Kamayut → Hletan	1,533	4,145	5,746	7,743	9,869
Circular Line East Side Kanbe → Bauktaw	1,003	2,712	3,759	5,066	6,457
Suburban Line Hninzigon → Mahlwagon	865	2,339	3,243	4,369	5,569

Source: Study estimates

(3) Future railway OD

The future railway OD table between townships is shown in Table 4.3.8. for the "With the Project" case. The following compares the present and forecast values of the production volume by the main townships.

Table 4.3.6 Future Production

(Unit: Person per day)

	Present (1982)	Future (1990) with the project	Future/ Present
CBD	16,111	25,207	1.6
Kamayut	2,698	10,363	3.8
Insein	8,943	46,316	5.2
Mingaladon	6,567	14,957	2.3
North Okkalapa	7,546	18,325	2.4
South Okkalapa	3,041	4,180	1.4
Thingangyun	7,292	17,212	2.4
Total (incl. others)	86,849	233,838	2.7

Source: Study estimates

Of these townships, the townships of Insein and Kamayut show a high increase while the CBD and South Okkalapa show an increase which is lower than the overall increase.

The forecast and present values of the share (the share for each originating zone) of the railways are then compared.

Each township has a forecasted share which is higher than its present one, but there are big differences (from 6.3% to 0.3%) between townships.

Table 4.3.7 <u>Changes in the Railway Share of the Main Townships</u>

Originating Township	Present	Future (1990) with the project	Future/Present
CBD	2.5	3.5	+1.0
Kamayut	6.0	8.6	+2.6
Insein	23.4	29.0	+5.6
Mingaladon	24.5	26.8	+2.3
North Okkalapa	15.0	16.8	+1.8
South Okkalapa	3.4	5.9	+2.5
Thingangyun	14.3	17.4	+3.1

Source: Study estimates

Table 4.3.8 Railway OD Table between Townships (1990)

(Unit: Person)

	1. PZG	2. BTTG	3. KYKT	4. PBD	5. LTH	6. LAW	7. SEKN	8. DGN	9. ALN	10. KMDN	11. SNCG	12. KYT	13. HLNG	14. ISN
1. Pazundaung	9	7	58	71	15	9	0	26	35	18	16	59	301	220
2. Botataung	9	0	0	7	2	2	0	7	12	7	7	22	101	74
3. Kyauktada	78	0	1	56	18	16	0	60	100	55	64	190	850	627
4. Pabedan	84	1	10	64	45	42	0	138	197	110	113	560	2359	2069
5. Latha	9	1	9	20	5	5	0	19	38	23	27	106	627	313
6. Lanmadaw	5	2	15	37	7	3	0	15	28	20	25	68	375	185
7. Seikkan	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8. Dagon	16	5	41	92	25	17	0	57	72	67	75	285	1454	948
9. Ahlone	35	7	59	114	43	35	0	82	59	119	103	506	2509	2014
10. Kemmendine	20	4	33	72	13	10	0	35	63	32	34	208	1517	1116
11. Sanchaung	20	5	44	81	14	11	0	40	66	44	35	256	1615	1395
12. Kamayut	53	15	128	437	105	81	0	291	468	229	272	652	3656	2261
13. Hlaing	270	106	899	2531	685	550	0	1819	2852	2040	2232	4588	6724	10259
14. Insein	286	67	576	1161	317	258	0	923	1770	1069	1344	2260	10932	11998
15. Mingaladon	255	41	318	458	62	41	0	137	212	72	105	133	651	2217
16. N. Okkalapa	434	70	609	804	96	52	0	162	195	57	81	103	314	2763
17. Mayangon	286	76	669	1049	187	237	0	769	1567	476	628	1085	3149	5949
18. S. Okkalapa	108	11	93	134	18	12	0	39	57	18	25	26	92	398
19. Yankin	38	6	46	69	10	6	0	20	24	7	10	12	61	165
20. Thingangyun	1039	190	1588	2263	278	159	0	437	527	102	175	90	335	311
21. Tamwe	94	24	196	263	41	27	0	96	132	28	29	79	230	271
22. Bahan	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23. Mingalataung	43	9	78	119	24	15	0	55	72	43	42	143	695	535
24. Dawbon	1	2	16	19	4	2	0	6	8	4	4	15	80	60
25. Thaketa	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26. Dallah	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27. Seikkyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28. Hlegu	6	3	25	24	1	0	0	0	0	0	0	0	0	0
TOTAL	3201	652	5512	9945	2016	1592	0	5233	8554	4643	5445	11448	38627	46148

Table 4.3.8 - continued

(Unit: Person)

		15. MGDN	16. N.OK	17. MYGN	18. S.OK	19. YKN	20. THNG	21. TMWE	22. BAHN	23. MGTG	24. DWBN	25. TKT	26. DALA	27. SKY	28. HLGU	Total
1.	Pazundaung	269	699	284	124	55	1185	90	0	38	2	0	0	0	9	3600
2.	Botataung	49	57	55	11	5	316	23	0	11	3	0	0	0	3	784
3.	Kyauktada	367	495	484	94	43	2636	187	0	93	22	0	0	0	22	6559
4.	Pabedan	610	696	799	131	69	2750	252	0	110	24	0	0	0	21	11255
5.	Latha	81	113	161	19	12	198	35	0	14	2	0	0	0	1	1841
6.	Lanmadaw	47	85	129	16	9	61	23	0	11	1	0	0	0	0	1168
7.	Seikkan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.	Dagon	142	218	462	46	26	167	85	0	36	4	0	0	0	0	4341
9.	Ahlone	113	178	871	58	27	204	113	0	57	9	0	0	0	0	7315
10.	Kemmendine	61	50	513	11	5	29	19	0	35	5	0	0	0	0	3885
11.	Sanchaung	93	75	549	17	8	40	28	0	39	5	0	0	0	0	4481
12.	Kamayut	105	83	1247	22	10	71	53	0	109	15	0	0	0	0	10363
13.	Hlaing	634	369	2380	126	58	300	306	0	686	70	0	0	0	0	40485
14.	Insein	1861	2591	7087	375	155	333	278	0	590	85	0	0	0	1	46316
15.	Mingaladon	1391	4800	1559	655	302	507	563	0	407	70	0	0	0	0	14957
16.	N. Okkalapa	4627	2168	1708	962	440	639	1205	0	720	117	0	0	0	0	18325
17.	Mayangon	1316	1574	690	390	197	348	534	0	563	72	0	0	0	0	21811
18.	S. Okkalapa	1040	1072	492	19	37	138	178	0	147	28	0	0	0	0	4180
19.	Yankin	407	538	233	37	18	35	63	0	57	10	0	0	0	0	1871
20.	Thingangyun	585	837	433	141	39	4633	983	0	1617	235	0	0	0	216	17212
21.	Tamwe	601	1434	544	208	96	967	145	0	165	23	0	0	0	8	5700
22.	Bahan	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23.	Mingalataung	439	954	504	165	75	1917	158	0	78	10	0	0	0	18	6192
24.	Dawbon	74	197	76	33	15	247	23	0	8	0	0	0	0	2	898
25.	Thaketa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.	Dallah	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.	Seikkyi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.	Hlegu	0	0	0	0	0	214	8	0	16	1	0	0	0	0	300
	TOTAL	14912	19283	21262	3661	1701	17934	5350	0	5607	814	0	0	0	300	233838

Source: Study estimates

4-3-4 Sensitivity Analysis of Competitive Factors

The sensitivity analysis is performed using the modal split model developed for this study. The simulation results of the factors and comments on their improvement are described in the following (cf. Table 4.3.9).

(1) Frequency

The average headway in major sections is 35 minutes and will be reduced to 25 minutes (70%). If the headway is reduced by a further 10% (22 minutes), or 20% (17 minutes), then the anticipated share increases are 0.6% and 1.1% respectively.

In order to improve the frequency, increase of number of rolling stock, suitable considerations on the diagram, and improvement of signal system for headway of more than 7.5 minutes, are required.

(2) Speed

A 10% increase in the standard speed to 25.3 km/hour along the Circular Line will raise the share by 0.3%. A speed increase of 20% (27.6 km/hour) will raise the share by 0.6%.

These speed increases will require improvements to the track, reconsideration (reduction of the number) of stations and upgrading of the train performance. Raising the speed thus poses to be more difficult than improving the other factors.

From a different point of view, a 10% speed reduction in the buses and expresses will result in a 0.7% raised share for the railways. This might possibly be what the future holds once the increasing severity of traffic congestion is taken into account.

(3) Dependability

A 0.1% increase in the share can be expected if the dependability is raised by only 2%. However, a decrease in the dependability from 95% to 80% will bring about a 0.6% decrease in the share.

The railway should maintain its dependability to at least as high as that of other modes if it is to secure a reasonable share of the urban transportation system.

(4) Access time

A 10% reduction in the access time will result in a share increased by 0.6%, while a 20% reduction will increase the share by 1.1%.

As one step towards achieving this, the access time for intending passengers could be improved through the rearrangement of approach roads and station fronts could be arranged in the manner which is being practised in North Okkalapa and South Okkalapa, etc.

(5) Overall comments

It would appear more effective to improve the frequency of trains rather than increase their speed, when the results of simulation are viewed as cost performance. The reduction in the access time is seen as one of the less expensive measures which can be taken to increase the share of the railways. Reorganization of the bus network connected with the main railway stations is one of useful improvements for the reduction in the access time. This will not only increase the railway share but will also benefit road transportation.

Table 4.3.9 Conditions and Results of Simulation

(Unit: %)

CASE \ FACTOR	Frequency (Headway)		Speed		Dependability		Access Time		Railway Passenger Demand in 1990	
UNIT	Future/present		Future/present		Punctuality/total		Future/present		1,000/day	Share
MODE	Rail	Bus & Express	Rail	Bus & Express	Rail	Bus & Express	Rail	Bus & Express	Rail	Rail
Base Case	70	100	117	100	95	95	100	100	233.2	10.7
Headway 5% reduce	65								239.7	11.0
Headway 10% reduce	60								246.3	11.3
Headway 20% reduce	50								257.2	11.8
Headway 5% increase	75								228.8	10.5
Speed more 10% up			128						239.7	11.0
Speed more 20% up			140						246.3	11.3
Bus, Express Speed 10% down				90					248.5	11.4
Dependability 2% up					97				235.4	10.8
Dependability 15% down					80				220.1	10.1
Access Time 10% reduce							90		246.3	11.3
Access Time 20% reduce							80		257.2	11.8

Source: Study estimates

4-3-5 Comments on Results

The results of the demand forecast show that electrification will bring diversion of the passengers to the railway, equivalent to 1.97 times the number of passengers for the "Without the Project" case in 1990. This number is estimated to be 233 thousand persons (2.7 times the present) in 1990 and 555 thousand persons (6.4 times the present) in 2020.

The following evidence indicates that this forecast is a rather conservative one.

(1) Existence of dramatic diversion accompanying electrification

There are some cases in which electrification dramatically diverted passengers to railways. In the case of the Kansai Line which is one of JNR commuter lines connecting Osaka with Nara, the electrification in 1973 brought 2.3 times as many passengers as the previous year to this line at the peak hour. The major reasons are that JNR had provided frequent services by combination of normal and express operations and that competitive lines and modes were over their capacities. The conditions as such are quite similar to those of the Circular and Suburban Lines.

(2) Higher share of a railway in a city with the railway line

In 1982, the railway lines had the share of about 72% in Tokyo, and 67% in Osaka. In comparison with these figures, the railway share is extremely low in Rangoon, as a city which has railway lines connecting the CBD with the suburbs.

(3) No consideration for worsening the level of bus and express services

In the modal split estimation, the competitive factors of the other modes are assumed to be constant, however, riding time on the buses and expresses will surely become longer than the time assumed, because of worsening road congestion. As shown in section 4-3-4 (Sensitivity Analysis of Competitive Factors), speed reduction in the buses and expresses will divert a considerable number of passengers to the railway.

CHAPTER 5 PRESENT STATUS OF ROLLING STOCK AND FACILITIES

CHAPTER 5 PRESENT STATUS OF ROLLING STOCK AND FACILITIES

5-1 Rolling Stock

5-1-1 Current Status

The rolling stock currently in use on the Circular and Suburban Lines are diesel electric locomotive and carriages, and all fall within the maximum moving dimensions of B.R.C. for rolling stock (cf. section 8-1-4).

Table 5.1.1 shows the rolling stock currently used.

Table 5.1.1 Existing Rolling Stock of B.R.C.

(March 1984)

Description	Age in years			Total	Remarks
	Under 10 years	10 to 20 years	Over 20 years		
Diesel Locomotives					
D.E.L.	58	36	32	126	
D.H.L.	21	44	28	93	
Total	79	80	60	219	
Steam Locomotives			141	141	All over 30 years
Carriages	134	382	817	1,333	
Wagons	111	1,285	7,587	8,983	Bogie: 2,117 4-wheeler: 6,866

Source: B.R.C.

5-1-2 Overview of Diesel Electric Locomotives

Thirteen diesel electric locomotives are presently assigned to the Circular and Suburban Lines. These locomotives are relatively new, being generally not older than ten years. Their brake systems are adaptable to both air and vacuum brake operation as the carriages which they haul are equipped with either air or vacuum brakes.

The major specifications of the locomotives currently in use are as follows:

Type : 900 HP diesel electric locomotive
Model of locomotive : Single hood monocab type
Axle arrangement : Bo-Bo
Weight in working order : 48 long tons
Maximum service speed : 88.5 km/hour
Maximum tractive effort : 12,500 kg
Continuous rating tractive effort : 8,640 kg
Maximum length : 11,534 mm
Maximum width : 2,820 mm
Maximum height : 3,502 mm
Bogie centre distance : 5,850 mm
Bogie wheel base : 2,200 mm
Driving wheel diameter : 1,000 mm
Diesel engine : MGO-V12 ASHR, 885 HP/1,500 rpm
Main generator : Alsthom GP 830 H
Traction motor : Alsthom TA 641, 160 kw × 4 units
Gear ratio : 16:77 = 1:4.8
Brake system : Air brake and vacuum brake (changeover possible)

5-1-3 Overview of Carriages

The carriages now in use include 54 reconstructed diesel railcars and 30 others made of either steel or wood, making total of 84 carriages. They are all with two-axle bogies and, except for certain steel carriages, are all fairly deteriorated.

(1) Carriage age

Table 5.1.2 shows the length of operation of the carriages in current use.

Table 5.1.2 Existing Rolling Stock of the Circular and Suburban Lines

Description	Total	Age in year		
		Under 10 years	10 to 20 years	Over 20 years
Reconstructed Diesel Railcar	54			54
General Steel	14	9	5	
General Wood	16		14	2
Total	84	9	19	56

Source: B.R.C.

The reconstructed carriages have been rebuilt from diesel railcars of lightweight construction and now show signs of corrosion of the steel surface, particularly under the floor, and their interiors now appear old and worn.

(2) Major specifications

The carriages now in operation are built of either steel or wood, and can be broadly classified into about ten different models. Table 5.1.3 shows the major specifications of the typical models.

Table 5.1.3 Major Specification of Typical Carriages

Type	LBTX (RC)	BDTX (PP)	LBTX
Tare weight (ton)	22.5	20.5	23.2
Seating capacity (person)	94	59	62
Outside length of car body (mm)	approx. 18,300	approx. 17,680	approx. 18,300
Outside width of car body (mm)	approx. 2,820	approx. 2,590	approx. 2,820
Maximum height (mm)	approx. 3,405	approx. 3,405	approx. 3,405
Side entrance	2 on one side	3 on one side	3 on one side
Brake system	air	vacuum	vacuum
Body structure	steel	steel	wood
Remarks	Reconstructed diesel railcars	Wooden body remodeled with steel	

Source: B.R.C.

(a) Reconstructed diesel railcars have air brake systems while the remainder of the carriages have vacuum brake systems.

(b) Some carriages have two doors on each side of the carriage, while others have three. Reconstructed diesel railcars have two 1,100 mm entrances per side, while the others have three entrances, with the middle one ranging from about 1,100 to 1,300 mm in width, and wider than the doors at the ends.

(c) The term "nominal riding capacity" designates total number of seats, which are arranged in five columns, two on one side and three on the other.

5-2 Track

The standards for track are as follows.

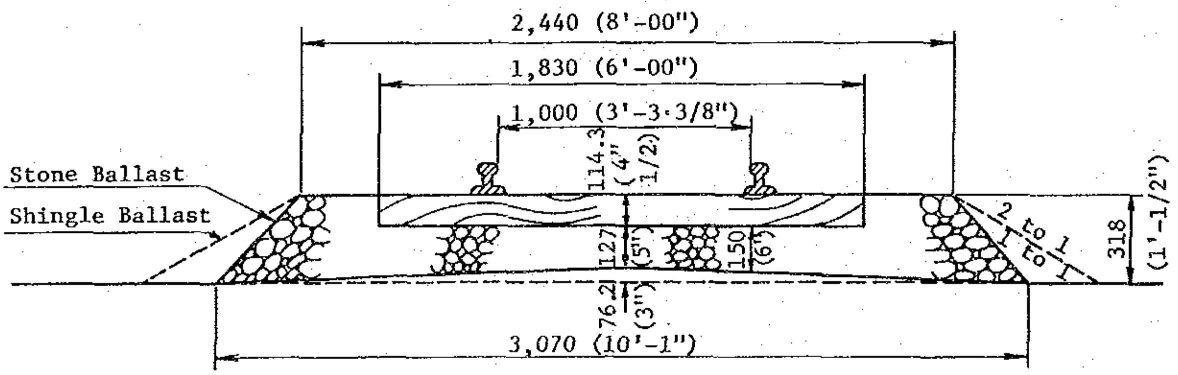
Crushed stone ballast	: Thickness 150 mm, width across top 2,440 mm, width across bottom 3,070 mm
Sleeper	: Length 1,830 mm, thickness 114 mm, width 203 mm Spacing 790 mm (Circular line) or 740 mm (Suburban line)
Rail	: Weight 37 kg/metre (75 lb/yd), length 11,890 mm per unit
Joint	: Suspended joint
Fastening	: Track spikes, elastic spikes
Anti-creeping	: Anti-creeper

Reinforced concrete ties and long rails (of six common rail length) are used, but this is done only as a trial and is limited to a very small part of the entire B.R.C. railway network.

Fig. 5.2.1 illustrates the track structure employed.

The present states of track maintenance requires that the ballast be filled with more crushed stone and that the sleepers should be adjusted to the correct spacing.

(Unit: mm, ( ); inch)



Stone Ballast 0.706 Cubic Metre per Metre Run } Allowing for Sleeper
Shingle Ballast 0.761 Cubic Metre per Metre Run

Fig. 5.2.1 Standard Ballast Section

Source: B.R.C.

The track profile of the Circular and Suburban Lines is shown in Appendix 1. The track is laid on surface of gentle grade up to a maximum slope of 5‰. The minimum radius of curvature is 291 metres (six degrees).

There are a total of 35 level crossings but only half have crossing gates, and are paved.

The Circular and Suburban Lines intersect at a point between Rangoon and Pazundaung, where #6 diamond crossing with #8.5 and #12 turnouts are installed. However, this site of the rail line crossing is built to reduce the rail line routes from the normal six to four, which poses speed restrictions.

5-3 Structure

5-3-1 Roadbed

Banks are generally slightly raised, and long years of service have left them firm enough to resist the seasonal heavy rains.

The stretch between Rangoon and Kemmendine stations has a continuous cut. This section is the only one in the entire network that is provided with a side ditch. However, a provision of this ditch is not sufficient to prevent occasional track inundations because of the rather limited drain of the ditch and the poor divergence of discharged flood water at the ditch ends. Damage is often reported as a result of heavy rainfalls in the vicinity of Rangoon station, Mission Road station and Mahlwagon station.

B.R.C. generally possesses a sufficiently large area of railway territory to provide for subsequent extensions to platforms and for track additions.

Fig. 5.3.1 shows the railway diagram.

5-3-2 Railway Bridges

There are a great number of pipe culverts and railway bridges of either I-beam, deck plate girder, prestressed concrete beam or truss structures. All except the truss bridges they have standard short spans.

Girders are mounted on brick masonry piers.

Most of the bridges were built at the start of operation in the early 1900's, and the older ones are beginning to be reconstructed using prestressed concrete girders.

The Ngamoyeik bridge is 210 metres long and has six spans, two of which are 76.2 metre trusses braced by four metre portals.

Fig. 5.3.2 shows the standard loading diagram.

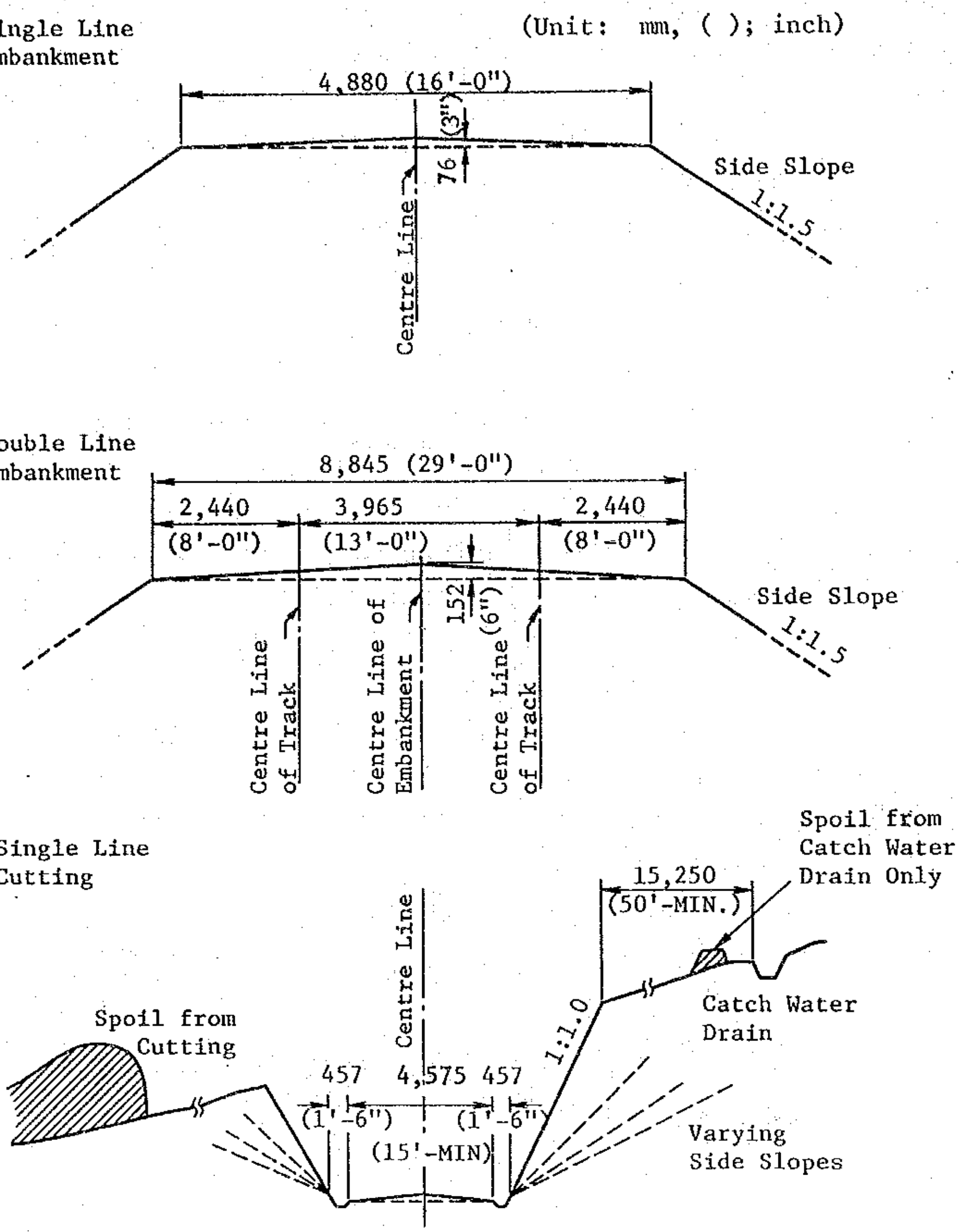


Fig. 5.3.1 Railway Diagram

Source: B.R.C.

(Unit: ton, cm, ( ); inch)

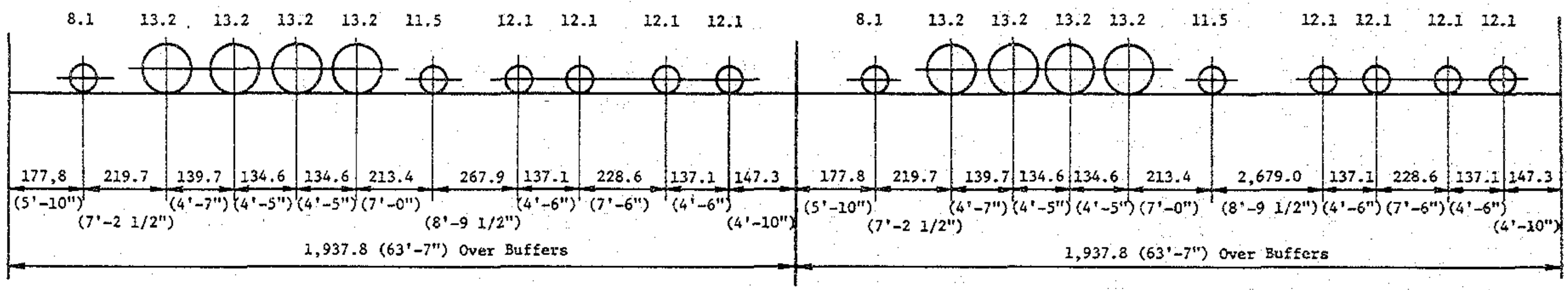


Fig. 5.3.2 Standard Loading Diagram

Source: B.R.C.

5-3-3 Stations

The track layout in the stations is shown in Appendix 2. The interstation intervals are short, with a minimum of 0.4 kilometres.

Platforms have a mean separation of 1.4 metres between the centre of the track and the front of the brick wall and earth platform, and are rarely paved, except for those at the main stations. As shown in Table 5.3.1, the mean height from the rail level to the top of the platform is 0.35 metres.

As shown in Table 5.3.2, there are 40 passenger overbridges, most of which are of rolled steel structure with through-bridge type trusses. The lowest bridge has track clearance of 3.785 metres measured from the rail level.

5-3-4 Station Buildings

There are 38 station buildings in total, composed of 22 brick and 16 timber ones.

Most structures on the platforms are steel framed and range from 13.8 to 18.3 metres in length. Those at Rangoon station are constructed to the length of the trains.

Most platform roofs extend to the edge of the platform.

5-3-5 Road Overbridges

As shown in Table 5.3.3, the main roads in Rangoon City are grade separated.

Most road overbridges are old, and the concrete reinforced sublayers beneath the floor plates are flaked at points, exposing the internal reinforced bars to corrosion.

Table 5.3.1 Length, Width and Height of Platform

Inner				Outer			
Length (m)	Width (m)	Height (m)	Name of station	Length (m)	Width (m)	Height (m)	Name of station
106.68	4.877	0.305	Tamwe				
				114.91	5.812	0.305	Tamwe
121.92	2.667	0.356	Aungsan Myo	121.92	2.743	0.356	Aungsan Myo
121.92	2.362	0.406	Danyingon	121.92	7.010	0.406	Danyingon
121.92	3.658	0.457	Golf Course	121.92	4.877	0.432	Golf Course
121.92	3.353	0.381	Hletan	121.92	3.353	0.381	Hletan
128.016	4.724	0.381	Mingaladon Bazaar	128.016	4.877	0.483	Mingaladon Bazaar
128.016	8.534	0.381	Mingaladon Cantt	128.016	4.877	0.330	Mingaladon Cantt
128.016	3.353	0.381	Burma Air Force	128.016	4.877	0.457	Burma Air Force
128.016	4.877	0.406	Okkalapa	128.016	4.877	0.457	Okkalapa
128.016	4.572	0.406	Paywetseikkon	128.016	4.877	0.406	Paywetseikkon
128.016	8.839	0.381	Tadagale	128.016	4.877	0.406	Tadagale
128.016	7.925	0.432	Yegu	128.016	4.267	0.432	Yegu
				129.235	4.267	0.381	Bauktaw
129.540	8.839	0.381	Kanbe				
				129.845	4.572	0.381	Kanbe
137.160	2.946	0.381	Ywama	137.160	2.286	0.432	Ywama
140.208	3.353	0.254	Paryame	140.208	3.658	0.406	Paryame
177.394	5.486	0.381	Pazundaung	177.394	5.486	0.381	Pazundaung
182.880	5.791	0.457	Hume Road	182.880	5.791	0.457	Hume Road
182.880	1.930	0.381	Hanthawaddy	182.880	3.048	0.381	Hanthawaddy
182.880	4.572	0.432	Kamayut	182.880	5.486	0.432	Kamayut
182.880	4.877	0.406	Thirimyaing	182.880	2.896	0.406	Thirimyaing
182.880	3.658	0.305	Gyogon	182.880	3.505	0.356	Gyogon
182.880	6.096	0.279	Insein	182.880	6.096	0.305	Insein
182.880	5.029	0.432	Kyaikkale	182.880	4.877	0.432	Kyaikkale
182.880	7.620	0.381	Bauktaw				
182.880	6.096	0.356	Mahlwagon	182.880	6.096	0.356	Mahlwagon
188.062	7.315	0.305	Lanmadaw	188.062	7.315	0.305	Lanmadaw
188.970	3.658	0.305	Mission Road				
188.976	5.486	0.432	Gymkhana	188.976	5.486	0.432	Gymkhana
				188.976	3.658	0.305	Mission Road
189.586	8.153	0.356	Pagoda Road	189.586	5.969	0.356	Pagoda Road
198.120	3.048	0.356	Okkyin	198.120	4.572	0.330	Okkyin
204.216	3.861	0.305	Prome Road	204.216	3.861	0.381	Prome Road
				289.554	7.620	0.381	Kemmendine
292.608	8.839	0.356	Rangoon	292.608	8.839	0.356	Rangoon
304.794	5.182	0.381	Kemmendine				

Source: B.R.C.

Table 5.3.2 Passenger Overbridges

No.	Name of Bridge	Height of Bridge from Rail level (metre)	Length of spans (metre)	Head width (metre)	Structure	Note
1	Rangoon Station	4.572	3×13.564+24.841+22.098+16.916+17.678=196.748	8.38	Steel	
2	Bogyoke Market	4.521	1×34.138	4.32	"	P.
3	Pagoda Road F.O.B. to Bogyoke Market	4.674	1×14.326	1.68	"	P.
4	Pagoda Road F.O.B. to Pagoda Road	3.988	5.182+5.486+3.048=13.716	2.21	"	Attached to R.O.B.
5	Lanmadaw Station	3.835	1×5.283	1.91	"	- ditto -
6	Prome Road Station	3.810	7.213+8.236=15.449	2.13	"	- ditto -
7	Nurses Quaters	4.318	1×18.54	2.13	"	P.
8	Gymkhana Station	4.318	1×12.751	2.23	"	Attached to R.O.B.
9	Mission Road Station	3.785	1×10.674	1.37	"	- ditto -
10	Hume Road Station	4.293	1×8.858	1.37	"	- ditto -
11	Short Street	4.293	1×14.427	1.83	"	P.
12	Kemmendine Station	4.115	19.964+2×21.641+8.534=71.780	2.80	"	
13	Thantada	4.216	17.374+15.545=32.919	1.98	"	P.
14	Hanthawaddy Station	4.826	1×12.802	1.58	"	
15	Hletan Station	4.877	1×12.26	1.58	"	
16	Kamayut Station	4.445	1×14.478	1.68	"	
17	Okkyin Station	4.343	1×14.630	1.68	"	
18	Thamaing Station	4.369	1×14.630	1.68	"	
19	Gyogon Station	4.267	1×14.630	1.83	"	
20	Insein Station	4.115	1×15.800=31.700	1.83	"	
21	Insein Station To Workshop	4.039	24.689+9.906+27.127+19.507=81.729	1.83	"	P.
22	Ywama Station	4.953	1×16.154	1.58	"	
23	Aungsan Myo Station	4.877	1×16.154	1.58	"	
24	Danyingon Station	4.851	1×16.154	1.58	"	
25	Golf Course Station	5.004	1×12.192	1.58	"	
26	Mingaladon Bazaar Station	5.004	1×12.49	1.58	"	
27	Mingaladon Cantt Station	4.953	1×12.192	1.58	"	
28	Burma Air Force Station	4.978	1×12.192	1.58	"	
29	Okkalapa Station	4.953	1×12.192	1.58	"	
30	Paywetseikkon Station	4.978	1×12.192	1.58	"	
31	Tadagale Station	4.978	1×12.192	1.58	"	
32	Yegu Station	4.928	1×12.192	1.58	"	
33	Kanbe Station	4.953	1×12.192	1.58	"	
34	Bauktaw Station	4.978	1×12.192	1.58	"	
35	Tamwe Station	4.902	1×12.192	1.58	"	
36	Mahlwagon Station	4.928	1×30.48	1.98	S.R.C.	Over tacks station
37	Pazundaung Station	4.775	22.555+11.582=34.137	2.13	"	- ditto -
38	Kyidaw	4.724	1×27.28	1.95	Steel	P.
39	Wut Kyaung Street	4.851	1×32.39	1.37	"	P.
40	Taingangyon	4.343	1×16.924 1×13.716	2.314	"	

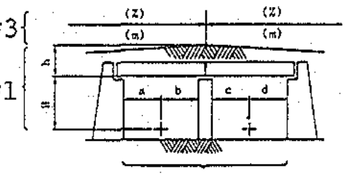
Source: B.R.C.

Note: P; Pedestrian bridge
Others; Passenger overbridges

Table 5.3.3 Road Overbridges on the Circular and Suburban Lines

Name of Bridge	H (metre) (*1)	h (metre) (*1)	Width (metre) (*4)	Span (metre)	Distance from Rail Centre(*2) (metre) a	b	c	d	e	Structure Girder	Abut-ment	Pier	Road Grade (*3) Outer (%) (metre)		Inner (%) (metre)		Rail Level to Bottom of Founda-tion (metre)	Joint Use of the Bridges by Other Department Pipes	Elect-ric wire	Tele-phone wire
1 Sule Pagoda Road	3.835	2.057	19.76	45.72×1	5.50			2.53		T	Brick		1.79 45.72	0.86 30.48	0.61 30.48	3.17 91.44	1.83		mm 12×9	mm 25×1 6×11
2 Pagoda Road	3.988	0.829	22.10 (2.18)	5.91×2	2.67	1.92	2.35	2.24		S.R.C.	Brick	S.R.C.		2.37 45.72	2.6 15.24	4.68 45.72	1.83	50×1		3×18
3 Lanmadaw	3.835	0.466	17.25 (1.90)	4.91×2	2.73	2.19	2.72	2.19		S.R.C.	Brick	S.R.C.		3.83 45.72	4.12 45.72	3.47 60.96	1.73	254×1	6×1	3×18
4 Prome Road	3.810	1.003	25.96 (2.08)	7.61×1 8.75×1	5.68	1.94	2.51	6.24		S.R.C.	Brick	H		1.85 91.44	1.12 15.24	2.52 106.68	1.80	50×2	101×1 25×1	3×18
5 Leeds Road	3.835	0.753	7.85	7.95×1	2.08			2.09	3.80	S.R.C.	Brick			3.69 60.96	3.04 30.48	2.28 60.96	1.52	152×1 76×1	12×1	3×18
6 Gymkhana Road	3.937	0.762	13.95 (3.10)	9.50×1	2.38			2.25	4.87	Gd	Brick			2.50 60.96	2.05 30.48	2.07 45.72	1.75	152×1 76×1	101×1 6×4	3×21
7 Mission Road	3.785	0.712	12.30 (1.43)	9.38×1	2.98			2.32	4.08	Gd	Brick			-1.13 121.92	3.44 15.24	3.30 76.20	2.13		12×13	3×5
8 Hume Road	3.835	1.090	10.90 (1.55)	29.72×1				4.48	9.03	T	Brick		3.71 106.68	-0.72 15.24	1.32 60.96	2.26 60.96	3.38	152×2	38×1 6×8	3×2
9 Hantha-waddy	3.886	0.770	8.40	7.70×1	1.83			1.83	3.61	Gd	Brick		2.05 30.48	3.68 30.48	2.22 30.48	4.60 45.72	1.78	152×1 25×1	50×1 38×1 25×1 6×5	3×16
10 Hletan	3.861	1.366	10.04	10.35×1	3.20			3.12	4.04	Gd	Brick		2.78 76.20	0.76 30.48	0.42 15.24	2.21 60.96	1.73		6×6	3×16
11 Kyaikkale	4.623	0.806	9.30	9.45×1	2.22			2.22	4.47	R.C.		R.C.	0.20 76.20	0.19 30.48	0.23 60.96	0.13 45.72	2.06		6×1	
12 Okponseik	5.334	0.858	12.50	8.84×18	2.22			2.22	4.12	R.C.	R.C.	R.C.	4.20 76.20	1.39 15.24	1.69 30.48	6.52 60.96	1.91		6×1	
13 Tamwe	4.801	0.876	12.20	9.46×9	2.50			2.08	4.38	R.C.	R.C.	R.C.	5.74 76.20	4.55 15.24	4.38 15.24	6.42 76.20	1.68		25×2	12×2
14 Masjid Road	4.648	1.172	18.20	8.63×1 8.59×1	2.43 2.30			2.31 2.29	3.89 4.00	R.C.	R.C.	R.C.	3.09 60.96	2.76 60.96	2.57 45.72	2.94 45.72	1.47	508×1	101×1 38×1 25×1 12×5	3×21
15 Mills Road	4.267	1.102	12.50	8.52×1 7.59×1 8.23×1	2.21 1.97			2.01 2.13 2.29	4.31 2.49 3.80	S.R.C.	R.C.	R.C.	2.70 60.96	1.44 45.72	2.01 45.72	3.29 45.72	1.93		12×1 6×7	3×18
16 Theinbyu (Stockade Road)	3.785	0.506	18.87	4.57×6	2.29 2.10	2.29 2.17	2.25 2.17	2.17 2.11		S.R.C.	Brick	H	2.66 76.20	1.00 15.24	0.40 15.24	4.01 30.48	1.83	254×1	50×3 28×1 6×1	3×21

Note: *3 *1



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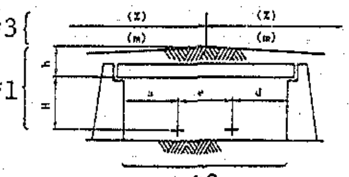
*3 *1



*2

*4 ( ); Passenger overbridges widths which are included in above figures.

Source: B.R.C., Field Survey

5-3-6 Freight Stations and Switching Yards

Some stations have freight platforms and industrial tracks equipped for freight transport.

A port railway runs along the Rangoon river with junctions leading to the freight stations and piers by means of the industrial track.

Mahlwagon and Kemmendine stations have marshalling yards to distribute wagons to the port railway and to configure goods trains for the trunk lines.

Another port railway, branching off from Togyaunggale station, is now under construction.

5-3-7 Track Material Repair Shop and Concrete Workshop

Repair and production of track materials and track fittings are performed at a track material repair shop where signal and telecommunication device repair is also performed.

Concrete ties and prestressed concrete girders are manufactured in the concrete workshop, which also has the maintenance crew to maintain the railway bridges.

5-4 Rolling Stock Shed

Diesel electric locomotives for operation on the Circular and Suburban Lines are based at the Insein shed, and the carriages are based at the Insein shed and Rangoon carriage shed which are both conveniently located for operation adjacent to their respective stations.

5-4-1 Insein Shed

The Insein shed has 19 diesel electric locomotives, including 13 diesel electric locomotives for operation on the Circular and Suburban Lines, and 54 carriages.

Functions of the Insein shed consist of the inspection and light repair of diesel electric locomotives and carriages, the management of fuel and assignment control of drivers. The Insein shed has 198 crew for inspections and light repairs, and 89 drivers.

Inspections of diesel electric locomotives are classified into a Grade-A inspection which is conducted for all the locomotives every night, and into Grade-B to Grade-D inspections conducted for one or two locomotives during the day.

Daily carriage inspections are conducted for five units of 30 carriages which are housed overnight at the Insein shed. There are eight tracks including six tracks with inspection and light repair pits in the maintenance yard, two tracks for fuel supply and three tracks for rolling stock storage.

The track layout at Insein shed is shown in Appendix 2.

5-4-2 Rangoon Carriage Shed

The Rangoon carriage shed is used only for performing inspections and light repairs to the carriages of the main lines, and for 30 of the carriages of the Circular and Suburban Lines.

Five units of carriages of the Circular and Suburban Lines are housed at Rangoon station overnight.

There are four tracks having inspection and light repair pits in the maintenance yard, two tracks in a roofed area with carriage washing equipment and tracks for storage of carriages for the main lines.

The track layout of the Rangoon carriage shed is shown in Appendix 2.

5-5 Rolling Stock Workshop

B.R.C. now has three rolling stock workshops for inspection and repairs of rolling stock; the Insein workshop situated in the suburb of Rangoon, the Ywataung and the Myitnge workshops in the suburb of Mandalay.

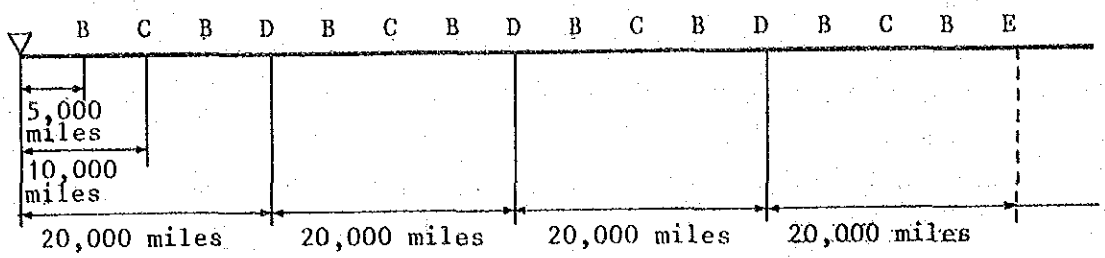
5-5-1 Inspection and Repair of Diesel Electric Locomotives

(1) Method

Inspection and repair of diesel electric locomotives is carried out in accordance with established rules which specify the procedure, items and cycle. As opposed to the Grade-A to Grade-D inspections performed at the Insein shed, Grade-E to Grade-G inspections, which include overhaul of rolling stock, are carried out at the Rangoon diesel electric locomotive depot and at the Insein workshop.

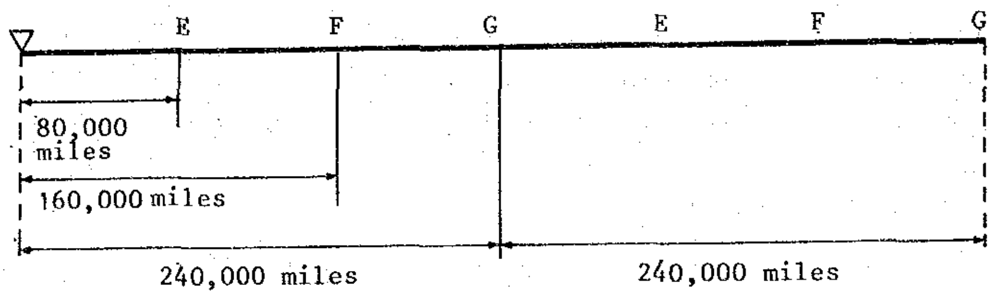
(2) Inspection items and cycles

a Inspection cycle for diesel electric locomotives



A inspection is done on daily or trip basis and B, C and D inspections are carried out in home depots, according to the mileage schedule.

b. Overhaul cycles for diesel electric inspection



E inspection (diesel engine top overhaul)
F inspection (intermediate overhaul)
G inspection (general overhaul)

(3) Standard process of general overhaul

The general overhaul of a diesel electric locomotive by standard process requires eight weeks (on a weekly five working day basis).

(4) Insein workshop

a. Assigned duties

This workshop performs the work of inspection and repair of steam locomotives, repair and production of the parts for steam and diesel electric locomotives, and rebuilding of diesel electric locomotives.

b. Workshop layout

The layout of the Insein workshop is primarily designed to facilitate the repair of steam locomotives, and has separate facilities for the rebuilding of diesel electric locomotives. Fig. 5.5.1 shows the layout of the workshop with an indication of the typical flow of the process for inspection and repair.

c. Inspection and repair facilities

The necessary inspection and repair facilities are provided at each shop but most of the machines are old.

d. Organization

The Insein workshop is organized into 14 shops (including storage space) and has 2,046 employees under the direction of the Works Manager.

5-5-2 Inspection and Repair of Carriages

(1) The items and cycle of inspection

Inspection and repair of carriages is carried out according to the established calendar time schedule.

All heavy overhauls are carried out on a two-year basis at the Myitnge workshop.

Other inspection items to be conducted every day, every 10 to 14 days, and every year are assigned to the Rangoon carriage shed and the Insein shed.

The exception is repairs to air brake systems of diesel railcar converted carriages. This is carried out at the Insein shed.

(2) Repair process

There are different standards established for the process, and these are applied depending on the type of the carriages. For steel carriages, the process requires a period of seven weeks. A diesel-railcar converted carriage requires 8.5 weeks while a wooden one requires 7.5 to 8.5 (on a weekly five working day basis).

(3) Myitnge workshop

This workshop inspects and repairs carriages and wagons while the new house will have equipment enabling the knock-down production of carriages and wagons.

The Myitnge workshop is organized into 13 shops, with 2,472 employees under the direction of the Works Manager.

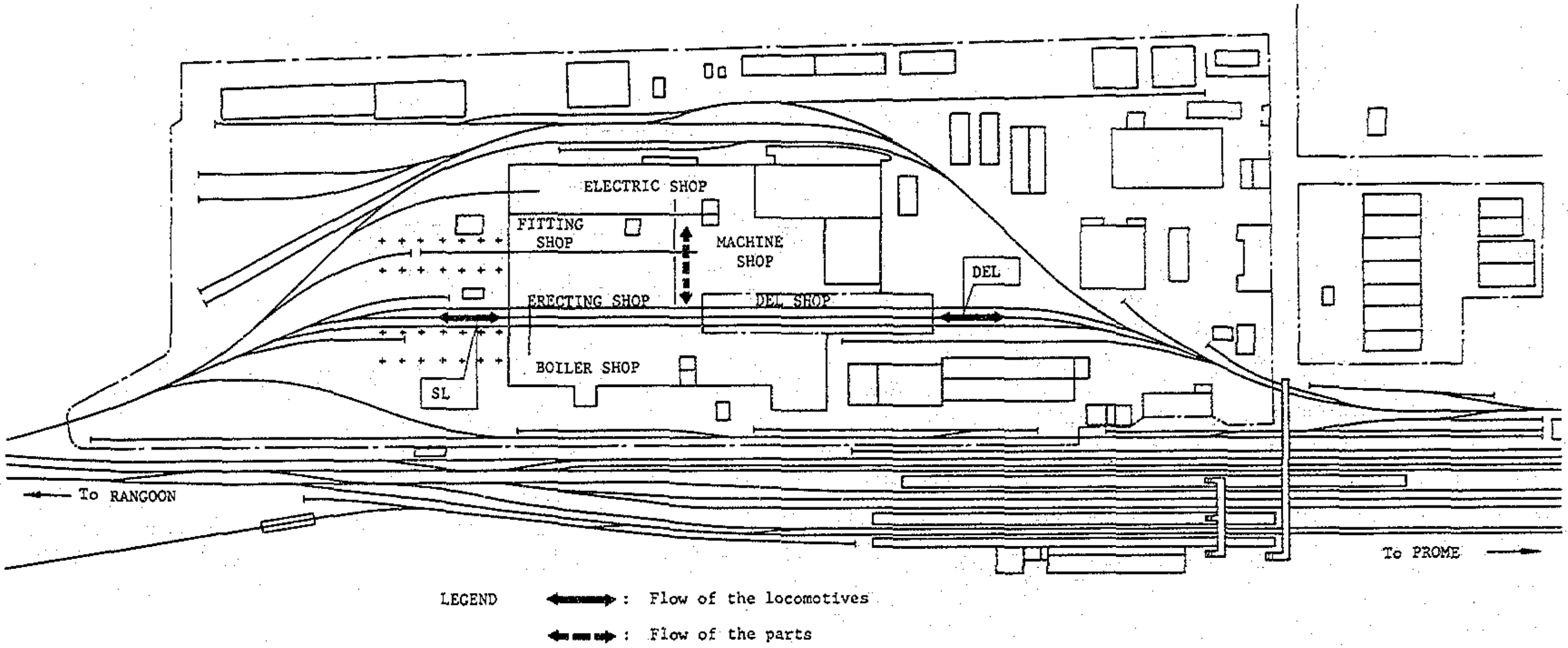


Fig. 5.5.1 The Layout of the Insein Workshop and a Typical Work Flow

Source: B.R.C.

5-6 Railway Electric Power

5-6-1 Railway Electric Power Facilities

Table 5.6.1 shows the main electric facilities used by the Circular and Suburban Lines.

Table 5.6.1 Electric Facilities in Rangoon Area and Insein Workshop

Electric Facilities	Rangoon Area	Insein Workshop
Emergency lighting generators		100 kW × 2 units
6.6 kV/400 V transformers		250 kVA × 3 units
Electrically driven machinery	300 units	500 units
Electrically lit staff houses	2,400 units	800 units
External light points	900 units	300 units
Overhead distribution lines	80 km	35 km
Electrically lit railway stations	34 units	8 units

Source: B.R.C.

5-6-2 Power Distribution System

Electric power for the B.R.C. signalling and lighting facilities is independently purchased from the E.P.C. by each station.

The Insein station has three high voltage transformers (6.6 kV, 250 kVA, three-phase) which supply power to the electric facilities at the rolling stock shed and workshop.

The Rangoon station and the Mahlwagon station receive three-phase current at 400 V while other stations receive single-phase current from the E.P.C. at a low voltage of 230 V.

5-6-3 Distribution Wires Spanning Tracks

There are a number of E.P.C. and B.R.C. overhead distribution wires with high and low voltages that span the tracks of the Circular and Suburban Lines at the numbers of places shown in Table 5.6.2.

Table 5.6.2 Distribution Wires Spanning Tracks

Name of Sections	Number of Circuit				Remarks
	33 kV	6.6 kV	400 V and/or 230 V		
	E.P.C.	E.P.C.	E.P.C.	B.R.C.	
Rangoon-Kemmendine		1	1	15	
Kemmendine-Insein		1		19	Including shed and workshop
Insein-Danyingon	1	1	7	5	
Rangoon-Mingaladon	1	1	3	20	
Mingaladon-Danyingon	1	1	5	2	
Hninzigon-Ywathagyi		2	2	10	
TOTAL	3	7	18	71	

Source: B.R.C.

5-7 Signalling Facilities

The budget for the modernization of the Circular Line signalling facilities has not been raised since 1972 . Most of the entire units or parts of the facilities have been left out of order as a result of theft or failure, or otherwise abandoned or removed due to general lack of materials and parts for the required replacement or repair. These do not function, and are in a general state of deterioration. As shown in Table 3.3.3, signal failure is responsible for 28% of the train operation accidents and troubles, and this is an obvious indication of the serious condition of the signalling facilities.

5-7-1 Block System

An automatic block system was first introduced on the Circular Line in the early 1970's. However, the system did not provide the desired efficiency and was subsequently replaced by the old lock and block system, except for those units installed between Kemmendine and Mahlwagon via Rangoon. Later, failure of the overhead bare lines borrowed from P.T.C. for operation of the lock and block system led to this antiquated system being replaced by the telephone block system of even lesser efficiency and reduced safety. As a result, the Circular and Suburban Lines employ the following three different types of block system (cf. Fig. 5.7.1).

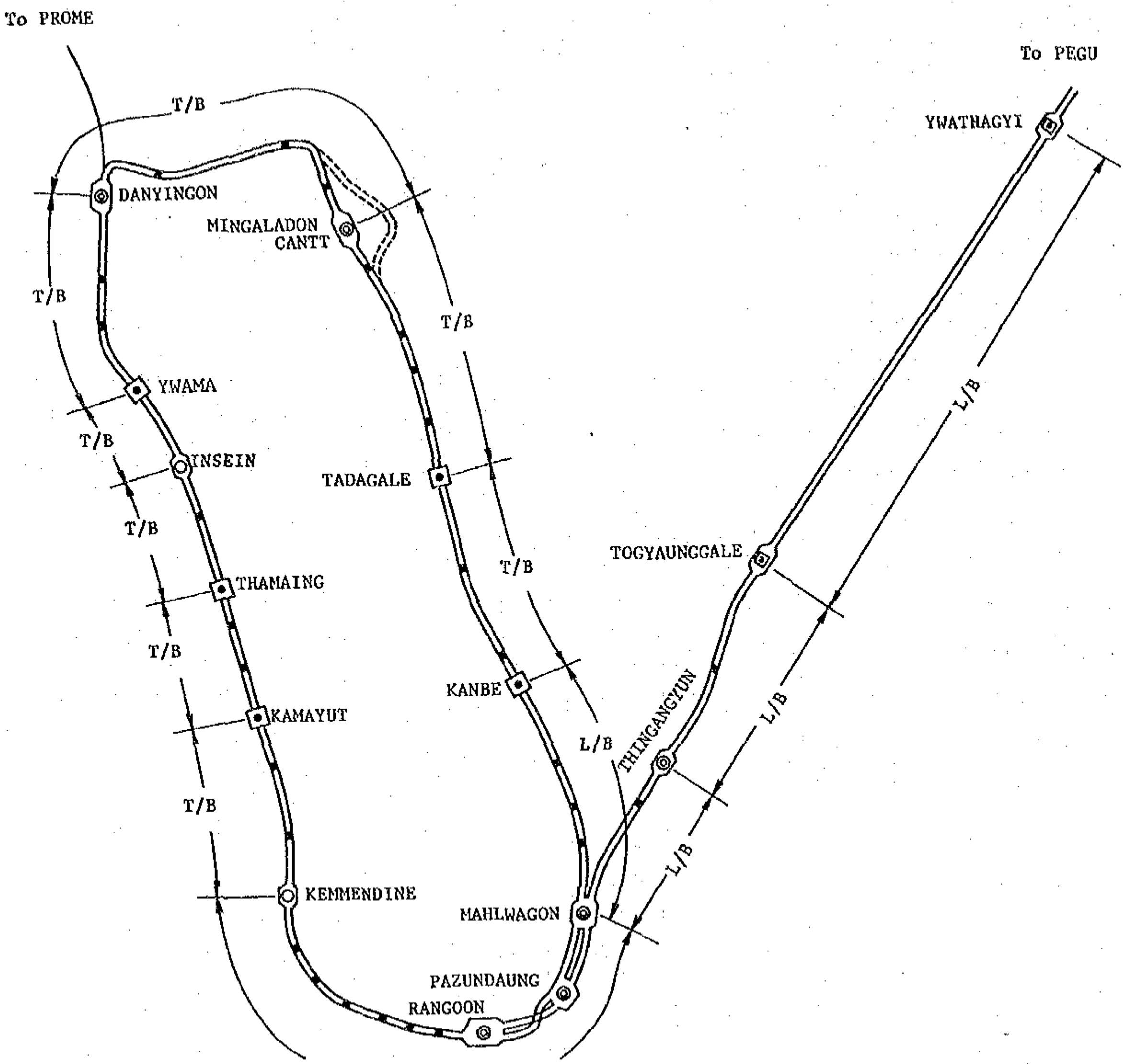
Automatic block section	13 km (20%)
Lock and block section	22 km (34%)
Telephone block section	31 km (46%)

A 600 foot long half lap block section for overrun protection is installed inside each outer signal.

5-7-2 Interlocking Device

There are six electric relay interlocking stations, two electro-mechanical interlocking stations, two key lock stations, and five stations which control trains by means of signals without interlocking (cf. Fig. 5.7.1).

Insein and Kemmendine stations have been using their respective interlocking devices for more than 35 years, and these facilities are now well past their service life. This situation now makes maintenance difficult and the prevention of malfunction depends solely on the attention of the operators.



NOTE		
	L/B ------	Lock and block section
	T/B ------	Telephone block section
	◎ ------	Electric relay interlocking station
	○ ------	Electro mechanical interlocking station
	▣ ------	No interlocking but Signal control station
	■ ------	No interlocking and No signal control station

Fig. 5.7.1 Signalling System and Block Section

Source: B.R.C.

5-7-3 Track Circuit

The direct current track circuits presently in use require insulated rail joints. Those used include the plastic lap and the locally produced wooden type. Track circuit adjustment is carried out three times every year, during the light rain period (April-May), the heavy rain period (May-June) and the end of the rainy season (October).

5-7-4 Signal Power Source

Signals between Rangoon and Kemmendine stations are supplied from a source of 110 V, 50 Hz electricity through buried cable. The power source room at Rangoon station has a 600 V, 50 Hz, 19.8 kVA diesel generator as an auxiliary power source while other stations are supplied from 230 V, 50 Hz sources and have 2 to 5 kVA portable diesel generators for auxiliary use.

DC current is supplied to track circuits at either 14 V or 3 V while 110 V DC power is supplied to electric power points. Signal lamps are supplied with either 30 V, 15 W/15 W or 12 V, 25 W AC power.

5-7-5 Level Crossing Protection

There are 27 level crossings on the Circular Line and five between Mahlwagon and Ywathagyi.

These crossings have gatekeepers operating gate barriers. Train approach indicators for the gatekeepers and automatic level crossing signals for the sake of pedestrians have been either removed or broken.

5-7-6 Causes of Failure

The reported failures are classified in Table 5.7.1 by month and the type of facilities on which they took place. The data indicates a high failure rate for the rainy seasons.

5-7-7 Maintenance Crew

The Circular and Suburban Lines employ a total of 62 maintenance personnel.

Table 5.7.1 Signal and Telecommunication Failures (1981/1984)

No.	System	/ Rainy Season					/	Cool Season			/ Hot Season		
		Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jun.	Feb.	Mar.	Total
1	Track circuit	10	22	9	7	8					2	4		62
2	Point	2	9	8	7		2		1		2			31
3	Power supply		6	2	7		3		1					19
4	P.T.C. bare wire	3	2	8	4							1		18
5	Signal					2	1	4						7
6	Block Equipment			2	1									3
	Total	15	39	29	26	10	6	4	2		4	5		140

Note: Figures are the sum for 2 years (Apr. 1981 - Mar. 1983)
Rainy season began from April in 1982

Source: B.R.C.

5-8 Telecommunications

5-8-1 Telecommunication Lines

The P.T.C. overhead bare lines are, as shown in Fig. 5.8.1, laid along the railway line. B.R.C. has a contract with P.T.C. for three lines for the Circular Line and six lines for the Suburban Line. Fig. 5.8.2 shows the usage of the telecommunication lines. The overhead bare lines tend to cause communication difficulties during the rainy season (Table 5.7.1).

5-8-2 Dispatcher Telephones

The master set is situated at the dispatcher room at Rangoon station and almost every station has a local telephone, as shown in Fig. 5.8.3. These telephones are of the key-ringing type which has calls from the master set to the stations, using selector codes at 200 V DC and 3-1/2 Hz.

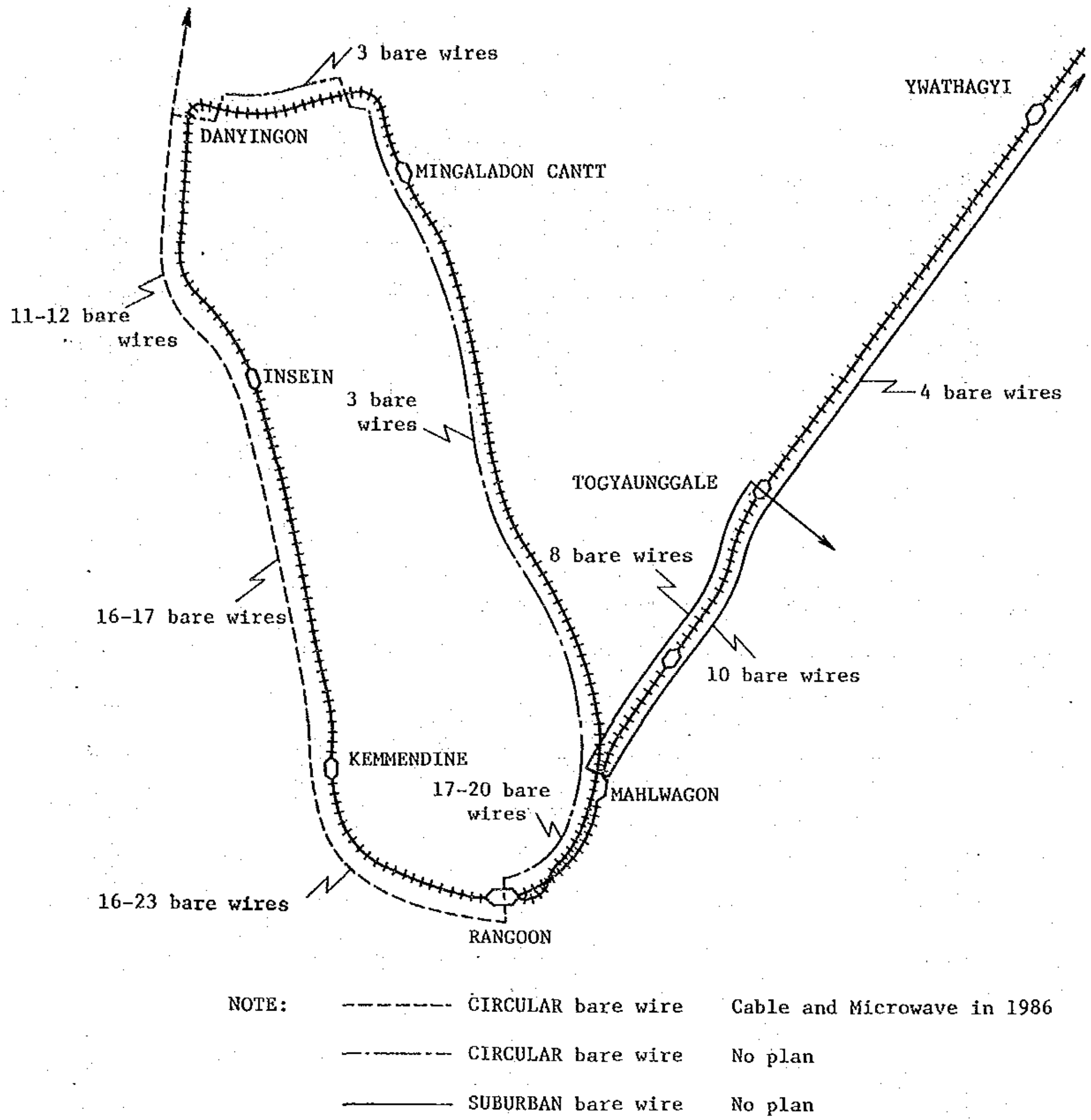
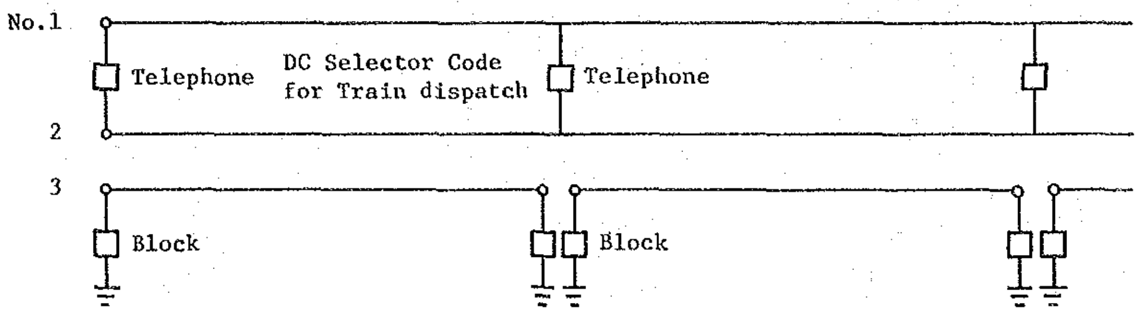


Fig. 5.8.1 P.T.C. Telephone Line Routes

Source: P.T.C.

CIRCULAR LINE ----- 3 overhead bare copper wires



SUBURBAN LINE ----- 6 overhead bare copper wires

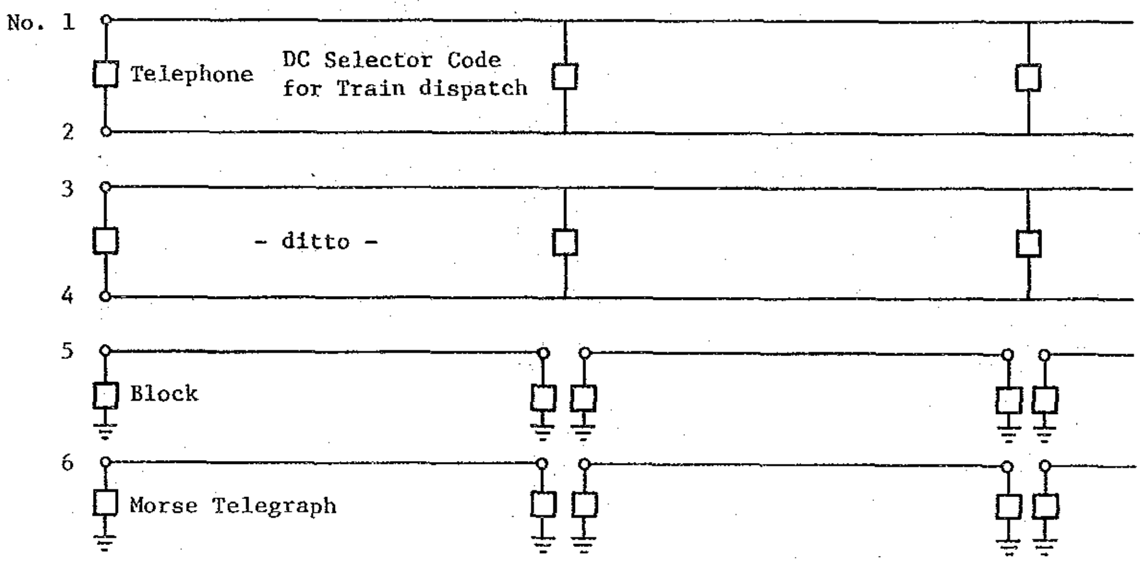


Fig. 5.8.2 Telecommunication Lines

Source: B.R.C.

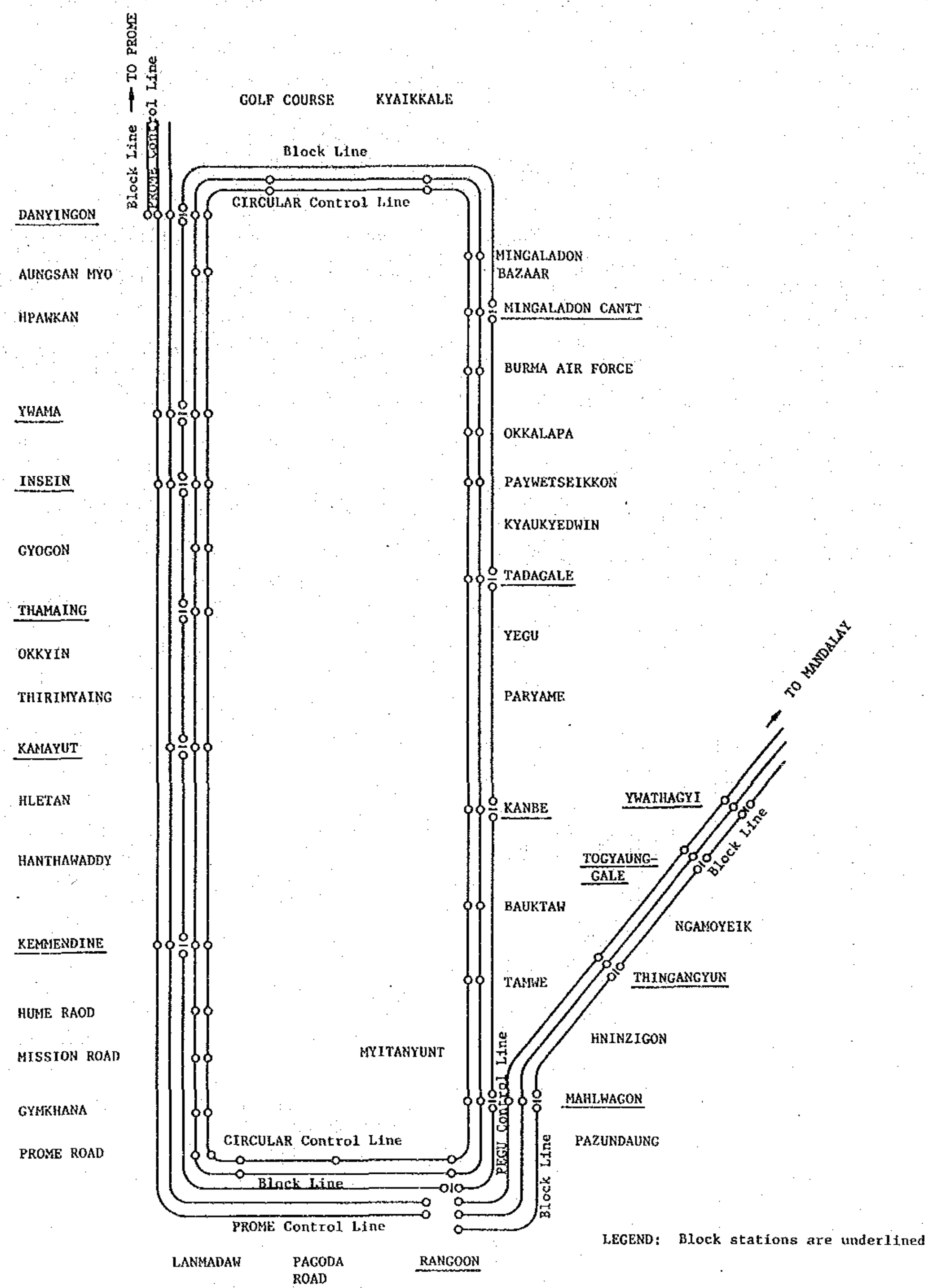


Fig. 5.8.3 Network of Telecommunication Channel

Source: B.R.C.

5-8-3 Telephones for Blocking System

Telephone block stations are equipped for communication with their adjacent stations by means of magneto telephones operated by switch changeover. Single separate telephone channels are laid between these stations.

5-8-4 Magneto Telephone Switchboard

Magneto telephone switchboards are provided at Rangoon station (for 250 lines), Insein station (for 20 lines), Mahlwagon marshalling yard (for 10 lines) and the Botataung store depot (for 10 lines) which is used for imported goods. All are interconnected with P.T.C., but the jacks are responsible for almost daily telecommunication failures.

5-8-5 Maintenance Crew

Fifteen persons are assigned for maintenance of the telecommunication facilities of the Circular and Suburban Lines.

CHAPTER 6 ELECTRIC SYSTEM AND TRACTION SYSTEM

CHAPTER 6 ELECTRIC SYSTEM AND TRACTION SYSTEM

The selection of either direct or alternating current as the power source for the electric railway system, and of either the electric locomotive or electric railcar traction system, is based on an overall comparison and study of the estimated demand, the transport plan and the investment plan.

The following analysis recommends that the 50 Hz single phase AC 25 kV system and the electric locomotive traction be selected.

6-1 AC or DC Electric System

6-1-1 Worldwide Trend

The type of electric railway system newly adopted by a country is determined by the level of railway technology, the technical outlook, and the national economy at the time of railway planning. Plans for expansion of electric railway systems depend on the requirement of application in connection with the existing railway equipment and system.

The present general trend in electric railway systems is directed to the three main systems of the direct current/3000 V, the direct current/1500 V and the commercial frequency single-phase alternating current/25 kV.

There are eight countries in the world which have introduced electric railway systems in the last decade. Of these countries, seven have adopted the commercial frequency single-phase alternating current/25 kV system. General assessment is that this commercial frequency single-phase alternating current/25 kV is superior to other systems. Also, this system is the international standard for the U.I.C.

6-1-2 Comparison of Electric Systems on the Lines

(1) Technical conditions

An overall study of electric system for the Circular and Suburban Lines was conducted with regard to the following various current conditions.

a. Power source

There is no problem regarding the availability of the electric power necessary for the planned electric traction on both lines.

However, it is necessary to equip the lines with a proper power supply system including long-distance transmission lines and railway substations interconnected by these lines. From the economic standpoint, the AC electric traction system is more preferable since it requires a lesser number of railway substations than does the DC system.

b. Road and passenger overbridges

There are a great number of road and passenger overbridges that overlie the track of both the Circular and Suburban Lines. In the case of AC traction, a greater distance of insulation than required for DC traction, must be maintained between these structures and the electric facilities for power supply, such as pantographs and the live parts of the catenary. Moreover, road overbridges need improvement to secure electrified operation. The total volume of such work for the DC traction system is less, although the number of spots that might need such improvement is the same as for the case of AC.

c. Signalling system

Both the Circular and Suburban Lines use DC current systems for the track circuits of the signalling systems. The introduction of DC traction system therefore requires that the existing track circuits be completely changed.

d. Communication lines

The introduction of AC traction system results in an interference problem caused by induction in the existing bare overhead lines. These lines must therefore be spaced away from the track or built into a shielded cable if the AC system is to be employed.

(2) Initial investment

In comparison with the estimated initial investment for AC and the DC traction systems, the former requires an initial investment which is about 80% of the latter.

(3) Experience in electrification

The Circular and Suburban Lines will be the first electrified lines in B.R.C. and so there are no railway engineers who are experienced in electric railway operation. Consequently, the electrification should be of a type that is simple to construct and maintain. Also, the system should be of a type that is one of the more widely adopted systems in the world because technical introduction can readily be achieved. This all suggests that the commercial frequency single-phase AC 25 kV system be adopted.

In passing, it may be pointed out that this commercial frequency single-phase AC 25 kV system is going to be introduced, with the cooperation of B.R.C., for the Kyangin Cement Line by the Ceramic Industries Corporation.

6-2 Electric Locomotive or Electric Railcar

6-2-1 Transport Capacity

The railway passenger volume is forecast to reach 542 thousand per day (6.3 times the present volume) by the end of the project in the year 2019. The electric locomotive traction system will have sufficient capacity to carry this increased number of passengers by shortening the minimum headway to 7.5 minutes. Therefore, there is no need for further shortening of the minimum headway by adopting the electric railcar traction system.

6-2-2 Ground Facilities

In the case of the Circular and Suburban Lines, the electric railcar traction system will require a greater increase in the ground facility investment, compared with the electric locomotive traction system. This is because of the necessity of maintaining the overhead clearances.

The electric railcar traction system needs a position for the overhead contact wire, which is approximately 400 mm higher than the electric locomotive traction system to maintain passenger head clearance beneath the pantographs of carriages. This will considerably increase the civil engineering costs due to modifications (such as raising or removing) of road overbridges.

The existing sheds, workshops and carriages will be utilized to a greater extent with an electric locomotive traction system, than they would be in an electric railcar traction system.

6-2-3 Effects of Speed Increase

The electric railcar traction system is generally suitable for lines such as the Circular Line, which have shorter distances between stations, because this traction system has higher accelerating and braking performance than the electric locomotive traction system. This advantage, however, will not be sufficiently realized due to the maximum speed remaining the same as that for the existing track condition. Consequently, any speed increase by changing the system will be insufficient to compensate for the increase in the rolling stock procurement costs. This is clarified by the following calculation.

The electric railcar traction system will increase the scheduled speed by about 20%, and this is estimated to increase railway passenger demand by 5% in the commissioning year, according to "the modal split model". Moreover this increase in passenger will grow at an annual average rate of 2.9% for the entire project life. Thus revenue will increase in proportion to the incremental number of passengers. The revenue increase can be accordingly given by the following formula.

Revenue increase in the first year of the project

= Number of passengers × Increase rate × Average fare

(per day)(days) (Kyat)

$$= 233 \times 10^3 \times 365 \times 0.05 \times 0.4 = 1{,}700 \text{ thousand Kyats/year}$$

Revenue increase over the life of the project

$$= \sum_{i=1}^{30} \text{Revenue increase in 1990} \times (1 + \text{Growth rate})^{i-1}$$

$$= \sum_{i=1}^{30} 1700\ (1 + 0.029)^{i-1} = 80 \text{ million Kyats}$$

The electric railcar traction system will require a further investment of 200 million Kyats (refer to Table 6.2.1). These two figures clarify that the electric railcar traction system will not have sufficient economic merit when compared to the electric locomotive traction system.

Table 6.2.1 Comparison of Rolling Stock Procurement Costs

(Unit: Million Kyats)

Traction System	1990	2000	2010	Total
Electric Locomotive	316	89	116	521
(No. of Locomotives)	(19)	(5)	(7)	(31)
(No. of Carriages)	(105)	(31)	(37)	(173)
Electric Railcar	445	120	156	721
(No. of Railcars)	(111)	(30)	(39)	(180)
Differences	129	31	40	200

Source: Study estimates

6-2-4 Maintenance and Storage

Electric locomotives have motors on a locomotive only, and are hence simpler to maintain and manage than electric railcars which have motors on two or more cars in a train.

CHAPTER 7 TRANSPORT PLAN

CHAPTER 7 TRANSPORT PLAN

7-1 Premises for Transport Plan

7-1-1 Demand for Transport

The transport plan is based on a 2.7 times estimated increase of the transport demand and a 70% increase in train frequency, between 1982 and 1990 when electrified operation is to begin.

7-1-2 Transport Network

The recent cross section passenger volume shown in Fig. 3.3.3 indicates large volumes between Rangoon and Insein and between Rangoon and Mingaladon Cantt on the Circular Line as well as between Rangoon and Thingangyun on the Suburban Line. There is a small volume for most other sections, particularly between Thingangyun and Ywathagyi on the Suburban Line.

(1) Determination of train operating schedule

Determination of the train operating schedule requires meeting the demand for transport with increased efficiency and with the least number of carriages.

After the electrification, locomotive traction system is adopted. Therefore, train reformation to couple the electric locomotive at the head of the train for shuttle service needs about ten minutes.

The policy is to minimize switching operations of locomotives in stations in order to increase train frequency.

As a result, this schedule reduces the switching operation of locomotives at Rangoon station.

Since Mingaladon township is one of the development areas, a boost in the number of railway passengers is expected with the relocation of the terminal station further along the line at Mingaladon Bazaar.

(2) Rearrangement of station track layout

The facilities in terminal stations are improved for shuttle operation, as follows.

(a) Mingaladon Bazaar : new layout of an auxiliary main track and change to relay interlocking

(b) Togyaunggale : new installation of a point and changes to relay interlocking

7-1-3 Train Speed

It is necessary to increase the scheduled speed in order to increase train frequency.

Under the given track and signalling conditions, any increase in the scheduled speed depends on increases in the acceleration, deceleration, the maximum speed, and reductions in the stopping time.

(1) Electric locomotive acceleration and deceleration

The electric locomotive average starting acceleration and stopping deceleration of 1.7 to 1.8 km/hour/second, respectively, is used (cf. section 8-2-2).

(2) Maximum speed

The short interstation distances on the Circular Line and Suburban Lines, B.R.C. operating standards and present track conditions, result in the maximum speed being set at 48 km/hour for the Circular Line and at 56 km/hour for the Suburban Line. However, future improvements to the track will enable higher maximum speeds.

(3) Stopping time

The stopping times for the following stations are determined with reference to the number of passengers boarding and alighting at the stations as follows.

(a) Rangoon	: 2 - 4 minutes
(b) Insein	: 2 minutes
(c) Mingaladon Bazaar, Kemmendine, Kamayut, Thingangyun	: 1 minute
(d) Other block stations	: 30 seconds
(e) Other non-block stations	: 15 - 30 seconds

(4) Operating time

The interstation operating time is assessed by preparing a running distance-speed curve, a train running curve, computing the average speed, and by assessing the time on a 30 second basis.

(5) Scheduled time

The required time between adjacent pairs of main stations is given in Fig. 7.1.1 and Table 7.1.1.

The Circular Line

	Rangoon		Mingaladon Bazaar		Insein		Rangoon
Operating	0 km 46.6 km	← 43' →	20.6 km 26.0 km	← 22' →	32.1 km 14.5 km	← 35' →	46.6 km 0 km
Stopping	(4')	(5')	(1')	(2')	(2')	(6')	(4')
Inner Train	0	→	48'	→	73'	→	116'
Outer Train	116'	←	67'	←	41'	←	0

The Suburban Line

	Rangoon		Thingangyun		Togyaunggale		Ywathagyi
Operating	0 km 20.7 km	← 16' →	7.3 km 13.4 km	← 8' →	11.7 km 9.0 km	← 13' →	20.7 km 0 km
Stopping	(10')	(1'15")	(1')	(15")	(30")	(0)	(15')
Up Train	0	→	17'15"	→	26'30"	→	40'
Down Train	40'	←	21'45"	←	13'	←	0

Fig. 7.1.1 Train Operating and Stopping Time

Source : Study estimates

Table 7.1.1 Train Operating Time

Section	km	Present (A)	Electrification (B)	Shortening (B-A)	Ratio [(B-A)/A] %
Rangoon-Rangoon	46.6	2°20'	1°56'	- 24'	17.1
Rangoon-Rangoon	46.6	2°25'	2°00'	- 25'	17.2
Rangoon-Insein	14.5	45'	41'	- 4'	9.0
Rangoon-Mingaladon Bazaar	20.6	58'	48'	- 10'	17.2
Rangoon-Togyaunggale	11.7	35'	26'30"	- 8'30"	24.3
Rangoon-Ywathagyi	20.7	53'	40'	- 13'	24.5

Source: Study estimates

7-1-4 Train Headway

The train headway is affected by the train running speed and the presence of block systems and block sections both installed for the safety of operation.

The telephone block system extends over 31 kilometres, with the largest section on the Circular Line being seven kilometres. It is possible to increase the present train frequency by improving the block system facilities.

(1) Minimum headway

It is planned that the block sections between the Kemmendine-Rangoon-Mahlwagon track retain their present automatic block system, and other sections of the Circular Line are equipped with a better block system. In this improvement the minimum headway is set as 7.5 minutes.

(2) Railway lines crossing between the Suburban Line and the Circular Line in Rangoon-Pazundaung section

At Rangoon station, the long-distance Mandalay and Prome lines, share tracks 1, 2 and 3, while the Suburban Line uses tracks 4 and 5, and the Circular Line uses 6 and 7.

Because of this track layout, both the Circular Line and the Mandalay line must intersect at level between Rangoon and Pazundaung. Consequently, a delay in the operating schedule on one line can cause delays in the other lines, and resulting in difficulties in maintaining the timetable.

In order to attain the minimum possible headway, the present track layout of Rangoon station is altered that the Circular Line is routed to not intersect the Mandalay line.

(3) Rearrangement track layout at Rangoon station

The rearrangement of arrival and departure tracks at Rangoon station is as follows.

(a) No. 1 track : for the trunk line super class trains
(b) No. 2 track : trunk line spare track
(c) No. 3 track : for Circular Line inner train
(d) No. 4 track : for Circular Line outer train
(e) No. 5 track : common track shared by the Circular and Suburban Lines
(f) No. 6 and 7 tracks: common track shared by the trunk (ordinary class train) and Suburban Lines
(g) No. 8 track : locomotive run-round track

The track layout is set to correspond to the above rearrangements.

7-2 Transport Plan

7-2-1 Transport Capacity to Meet the Demand

The number of trains is determined by the passenger demand of the interstation section with the largest cross-section volume for a given line.

(1) Number of carriages in unit train formation

The existing six carriage train formation is retained, and covers the increased passenger volume dealt with by increasing the frequency.

(2) Carriage riding efficiency

The seating capacity for carriages is set at 64 persons with standing space for 36, so that the total capacity of a train is 600 persons (cf. Section 8-2-3).

The estimated riding efficiency rates for the maximum cross-section passenger volume on the Circular and Suburban Lines for the initial year of electric traction are as follows.

(a) Peak time zone : 150% [1.5 (times) × 600 (persons) = 900 persons per train]

(b) Other time zones: 125% [1.25 (times) × 600 (persons) = 750 persons per train]

(3) Number of scheduled trains

a. Number of scheduled trains

The number of scheduled trains is computed as follows, on the basis of the estimated demand for the initial year of electric traction.

The number of scheduled trains per hour is obtained by the following formula.

$$T_{ij} = D_{ij} / N \cdot \eta$$

where T_{ij}: number of trains per hour in i section during j time zone

D_{ij}: maximum cross-section passenger volume per hour in i section during j time zone

N : capacity per train (600 persons)

η : riding efficiency (peak time: 150%, other time: 125%)

b. Number of scheduled trains between main sections of the Circular and Suburban Lines

The numbers of scheduled trains required for the main sections in the Circular and Suburban Lines are computed using the above formula and shown in Table 7.2.1.

c. Number of shuttles at Rangoon station

The number of shuttles at Rangoon station is calculated at eleven.

d. Headway for Circular and Suburban Lines

Table 7.2.2 shows a percentage change in the headway for the current year and for the initial year of electric traction. As a result, it shows a reduction to 70% of that at present.

Table 7.2.1 Number of Scheduled Trains (1990)

Item			Insein -Rangoon	Mingaladon Bazaar -Rangoon	Mingaladon Bazaar -Insein	Ywathagyi -Rangoon
Morning Peak Time	Hourly Passenger (*1)	Interstation Section	Kamayut-Hletan	Kanbe-Bauktaw	Ywama-Insein	Hninzigon -Mahlwagon
		For 1982	1,533	1,003	268	865
		For 1990	4,146	2,713	725	2,339
	Required Number of Trains per Hour	For 1990	4.7	3.1	2.0 (*2)	2.6
Evening Peak Time	Hourly Passenger (*1)	Interstation Section	Kamayut-Hletan	Myithanyunt -Mahlwagon	Ywama-Insein	Hninzigon -Mahlwagon
		For 1982	1,218	949	241	734
		For 1990	3,294	2,567	652	1,985
	Required Number of Trains per Hour	For 1990	3.7	2.9	2.0 (*2)	2.3
All Day	Hourly Passenger (*1)	Interstation Section	Kamayut-Hletan	Yegu-Paryame	Kyaikkale-Mingaladon Bazaar	Hninzigon -Mahlwagon
		For 1982	766	542	150	301
		For 1990	2,072	1,466	406	814
Off Peak Time	Hourly Passenger (*1)		1,602	1,131	326	429
	Required Number of Trains per Hour	For 1990	2.2	1.6	1.0 (*3)	1.0 (*3)
All Day's Operating Time	Total Required Number of Train for Day		96	70	44	48

Notes: (*1) At the maximum cross-section
(*2) Operation of a minimum of two trains
(*3) Operation of minimum of one train

Source: Study estimates

Table 7.2.2 Headway Reduction Ratio

Section	Current Number of Trains	Number of Trains in Initial Year
Rangoon-Insein	62	96
Rangoon-Mingaladon Cantt	52	
Rangoon-Mingaladon Bazaar		70
Insein-Mingaladon Cantt	32	
Insein-Mingaladon Bazaar		44
Rangoon-Thingangyun	38	48
Thingangyun-Togyaunggale	24	32
Togyaunggale-Ywathagyi	6	12
Total	214 (A)	302 (B)
	(A)/(B): 70.9%	

Source: Study estimates

7-2-2 Train Operation Diagram and Number of Scheduled Trains

The train operation diagram is determined on the basis of the above studies, and the number of scheduled trains calculated as follows.

(1) Train operation diagram

The organization of the train operation diagram is made with reference to the structure of the line arrangement, the time requirements of transport demand, the division of block sections, and the other equipment conditions.

The operating diagram proposed for application in the initial year of electric traction, is given in Appendix 3.

The maximum [hourly] number of peak time scheduled trains is set at five while the minimum headway determined for the peak time operation is nine minutes.

(2) Number of scheduled trains

The numbers of trains for different sections and lines are shown in Fig. 7.2.1.

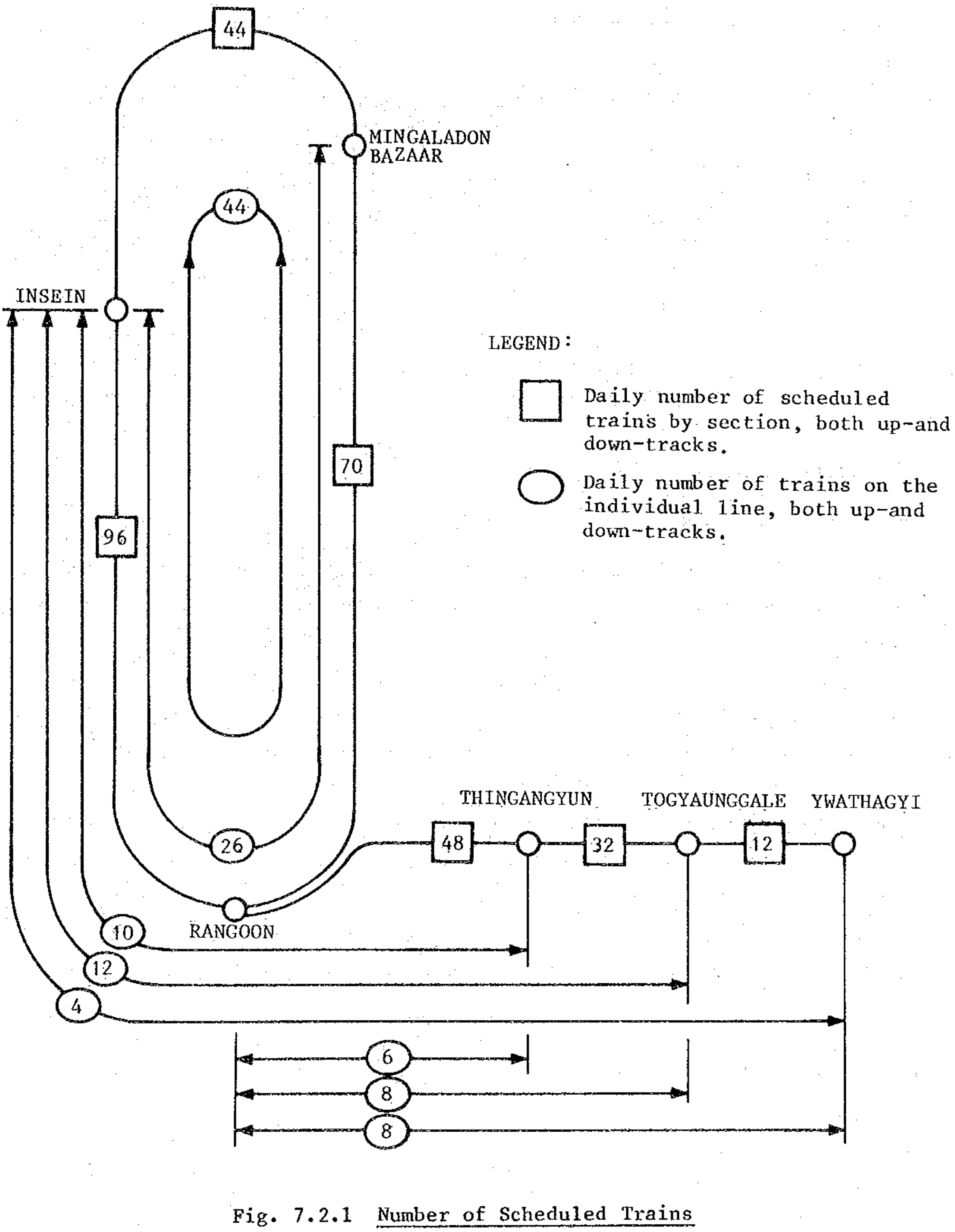


Fig. 7.2.1 Number of Scheduled Trains

Source: Study draws

(3) Long-term transport plan

The train diagram modifications planned for fiscal 2000 and 2010 to meet the long-term railway demand, will use essentially the same manner employed in the plan for 1990.

Table 7.2.3 Long-term Transport Plan

Fiscal Year	Average Headway During Peak Time (minutes)	Train-km (km/day)	Total Number of Scheduled Trains	Train Units Required (unit)
1990	12	3,939.2	302	16
2000	10	4,952.6	368	21
2010	7.5	6,358.4	458	26

Source: Study estimates

7-3 Utilization of Rolling Stock

7-3-1 Rolling Stock Utilization Concept

The utilization or allocation to service of rolling stock depends on the train operating diagram established for the initial year of electric traction.

The utilization of electric locomotives is centralized at the Insein shed. Electric locomotives begin to arrive about 20:00 every evening and are housed on the storage tracks in the shed after Grade-A inspection.

The utilization of carriages is based at the Insein and Rangoon sheds. At the Rangoon shed, carriages are presently housed overnight in train form, while at the Insein shed some carriages are kept next to the platforms overnight because of limited shed space.

Locomotives with carriages scheduled to begin or end the day's operation at Rangoon station, are deadheaded between Rangoon and Insein stations.

7-3-2 Train Kilometres

An effective plan is made for utilization of rolling stock, based on the above-mentioned conditions.

Table 7.3.1 shows the estimated electric locomotive running kilometres for the initial year of electric traction.

Table 7.3.1 Train Kilometres per Day (1990)

Section	Item	Present	Electrification	Difference
Rangoon – Rangoon	Operation Trains	87	96	9
	Train-km	2229.0	3340.0	1111.0
	Locomotives	8	(*)	
Rangoon – Ywathagyi	Operation Train	38	48	10
	Train-km	435.8	599.2	163.4
	Locomotives	2	(*)	
Total	Operation Trains	125	144	19
	Train-km	2664.8	3939.2 (A)	1274.4
	Locomotives	10	16 (B)	6
			(A)/(B): 246.2	

Remark: (*) Locomotives are used in common with the Circular and Suburban Lines

Source: Study estimates

7-3-3 Numbers of Rolling Stock

Table 7.3.2 shows the estimated numbers of electric locomotives and carriages for the initial year of electric traction as well as for the later years.

Table 7.3.2 Numbers of Electric Locomotives and Carriages

	1990		2000		2010	
	EL	Carriages	EL	Carriages	EL	Carriages
Circular and Suburban Lines	16	96	21	126	26	156
Maintenance and Stand-by	3	9	3	10	5	17
Total	19	105	24	136	31	173

Source: Study estimates

7-4 Education and Training

An appropriate education and training program must be instituted to provide instruction in the structure and operation of new electric locomotives to the drivers and maintenance crew at both rolling stock sheds. Also, high-level training for instructors will be given through programmes including studying abroad.

7-4-1 Drivers

A fixed-length course of theoretical instruction and on-the-job training must be instituted to educate the junior and senior drivers at the Insein Diesel shed.

The on-the-job training program must include the driving of an actual electric locomotive on a pilot section (cf. Chapter 9).

The length of the theoretical instruction and on-the-job training should be at least four and two months, respectively.

7-4-2 Maintenance Crew

Essentially similar education and training as for the crew must be instituted to educate the service staff at Insein shed. A course for maintenance, repair and safety supervision should also be included.

The length of the theoretical instruction and on-the-job training for the maintenance crew should be at least 3.5 and 1.5 months, respectively.

7-5 Safety Assurance

A safety assurance scheme is fully instituted in the electrification project. In this scheme, warning signs are provided at level crossings to warn drivers of the high-voltage lines, and barriers positioned to prevent the passage of vehicles with loads higher than the available clearance.

Moreover, every bridge over the track will have a guard fence on both sides to prevent people from touching the wires.

Other measures such as educating the people not to walk on the tracks, or ride on the roofs of carriages must also be instituted.

CHAPTER 8 RAILWAY ELECTRIFICATION PLAN

CHAPTER 8 RAILWAY ELECTRIFICATION PLAN

8-1 Basic Plan for Railway Facilities

8-1-1 Feeding System

(1) Types and characteristics of AC feeding systems

The available types of AC feeding systems and their characteristics are outlined in the following.

a. Simple feeding system

The simple feeding system is the most basic system and consists of the overhead contact line and the rail. The negative feeder (NF) simple feeding system is a variation in which the NF is extended along the rail and connected with the rail at every several kilometres by a connecting wire. This facilitates protective detection when insulator flashover occurs in the feeding circuit, and also serves to decrease the impedance of the feeding circuit.

The features of the simple feeding system (with NF) are as follows:

(a) This circuit is the most economical and the easiest to maintain since its feeding circuit is the simplest.

(b) Inductive interference to telecommunication lines is great.

(c) Rail potential is higher than that of other feeding systems.

(d) The feeding substation interval is about 50 kilometres.

b. Autotransformer (AT) feeding system

The AT feeding system is a system where the feeding voltage from the substation is increased to a level higher than the catenary line voltage (twice the catenary voltage in case of JNR), and then decreased to the required catenary line voltage by autotransformers located at every 10 to 15 kilometres along the track to supply power to the electric rolling stock.

The features of the AT feeding system are as follows:

(a) As the feeding voltage from the substation is high, it is suitable for supply of large power.

(b) Inductive interference to telecommunication lines is small.

(c) The feeding circuit is complicated as it requires another feeding wire.

(d) The substation interval is about 100 to 120 kilometres.

c. Booster transformer (BT) feeding system

The BT feeding system is a system by which the return current flowing in the rail is boosted by the booster transformers provided about every 4 kilometres and the BT section provided on the overhead contact line.

The BT system is divided into two types, in which one has the rail section insulated and the booster transformers inserted between the catenary line and rail, and the other having one NF provided and current boosted to the NF.

The features of the BT feeding system (with NF) are as follows:

(a) The inductive interference to telecommunication lines is smaller than for other feeding systems.

(b) The composition of the feeding circuit is complex because of the provision of the BT sections.

(c) The feeding substation interval is about 40 kilometres.

(2) Feeding systems of Circular and Suburban Lines

The optimum location of the railway substation is the place near the centre of loads for train operation and near the substation available as the power supply. Based on these conditions, the location of the railway substation is selected near Mahlwagon junction.

As the Circular Line is a loop, a feeder circuit is equivalent to a substation interval of 45.9 kilometres. The Suburban Line runs a distance of 16.2 kilometres between Mahlwagon and Ywathagyi. Therefore, the simple feeding system is selected because of the feeding distance.

(3) Feeding system diagram

Composition of the feeding system includes considerations and decisions on the following:

(a) The power supplied from Mahlwagon substation consists of two single-phase power supplies of different phases fed to Rangoon and Mingaladon Bazaar. The loads for train operation should be balanced for each phase as far as is possible.

(b) Dead sections are provided as points where two different phases meet.

(c) During maintenance and in case of accident to one overhead contact line, the power source for the other overhead contact line (section) should be secured as far as possible by a disconnecting switch.

(d) At the Insein shed, a 24-hour power source is required for the continuous inspection of rolling stock and so power should be readily supplied from either phase to the Insein shed.

(e) The effects to the Circular and Suburban Lines should be minimized when the overhead contact line is earthed due to mishandling during the rolling stock inspection in the Insein shed.

A feeding system satisfying these conditions is shown in Fig. 8.1.1.

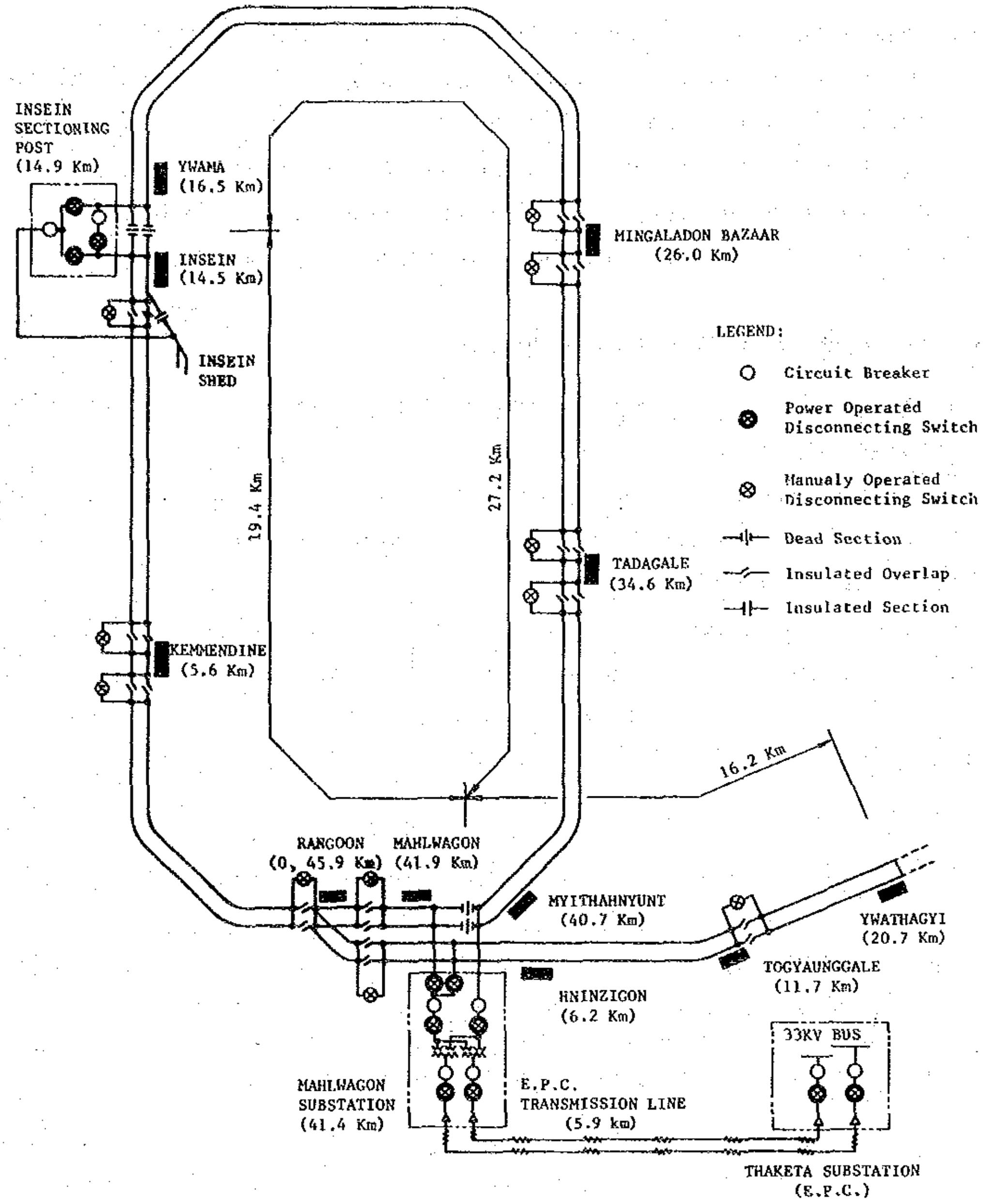


Fig. 8.1.1 Feeding System of the Circular and Suburban Lines

Source: Study draws

8-1-2 Rail Potential

The rail potential is set at 60 V maximum at a target value.

There is a trial calculation under following conditions:

(a) the rail is connected at every four kilometres with negative wires,

(b) the leakage admittance to earth of the rail is one siemens/kilometre,

(c) the load current is 100 A.

The result shows that the rail potential is less than 20 V.

In this electrification plan, the conditions are as follows:

(a) the negative wire is connected at every kilometre for the sake of safety measures against drop of the rail bond,

(b) The admittance is more than one siemens/kilometre,

(c) the maximum current of an electric locomotive is about 60A.

Thus the rail potential is far less than the target value.

8-1-3 Clearance under the Road Overbridges

There are 16 road bridges, with heights with respect to the rail level being as shown in Table 5.3.3.

As countermeasures to lack of the clearance, lowering the roadbed, installation or replacement of road overbridges, and raising the road overbridges may be considered.

Electric locomotive traction is adopted. It enables lowering the heights of the roof of the locomotives and of the overhead contact wires. Therefore, the lack of clearance under the road overbridges can be technically solved by lowering the roadbed.

(1) Electric clearance

The electric clearance is decided in conformity with the UIC code 606 (non-polluted area).

The static clearance between live conductors and the earth is selected as the minimum value of 200 mm in the code.

(2) Minimum height of overhead contact wire above rail level

The minimum height of the overhead contact wire is set at 3,800 mm by adding the height of maximum moving dimension (3,505 mm) and the electric clearance (290 mm) determined by the UIC code. This requires lowering of a part of the locomotive roof to mount the pantograph. The driver comfortability is nevertheless maintained by proper design of the locomotives.

(3) Clearance beneath road overbridges

The clearance beneath road overbridges is set at 4,100 mm by summing the following:

Minimum height of overhead contact wire (3,800 mm)
Dip of the overhead contact wire (50 mm)
Diameter of overhead contact wire (12.34 mm)
Dynamic lift of overhead contact wire (50 mm)
Allowance to displacement of overhead contact wire (10 mm)
Brief period clearance between live conductor and earthed structure (170 mm)

8-1-4 Height of Overhead Contact Wire above Rail Level

(1) Minimum height

From section 8-1-3, the minimum height of the overhead contact wire is set at 3,800 mm.

(2) Maximum height

The maximum height of the overhead contact wire is set at 5,200 mm. The height of the overhead contact wires above roads is stipulated by bylaw as being not less than 17 feet (5,182 mm).

For reference, the maximum loading height of automobiles is set at 14 feet (4,268 mm) by Municipal Bylaw. This height gives sufficient safety clearance below the 25 kV overhead contact wire.

(3) Standard height

The standard height of the overhead contact wire is set at 4,500 mm, which is at the middle of vertical range of pantograph movement and therefore provides a stable current collection.

8-1-5 Rolling Stock Gauge

The rolling stock gauge of AC electrified sections is determined on the basis of the present rolling stock gauge (cf. Fig. 8.1.2) and the rolling stock pantograph gauge.

(a) The gauge to the roof-top device, when the pantograph is folded, is set at 3,505 mm.
(b) The gauge, when the pantograph is fully expanded, is set at 5,380 mm.

The rolling stock gauge defined above, is illustrated in Fig. 8.1.3.

(Unit: mm, ( ); inch)

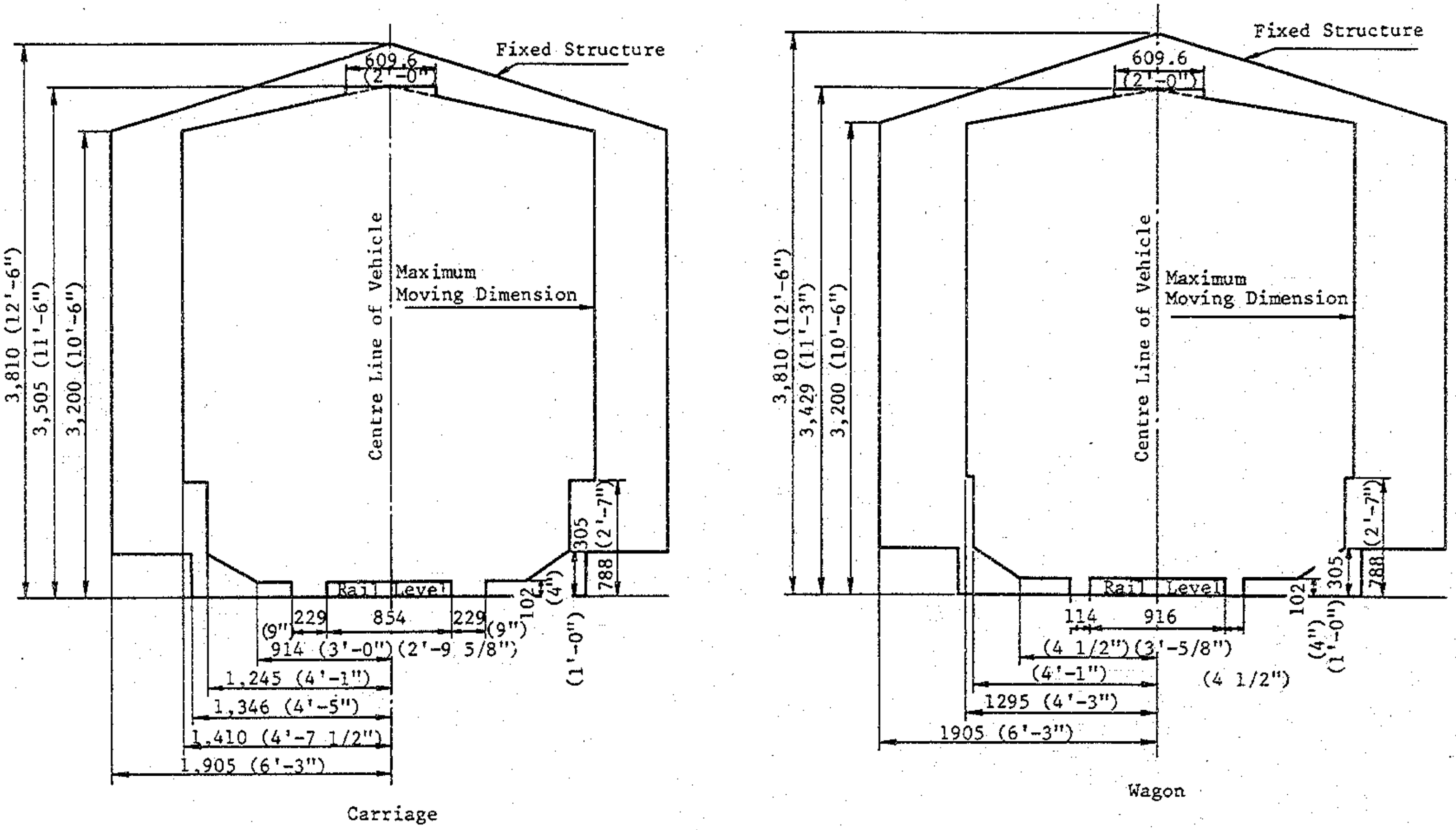
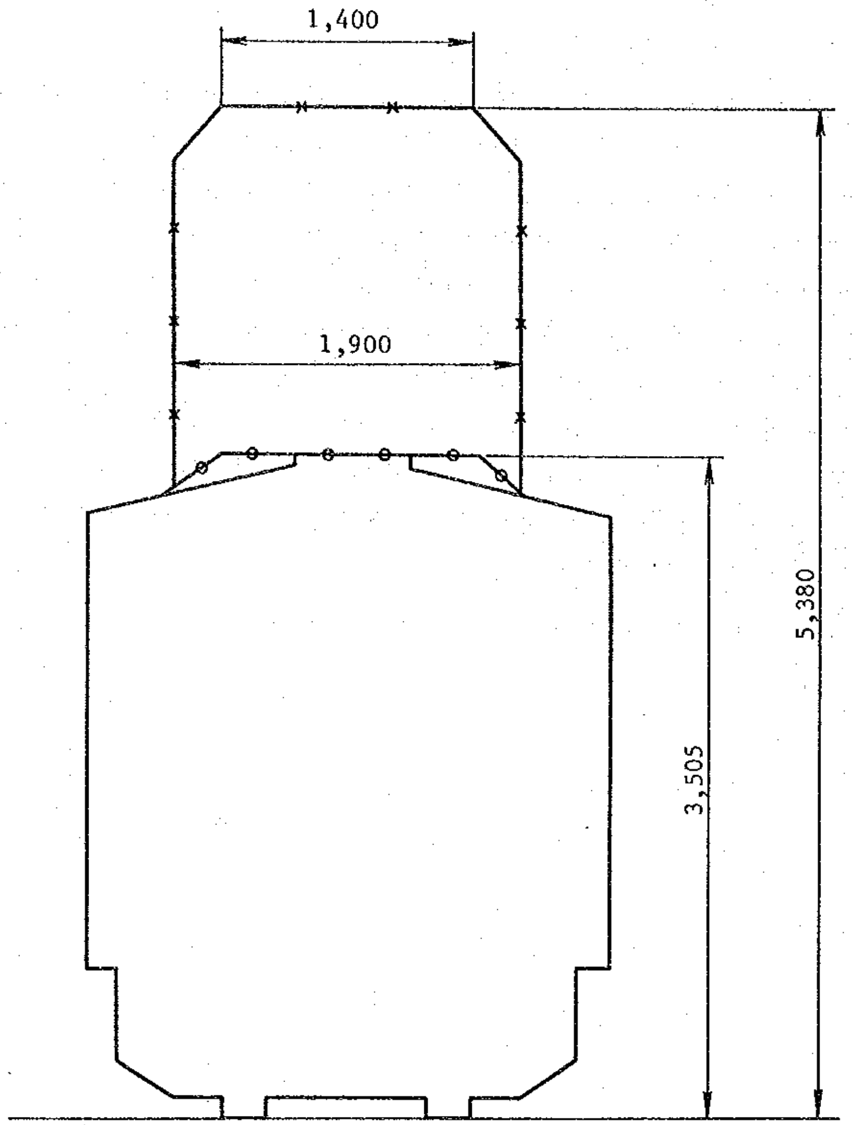


Fig. 8.1.2 Maximum Moving Dimensions for Rolling Stock

Source: B.R.C.

(Unit: mm)



LEGEND:

Maximum moving dimension for rolling stock

Rolling stock gauge, when the pantograph is folded down

Rolling stock gauge, when the pantograph is fully expanded

Fig. 8.1.3 Rolling Stock Gauge after Electrification

Source: Study draws

8-1-6 Construction Gauge

The construction gauge of the AC electrified section is determined for the following three cases.

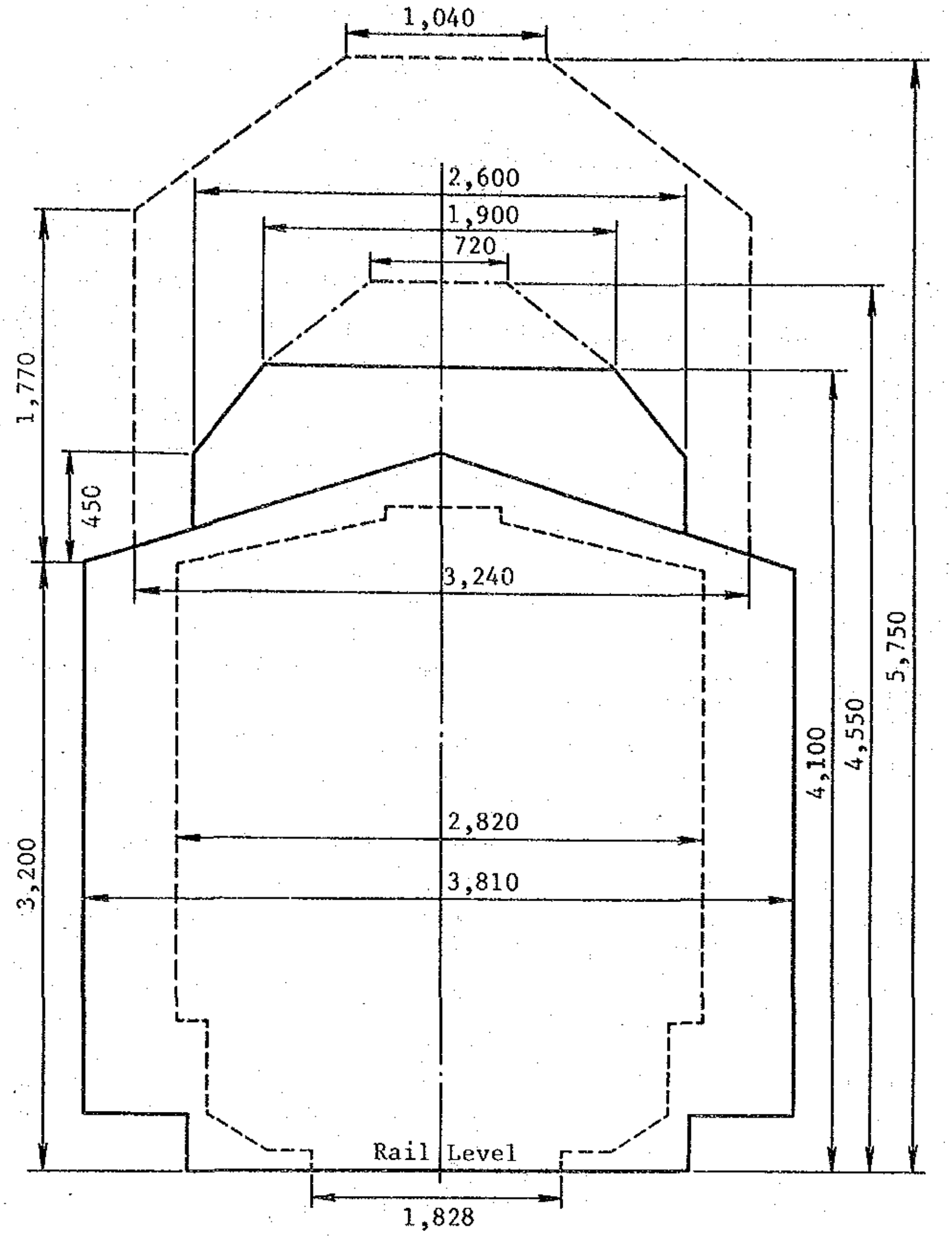
(a) The gauge applied to the case in which the standard height of the overhead contact wire (4,500 mm) is adopted.

(b) The gauge applied to the case in which the minimum height of the overhead contact wire (3,800 mm) is adopted.
This gauge is applied to the station structures (passenger overbridges, roofs, etc.)in order to secure electrical clearance between the live conductors and earthed structures.

(c) The gauge applied to the case in which the minimum height of the special overhead contact wire (3,800 mm) is adopted.
This gauge is applied to the road overbridges to secure clearance beneath road overbridges.

These three construction gauges are detailed in Fig. 8.1.4.

(Unit: mm)



LEGEND:

- - - - - For Standard height of overhead contact wire

-·-·-·- For Minimum height of overhead contact wire (applied to passenger overbridges, roofs of stations, etc.)

——— For Minimum height of special overhead contact wire (applied to road overbridges)

Fig. 8.1.4 Construction Gauge

Source: Study draws

8-1-7 Meteorological Conditions

The electric facilities are planned using the meteorological records and those for damage to railway facilities by inclement weather.

(1) Special weather conditions

a. Earthquakes

The records of earthquakes with a magnitude of greater than 6 (MM scale) over the past 100 years, are given in Table 8.1.1. According to these records, the maximum value ever recorded is 7, and the value corresponds to IV (moderate earthquake) of the Japanese seismic intensity scale.

Table 8.1.1 Earthquakes in Rangoon (More than MM scale 6)

Date of Occurrence	Intensity	Remarks
July 23 1884	Moderate	
Dec. 17 1927	Moderate (MM Scale 6)	Caused certain damage in Rangoon.
May 5 1930	Felt Strongly at Rangoon (MM Scale 6)	Pegu Earthquake. Caused total destruction together with 500 deaths at Pegu. Caused considerable damage and 50 deaths in Rangoon.
Feb. 9 1969	Moderate (MM Scale 6)	Cracked some buildings in Rangoon.
Sep. 9 1970	Moderate (MM Scale 7)	Cracked over 60 buildings in Rangoon and caused many instances of falling plaster. Bells fell off Shwedagon Pagoda.

Source : Department of Meteorology and Hydrology
Remarks: MM Scale - Modified Mercallit Scale

b. Lightning

Records of visual observation indicate that thunderstorms occur on an average of 35 days per year.

c. Cyclones

Cyclones occur during the months of May to October, but pass through Rangoon only once every four years. The maximum wind velocity of cyclones upon reaching Burma exceeds 100 miles/hour (44.7 metres/second), but weakens to 70 miles/hour (31.3 metres/second) by the time the cyclone passes Rangoon (cf. Table 8.1.2).

Table 8.1.2 Tornados and Cyclones in Rangoon

Date of Occurrence		Remarks
Tornados	1950	At Rangoon Station. Caused 11 deaths and 41 persons injured.
	July 8 1959	At South Okkalapa. Caused 160 houses damage and 10 persons injured.
Cyclones	May 7 1975	Bassein Cyclone. Maximum wind speed: 70 miles/hour at Rangoon. Caused considerable damage to houses in the suburbs of Rangoon.
	May 5 1982	Gwa Cyclone. Maximum wind speed: 70 miles/hour at Rangoon. Caused considerable damage to houses in the suburbs of Rangoon.

Source : Department of Meteorology and Hydrology

(2) General weather conditions

Table 8.1.3 shows the weather conditions recorded for the past 30 years at Rangoon.

a. Precipitation

The rainy season of Rangoon is from May through October. A maximum 24-hour precipitation of 262 mm was recorded in May, 1980, but the rain actually fell continuously for two to three hours out of the recorded 24 hours.

b. Temperature

The maximum temperature is 41.1°C and the minimum temperature 13.3°C, the difference between the two being only 27.8°C.

c. Wind velocity

The maximum wind velocity is due to the effect of cyclones, and is 31.3 metres/second.

Table 8.1.3 Meteorological Statistics of Rangoon (1950 - 1983 Mean)

Description by Month		Maximum	Minimum
Rainfall	mm	609.6 (Aug.)	2.9 (Feb.)
No. of Rainy Days	days	25.11 (Aug.)	0.21 (Mar.)
Heaviest Rainfall in 24 Hrs	mm	262.0 (May)	22.0 (Feb.)
Highest Maximum Temperature	°C	41.1 (May)	34.4 (Sep.)
Lowest Minimum Temperature	°C	21.7 (Jun.Sep.)	13.3 (Jan.)
Maximum Wind Speed	metres/ second	31.3 (May)	12.5 (Jan.)

Source: Department of Meteorology and Hydrology

(3) Inundation of railway tracks

The rainy season of Rangoon lasts six months, and there is considerable precipitation, with railway tracks often being inundated. Records for this for 1983 are shown in Table 8.1.4.

Table 8.1.4 Railway Track Inundation (1983)

Particulars	Sections (km)	Period (min)	Number of Occurrences
Sections Inundated above Rail Head	Rangoon Railway Station Yard	5 - 40	3
	0.13 - 1.21	5	1
	3.15 - 3.42	10	1
	3.76 - 4.29	10 - 50	3
	5.63 - 5.97	15	1
	6.44 - 6.97	5	1
	43.02 - 43.83	5	1
Sections Inundated between Rail Head and Sleeper	4.83 - 5.16	-	3
	45.16 - 45.36	-	5

Source: B.R.C.

(4) Basic conditions of electric facilities

These meteorological data set the conditions for the facilities, as follows:

(a) The maximum seismic intensity is set at MM scale 7.

(b) Though the maximum wind velocity is 70 miles/hour (31.3 metres/second) on the record, the Burmese building standard of 80 miles/hour (35.8 metres/second) is set as the basis.

(c) Drainage of the sections is considered as a precaution against the inundation of railway tracks.

(d) 42°C maximum and 13°C minimum atmospheric temperatures, with a difference of about 30°C, is set as the basis.

8-2 Rolling Stock Plan

8-2-1 General Requirements

The basic requirements in deciding the performance of electric locomotives are as below.

Electrification system	Single-phase AC 25 kV. 50 Hz.
Rolling stock gauge	The current B.R.C. rolling stock gauge (cf. Fig. 8.1.2.)
Track requirement	
Gauge	1000 mm
Allowable axle load	12 tons
Grade	Maximum 5‰
Curve	Minimum radius 291 metres
Running requirement	
Maximum design speed	80 kilometres/hour
Distance between stations	

	Minimum	Maximum
Circular Line	0.4 km	2.8 km
Suburban Line	0.8 km	9.0 km

Hauling load — Carriage train

When made up of 6 carriages, 195 tons

When made up of 8 carriages, 260 tons

8-2-2 Outline Specification of Electric Locomotive

(1) Requirements in deciding the performance of electric locomotives

a. Train weight

(a) Electric locomotives

Maximum axle load as 12 tons on the basis of the current track requirement of B.R.C.

4 axles, 48 tons

(b) Carriages

Trains are planned to be configured of six carriages.

Tare weight	25 tons
Weight of loaded car	32.5 tons

b. Train resistance

The train resistance is the sum of the running, starting, grade and curve resistances.

These resistances vary with the structure of the vehicle and the track, and the formulas gained from experimental data differ between countries. The JNR formula is used for the electric locomotives and carriages with roller bearings.

c. Acceleration and deceleration

The designed acceleration and deceleration are both to be 1.7-1.8 kilometres/hour/second.

d. Adhesive coefficient

The adhesive coefficient is an important value in relation to the train tractive force (or brake) and varies widely with the rail condition.

The adhesive coefficient (μ) of AC electric locomotive is based on the experimental results of JNR, as below.

$$\mu = 0.28$$

e. Adhesive tractive force

The adhesive tractive force (Ta) of electric locomotives is given below based on the above requirements.

$$Ta = 13,440 \text{ kg}$$

(2) Electric locomotive performance

The performance curve of the planned electric locomotives and the characteristic curve of the traction motor are shown in Fig. 8.2.1 and Fig. 8.2.2.

(3) Outline of electric locomotive

a. General arrangement and main features

The general arrangement and the main features are shown in Fig. 8.2.3 and Table 8.2.1 respectively.

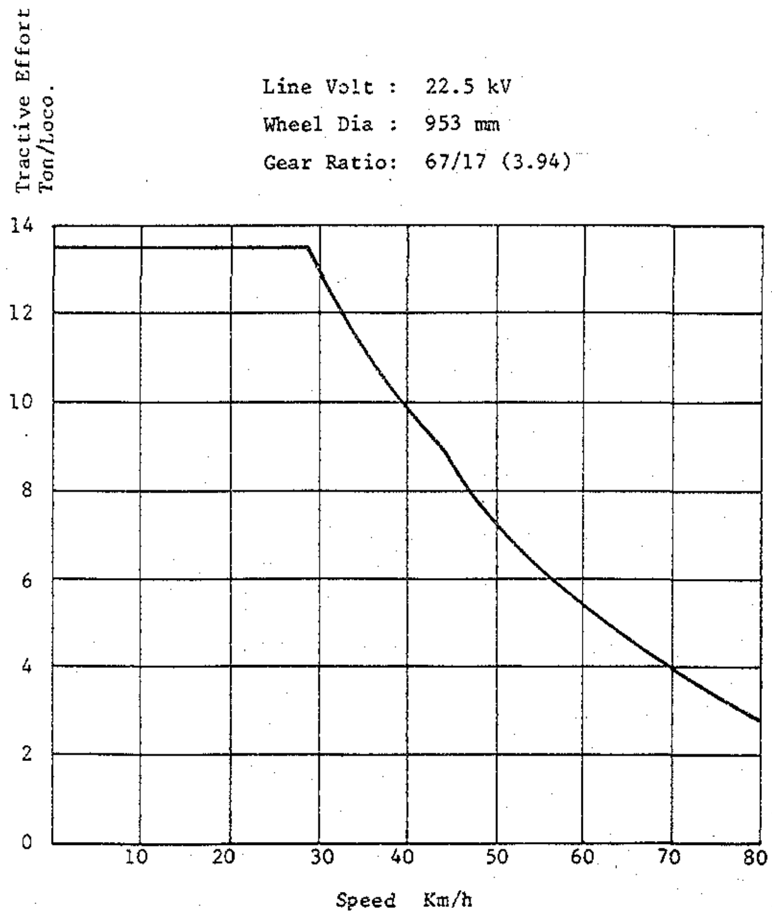


Fig. 8.2.1 Performance Curves

Source: Study draws

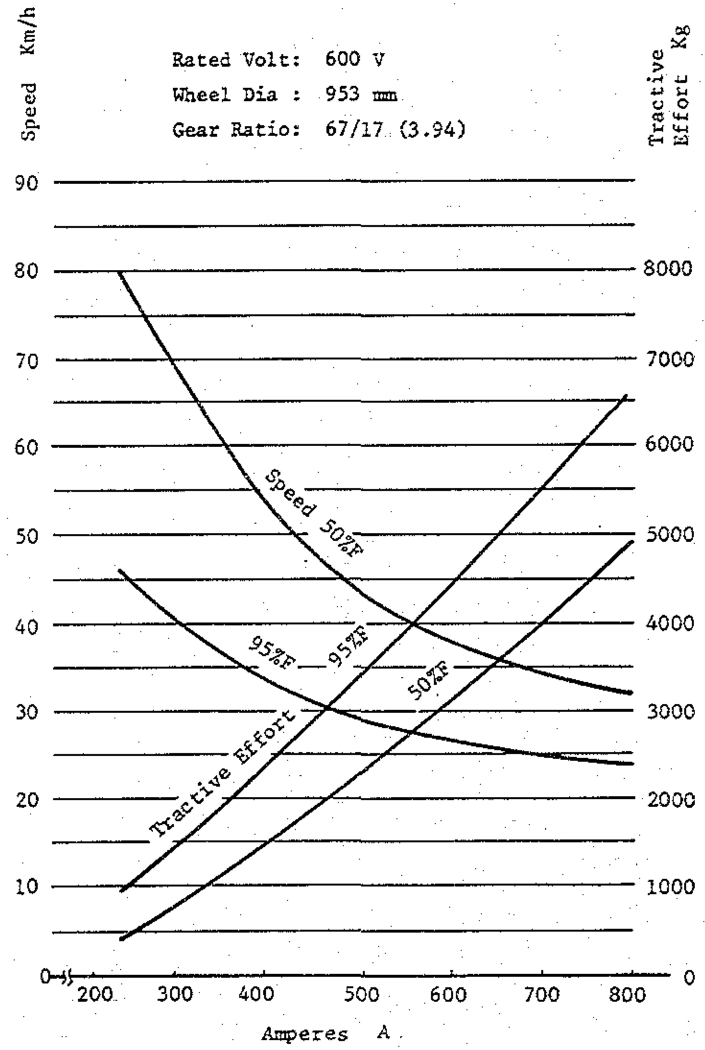
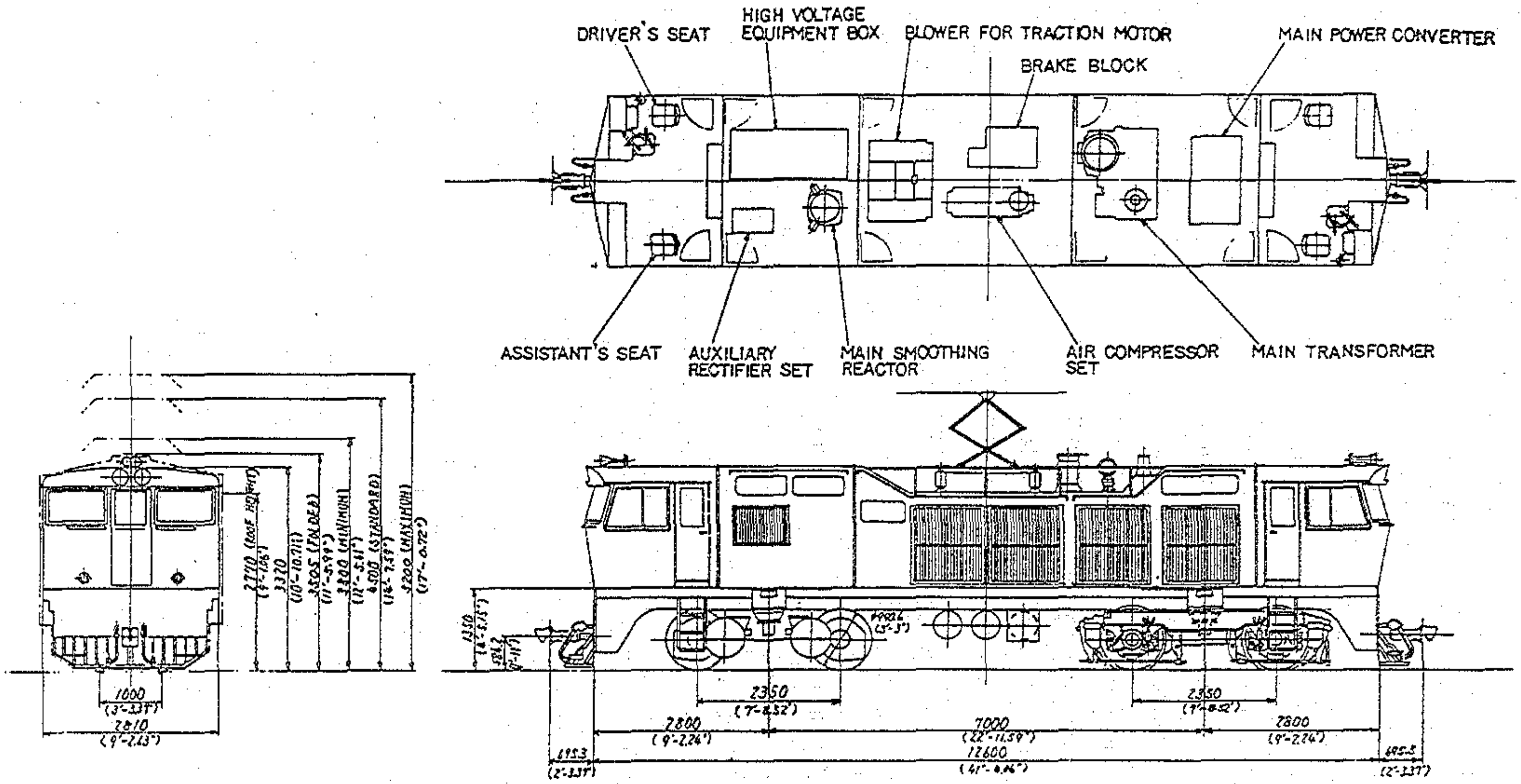


Fig. 8.2.2 Characteristic Curves

Source: Study draws



WEIGHT IN WORKING ORDER	48,000 kg (105.480 Lb)
MAXIMUM AXLE LOAD	12,000 kg (26.460 Lb)
ELECTRIC SYSTEM	AC 25,000V 50 Hz
OUTPUT POWER	1,000 KW AT 30 Km/h (18.6 mile/h)
MAXIMUM SPEED	80 Km/h (50 mile/h)
CONTROL SYSTEM	THYRISTOR CONTROLLED WITH SILICON RECTIFIER

BRAKE SYSTEM	AIR BRAKE SYSTEM HAND BRAKE FOR TWO BOGIES
WHEEL ARRANGEMENT	Bo - Bo

Fig. 8.2.3 General Arrangement of Electric Locomotives

Source: Study draws

Table 8.2.1 Main Features of Electric Locomotive

Electric System			25 kV AC 50 Hz
Form of Locomotive			Double Box Cab Type
Axle Arrangement			Bo-Bo
Weight	Working Order	(t)	48.0
	Axle Load	(t)	12.0
Main Dimensions	Maximum Length	(mm)	13,990
	Maximum Width	(mm)	2,810
	Maximum Height	(mm)	3,505
	Total Wheel Base	(mm)	9,300
	Bogie Wheel Distance	(mm)	7,000
	Pantograph Folded Height	(mm)	3,505
Bogie	Rigid Wheel Base	(mm)	2,300
	Wheel Diameter	(mm)	990
Performance	Continuous Rated:		
	Output	(kW)	1,000
	Tractive Effort	(kg)	12,000
	Speed	(km/h)	30
Maximum Service Speed		(km/h)	80
Axle Drive System			Single reduction gear with axle-suspension traction motor drive
Traction Motor	Type		Pulsating current, series wound, 4-poles, forced ventilated, axle-suspension type
	Continuous Rating	(kW)	250
		(A)	460
		(V)	600
Gear Ratio			17:67 = 1:3.94
Control System			Thyristor controlled with silicon rectifier
Brake System			Air brake system. Hand brake for two bogies
Main Transformer	Type		Shell form, oil forced air forced cooled
	Continuous Rating	(kVA)	1,365/1,285/80
		(V)	22,500/820 × 2/200

	Type		Single phase, thyristor/diode mixed bridge, Freon-boiling forced ventilation
Main Rectifier	Continuous Rating	(kW)	1,104
		(A)	920×2
		(V)	600
Auxiliary Machines			Main transformer blower
			Main rectifier blower
			Traction motor blower
			Air compressor
			Auxiliary air compressor

Source: Study estimates

b. Features of electric locomotive

(a) Selection of thyristor bridge phase control

Although speed control systems such as tap and phase control for AC electric locomotive are feasible, the thyristor phase control system is selected since it is a system capable of continuous control, improves the adhesive performance, and also because it has no abrasive mechanical parts and is easy to maintain.

(b) Selection of double box cab type

The double box cab type is preferable to the single cab semi-centre type because it has a wider forward visual field from the driver's seat. This increases the degree of safety since many pedestrians walk along the track. The double box cab type is also advantageous for the machine arrangement.

(c) Relation of rolling stock gauge and insulation distance

The rolling stock gauge is defined by the folded height of the pantograph and from the fact that the energized instruments on the locomotive roof must be within the height of the current B.R.C. maximum moving dimension of 3,505 mm. A safety fence on both sides is installed since the roof is low.

8-2-3 Outline Specification of Carriage

(1) Premises of plan

Premises for the newly planned carriage are as follows.

(a) High acceleration and deceleration require air brakes.

(b) Accommodation fitting urban passenger transportation is planned.

(c) Nominal passenger capacity includes seating capacity and standing capacity.

(d) Other premises are the same as the current B.R.C. features.

(2) Outline of carriage

a. General arrangement and main features

The carriages to be used at the electrification are limited to reconstructed diesel railcar and newly manufactured carriages with air brakes. In future, new additional carriages will be knock-down carriages.

The general arrangement of the planned carriage is shown in Fig. 8.2.4, main features are as follows.

Form	Steel, two axles bogie
Tare weight	25 tons
Nominal passenger capacity	100 (seating 64, standing 36)
Outside length of car body	18,290 mm
Outside width of car body	2,820 mm
Maximum height	3,405 mm
Side entrance	2 on one side
Brake system	Air brakes

b. Features of carriage

(a) Seat arrangement and entrance

The seat arrangement has cross seats installed at the centre, and long seats near the entrance to reduce confusion at rush times. Two 1,200 mm entrances are on each side.

(b) Nominal passenger capacity

The standing capacity is defined as follows;

Before the long seats	:	4 persons × 8 long seats (with hand holds)
Entrance space	:	2 persons × 2 spaces (with hand holds)

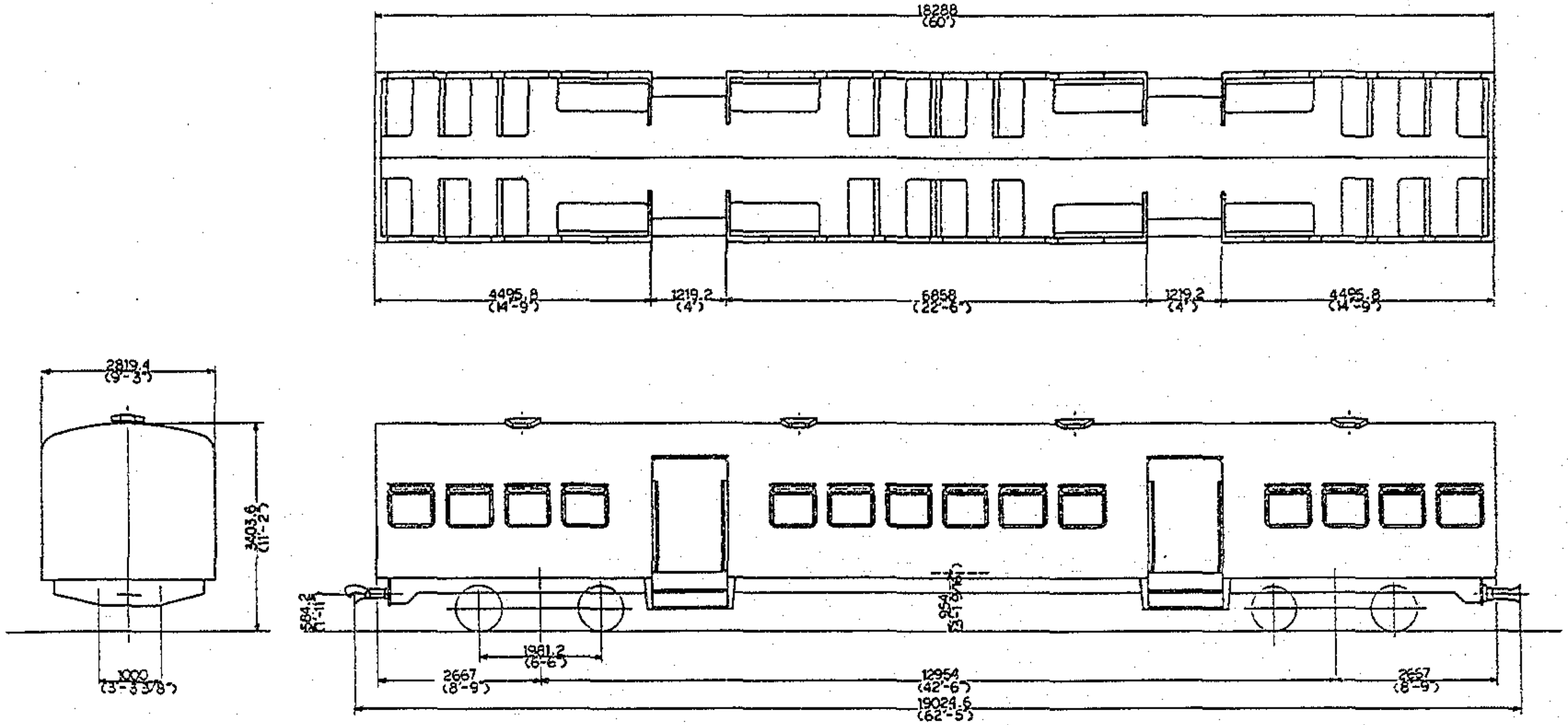
(c) Other equipments

Room lights and fans are furnished in the carriage room.

Axle generators are used as the power source. Gangways and vestibule diaphragms are not provided as before.

c. Conductor's room

A conductor's room is provided in one of the train carriages.



Tare Weight	about	25 tons
Max. Axle Load		10 tons
Passenger Capacity		
Seating		64 persons
Standing		36 persons
Total		100 persons

Fig. 8.2.4 General Arrangement of New Carriages

Source: Study draws

8-3 Electrification Facilities Plan

8-3-1 Power Source

High reliability is required of the power source for electric railways because of their public nature as a railway service.

Furthermore, three-phase imbalances caused to the general three-phase power network by the single-phase load for train operation must not adversely affect other electrical equipment.

(1) Transmission network

The principal power plant, substation and transmission system which are under the control of E.P.C. are as indicated in Fig. 8.3.1.

The Hlawga Substation (120 MVA) is located about 5.6 kilometres north of Golf Course station and is a major substation in Rangoon and receives power by one transmission system from the Kyunchaung gas turbine plant (54 MW), the Chauk gas turbine plant (54 MW) and the Lawpita hydro plant (168 MW). It also receives power by another transmission system from the Ywama gas turbine plant (36 MW) located near Rangoon. The total capacity of these power plants is 272 MW.

The Thaketa substation (100 MVA, future 200 MVA) is being constructed about 4.5 kilometres east of Mahlwagon station to increase power supply in Rangoon. Also, a new transmission system linking the substations of Chauk, Hlawga and Thaketa is being constructed for completion in 1986. The Mann gas turbine plant (36 MW), the Prome gas turbine plant (54 MW) and the Myanaung gas turbine plant (67 MW) will be connected to the new transmission system when it is completed.

In addition, there are the Kyaiklat gas turbine plant (14 MW) which has already been completed and the Sedawgyi hydro Plant (25 MW) and the Kinda hydro plant (14 MW) which are now under construction. These power plants are scheduled to be connected to the existing transmission system in 1986 by three new transmission lines.

When these are complete, almost all power plants will be connected as the one power network system with a total capacity of 524 MW, or nearly double the present level, thus greatly improving the power situation in Burma and the capital city of Rangoon.

Rangoon has two 33 kV transmission systems. One is the transmission system connecting the Ahlon gas turbine plant, the Ywama gas turbine plant and the Hlawga substation and the other is the transmission system

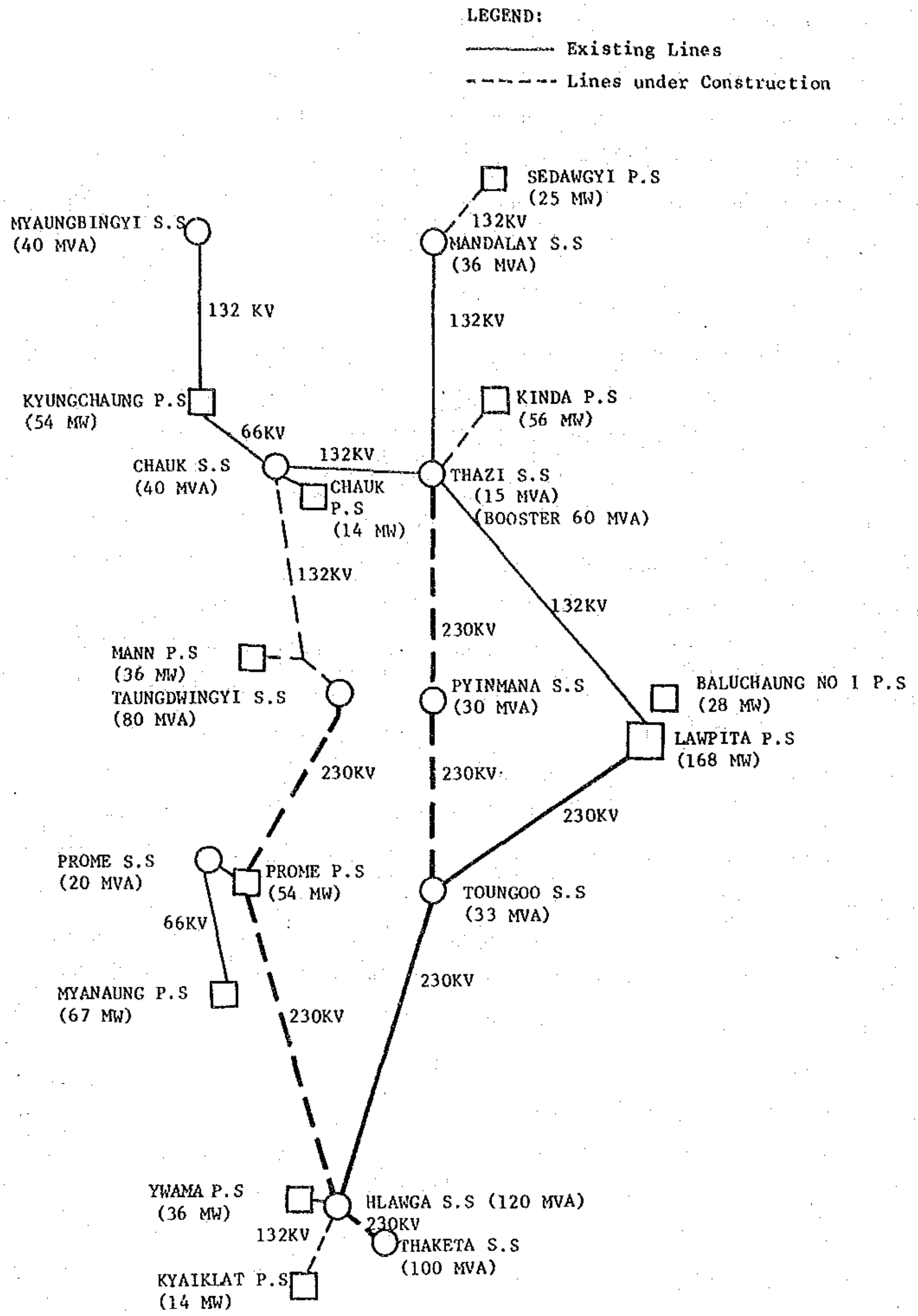


Fig. 8.3.1 E.P.C. Transmission Network

Source: E.P.C.

connecting the Hlawga substation, the Mayangon substation and several small-capacity substations in the city. These transmission systems are being used to the full extent of their capacities.

(2) Electric power for railway electrification

Electric power for railway electrification must be received from a highly reliable substation or transmission line.

Twenty four power failures have occurred at the Hlawga substation during the past three years. These lasted for five to ten minutes, with 15 minutes at the maximum, and were caused by lightning and flashovers. A planned power stoppage takes place once a year for about 12 hours. The present reliability of the Hlawga substation is not high, but a high reliability can be expected to have been achieved at the substations of Hlawga and Thaketa by the time of railway electrification because of the 1986 expansion of the power source network.

Therefore, either the Hlawga substation or the Thaketa substation is suitable as the E.P.C. substation to supply the railway substation for the Circular and Suburban Lines, and in view of the state of load for train operation. It is planned that electric power be received from the Thaketa Substation.

(3) Electric traction power

The daily load curve for electric traction power in the first year of electrification is shown in Fig. 8.3.2.

The Maximum demand per hour is 1,658 kW, and is equivalent to 0.22% of the 1982/83 Burmese electric power capacity, while consumption per year is 7,341 MWh, equivalent to 0.67% of the 1982/83 Burmese power consumption results.

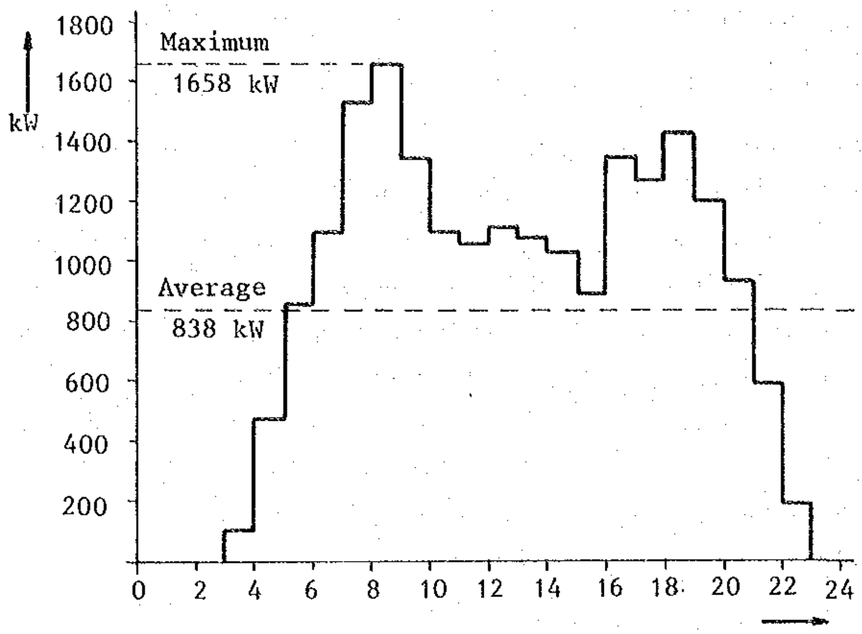


Fig. 8.3.2 Daily Load Curve for Electric Traction Power

Source: Study draws

(4) Effect of railway electrification on the electric power network system

The AC electric traction system requires single-phase power. Therefore, if electric traction power is received from a general three-phase power network, then voltage imbalances and negative-phase current will be caused to the three-phase power source network. Should these exceed the limit values, the electric rotary equipment of general users and the generators at power plants will be adversely affected.

JNR uses Scott connected transformers having two single phases of 90 degree phase difference obtained from the three-phases. This transformer is characterized by a general three-phase power source networks being balanced if the single-phase load of each is equal.

The transformer capacity at the railway substation is 5000 kVA for both M and T phases. The maximum imbalance occurs when one phase is 5000 kVA and the other phase is nil kVA. There is no problem when even in this extreme case, as shown the following calculations.

a. Voltage imbalance

(a) Allowable rate of voltage imbalance

Japanese legislation prescribes that the allowable limit of the voltage imbalance rate be less than 3% of the maximum load averaged for two consecutive hours.

The following equation is used to calculate the voltage imbalance rate:

Voltage imbalance rate $K = |P_M - P_T| \times 100/P_S$ [%]

Here, P_M, P_T: Loads in feeding section of each
Ps : Three-phase short-circuit capacity on secondary side of Thaketa substation

(b) Voltage imbalance rate

The results of calculation of the three-phase short-circuit capacity on the secondary side of the Thaketa substation based on E.P.C. data and the results of calculation of a voltage imbalance rate attained when 5000 kVA is the maximum power imbalance for railway electrification are shown in Table 8.3.1.

Table 8.3.1 Voltage Imbalance Rate at Secondary Side of Thaketa S.S.

Section of Power Stoppage					
Case - 1		Case - 2		Case - 3	
None		Prome P.S. - Hlawga S.S.		Toungoo S.S. - Hlawga S.S.	
Short -Circuit Capacity (MVA)	Voltage Imbalance Rate (%)	Short -Circuit Capacity (MVA)	Voltage Imbalance Rate (%)	Short -Circuit Capacity (MVA)	Voltage Imbalance Rate (%)
378	1.32	291	1.72	292	1.71

Source: Study estimates

b. Negative-phase current

(a) Allowable value of generator negative-phase current

Allowable value of the generator negative-phase current is prescribed in Publication 34-1 of the International Electrotechnical Commission as follows:

Turbine-type generators	8%
Salient pole machines	12%

(b) Negative-phase current

The results of the calculation of the rate of influx of negative-phase current into each power plant based on E.P.C. data and the results of calculation of the rate of negative-phase power for the capacity of each power plant attained when 5000 kVA is the maximum power imbalance for railway electrification are shown in Table 8.3.2.

There is no problem with the rate of negative-phase power of each power plant since it is much smaller than its prescribed value.

Table 8.3.2 Negative-Phase Power Rate at Each Power Plant

Power Plants		Sections of Power Stoppage								
		Case-1 None			Case-2 Prome P.S. Hlawga S.S.			Case-3 Toungoo S.S. Hlawga S.S.		
		Negative -Phase Current Rate between Power Plants	Negative -Phase Power	Negative -Phase Power Rate *at Each* Power Plant	Negative -Phase Current Rate *between* Power Plants	Negative -Phase *Power*	Negative -Phase Power Rate *at Each* Power Plant	Negative -Phase Current Rate *between* Power Plants	Negative -Phase *Power*	Negative -Phase Power Rate *at Each* Power Plant
	MVA	%	kVA	%	%	kVA	%	%	kVA	%
Lawpita	(186)	21.82	1091	0.59	30.11	1505.5	0.81	5.23	261.5	0.14
Kinda	(70)	6.54	327	0.47	8.09	404.5	0.58	2.48	124	0.18
Sedawgyi	(27.776)	3.27	163.5	0.59	4.04	202	0.73	1.24	62	0.22
Myanaung	(87.625)	12.71	635.5	0.73	2.10	105	0.12	18.32	916	1.05
Kyunchaung	(75.75)	9.12	456	0.60	7.62	381	0.50	7.02	351	0.46
Prome	(75)	11.84	592	0.79	1.96	98	0.13	17.06	853	1.14
Ywama	(50)	20.08	1004	2.01	30.77	1538.5	3.28	30.58	1529	3.06
Mann	(50)	4.99	249.5	0.50	2.47	123.5	0.25	5.57	278.5	0.56
Kyaiklat	(19.215)	7.26	363	1.89	11.12	556	2.89	11.05	552.5	2.88
Chauk	(19.215)	2.58	129	0.67	2.15	107.5	0.56	1.99	99.5	0.52
Total		100	5000		100	5000		100	5000	

Source: Study estimates

(5) Transmission facilities

The cost of constructing transmission equipment at the Thaketa substation and the transmission lines between the Thaketa substation and the Mahlwagon railway substation will be paid from the electrification expenses. However, the work on this equipment and their maintenance will be the responsibility of the E.P.C.

The equipment are as follows:

(a) Since the voltage on the secondary side of the Thaketa substation is scheduled to be increased to 66 kV in the future from 33 kV at the time of completion of the substation, the voltage class of the equipment is set at 66 kV.

(b) Because of the public nature of railways, two circuits, one for normal use and one as a reserve, are to be used for the transmission equipment and the transmission line of the Thaketa substation.

(c) The transmission lines are the underground cables required by E.P.C.

(d) The transmission lines are 200 mm^2 CV cable (triplex type).

8-3-2 Substation Facilities

(1) Substation

The substation is of the outdoor type and its one line diagram is as shown in Fig. 8.3.3. Its layout equipment is as shown in Fig. 8.3.4.

a. Power receiving equipment

Two circuits are used for the power receiving equipment. One is for normal use while the other is kept as a reserve.

No lightning arrester is provided because reception from the Thaketa substation is by underground cables. Though 33 kV is initially used for power reception at the time of electrification, the voltage class of all receiving equipment is for 66 kV, in consideration of the proposed increase to 66 kV.

b. Main transformers

As feeding transformers, two Scott-connected transformers of 10,000 kVA capacity apiece are installed. Double tapping for 33 kV and 66 kV is used for easy handling by future tap changes.

c. Feeding equipment

Feeding circuit breakers are provided at one circuit each for the M-phase and the T-phase: one, for Mingaladon Bazaar and the other, for Rangoon and the Suburban Line.

A reserve feeding circuit breaker common to two circuits is provided.

Each feeding circuit is protected with a distance relay (44F) and a back-up relay (50F) with a fault locator which can easily detect the point of fault.

d. Operation of apparatus

The apparatus is manually operated by the electric power dispatcher.

(2) Sectioning post

The sectioning post is of the outdoor type and its one line diagram and its layout of equipment are as indicated in Fig. 8.3.4 and Fig. 8.3.5 respectively.

a. Extended feeding equipment

A circuit breaker is installed to extend the feeding for emergency and maintenance.

b. Feeding equipment for rolling stock shed

A circuit breaker is installed to supply power to the Insein shed.

c. Operation of apparatus

The apparatus is manually operated under the telephone directions of the electric power dispatcher.

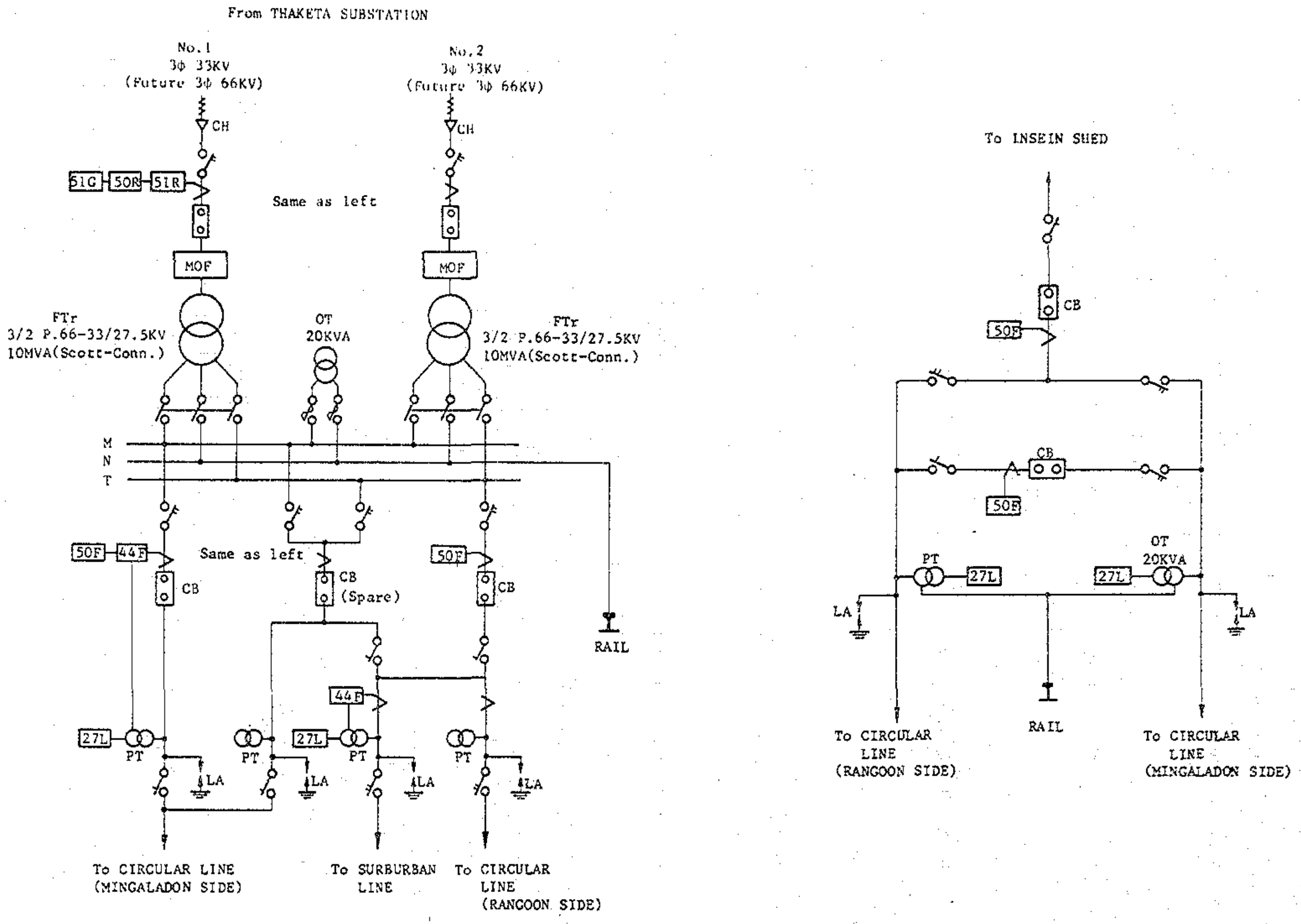


Fig. 8.3.3 <u>One-Line Diagram for Railway Substation and Sectioning Post</u>

Source: Study draws

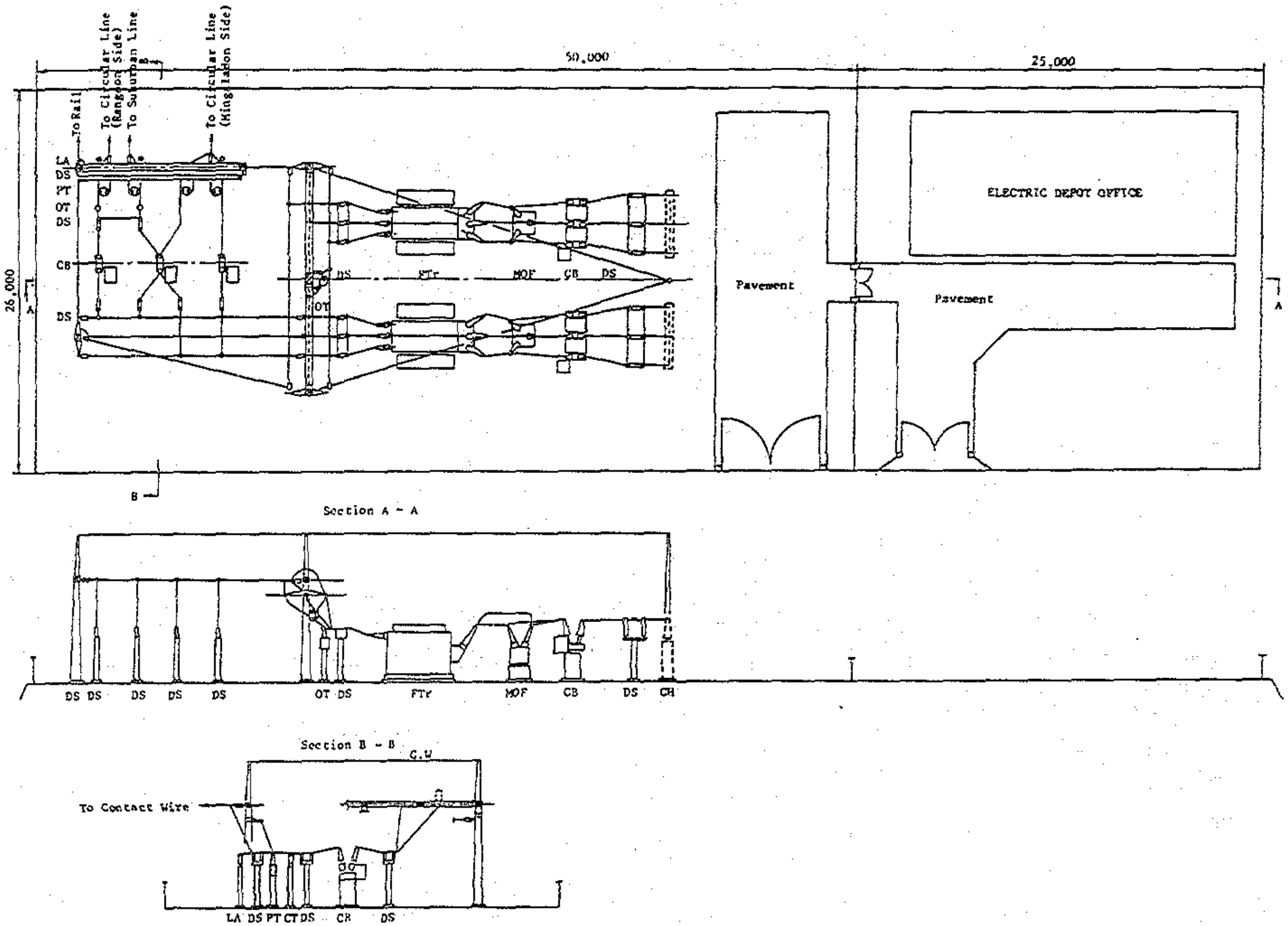


Fig. 8.3.4 Railway Substation Layout

Source: Study draws

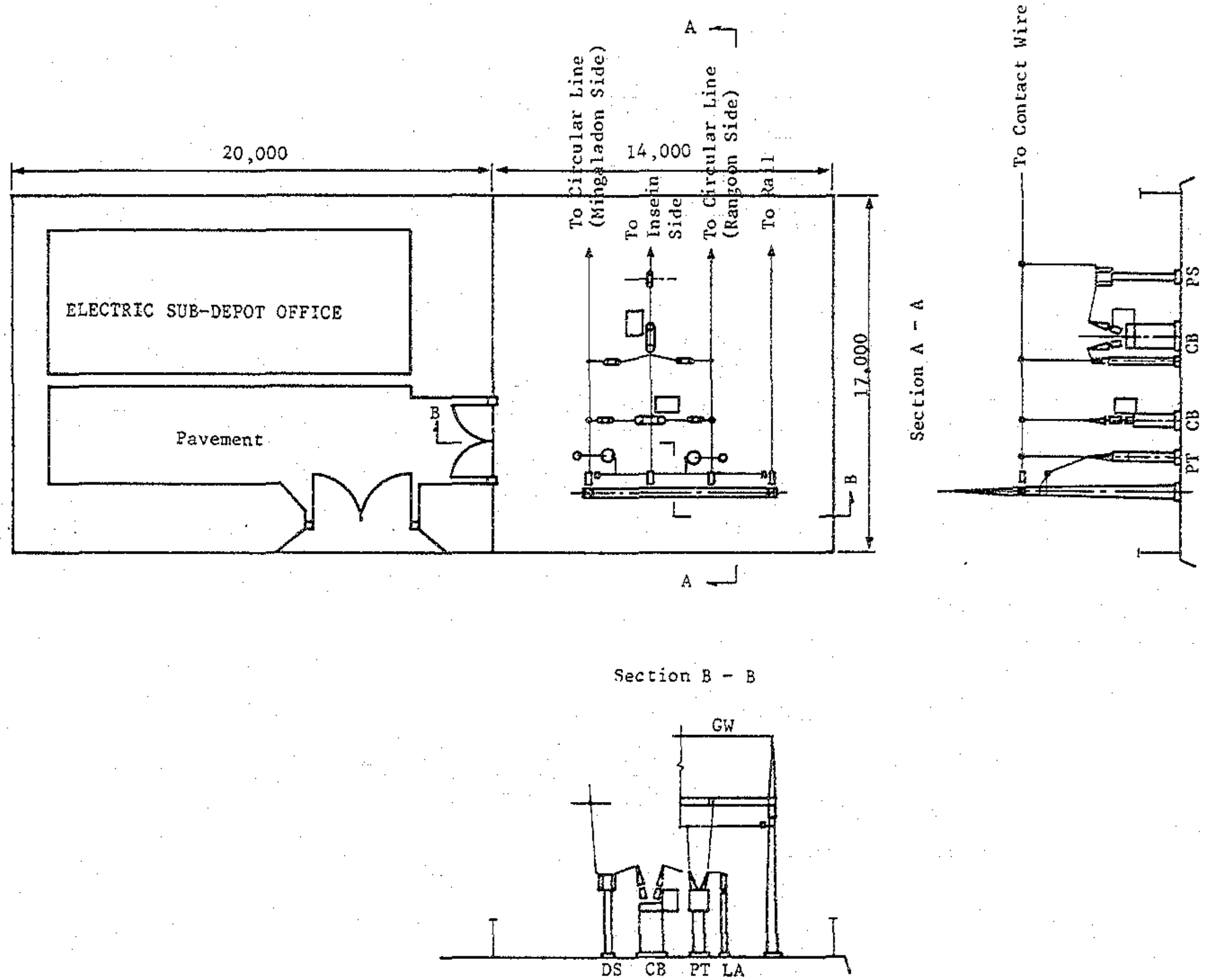


Fig. 8.3.5 Sectioning Post Layout

Source: Study draws

8-3-3 Overhead Contact System

(1) Selection of catenary suspension system

There are the two alternatives, the simple catenary system and the direct suspension system, as the catenary suspension system for the transportation plan and rolling stock plan of this project.

Their general characteristics can be summarized as follows:

a. Simple catenary system

The simple catenary system is more commonly used.

(a) Speed character: 120 kilometres/hour
(b) Loss of contact between the contact wire and the pantograph is rare.
(c) The contact wire has hardly any vertical motion.
(d) The contact wire can be easily maintained and its tension can be easily kept constant.
(e) Repair after wire breakage is simple.

b. Direct suspension system

The direct suspension system has begun to be used for relatively high speed railways as the result of recent progress of technical research, but it is commonly used only for street cars and trolley coaches.

(a) Speed character: 80 - 100 kilometres/hour
(b) The structure of overhead contact lines is simple.
(c) The contact wire has a great dip. (Maximum dip: about 300 mm for 60 metres span)
(d) Keeping the tension of the contact wire constant is technically more difficult than in the simple catenary system and therefore this system requires a higher technical ability to maintain.
(e) Repair after wire breakage takes time.

Either the simple catenary system or the direct suspension system can be used. Since this is the first B.R.C. venture into railway electrification, the simple catenary system is selected rather than the direct suspension system because of the simple maintenance and higher reliability.

(2) Tracks to be wired

The tracks to be wired are as indicated in Fig. 8.3.6.

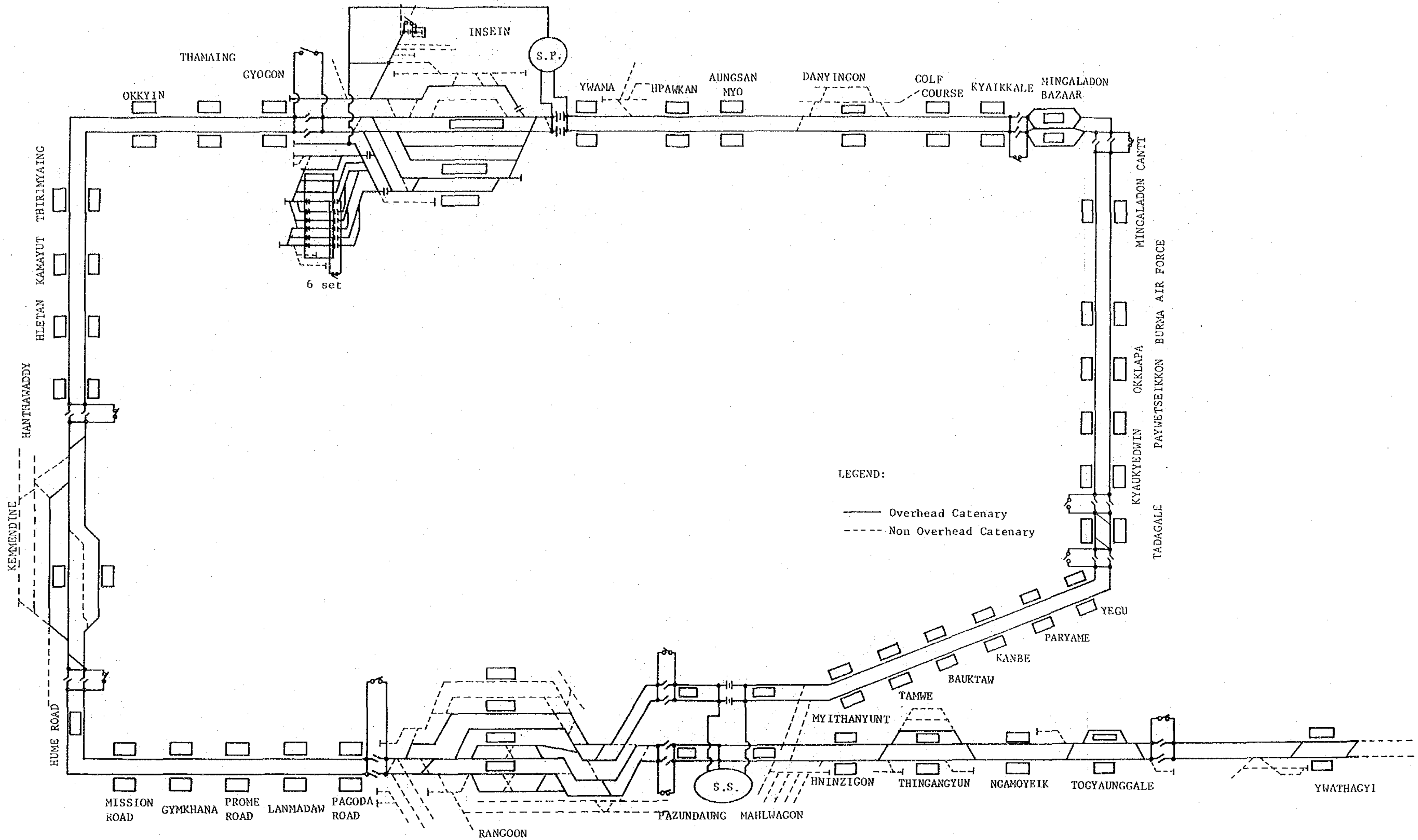


Fig. 8.3.6 Tracks to be Wired on the Circular and Suburban Lines

Source: Study draws

(3) Overhead contact system equipment

Special attention was paid to the following:

(a) Using 60 metres as the maximum span of the overhead contact wire to prevent it from disengaging the pantograph even at the maximum wind speed (31.3 metres/second).

(b) Taking into consideration the current capacity of wires to cope with the traction current, its ability to withstand vibration caused by the pantograph and wind and durability of components and material.

(c) Using a spring type tensioning balancer which automatically compensates for thermal expansion/contraction of the contact wire (30°C).

Consequently, the following equipment is adopted for overhead contact wire and the standard supporting structure will be as indicated in Fig. 8.3.7.

a. Overhead contact line equipment

Messenger wire	Galvanized zinc steel	90 mm^2
Contact wire	Grooved hard-drawn copper	110 mm^2
Automatic tensioning balancer	Spring type	

b. Support equipment

Poles	Prestressed concrete pole (Square steel lattice masts and secondhand rail built-up masts are used at special places.)
Foundations	Concrete foundations
Beams	Rigid beam (cross beams and V type beams)

c. Protective equipment

Negative feeder (Also used as flashover protective wire)	Aluminum cable steel reinforced 58 mm^2
Connecting negative wire	Vinyl insulated cable 38 mm^2

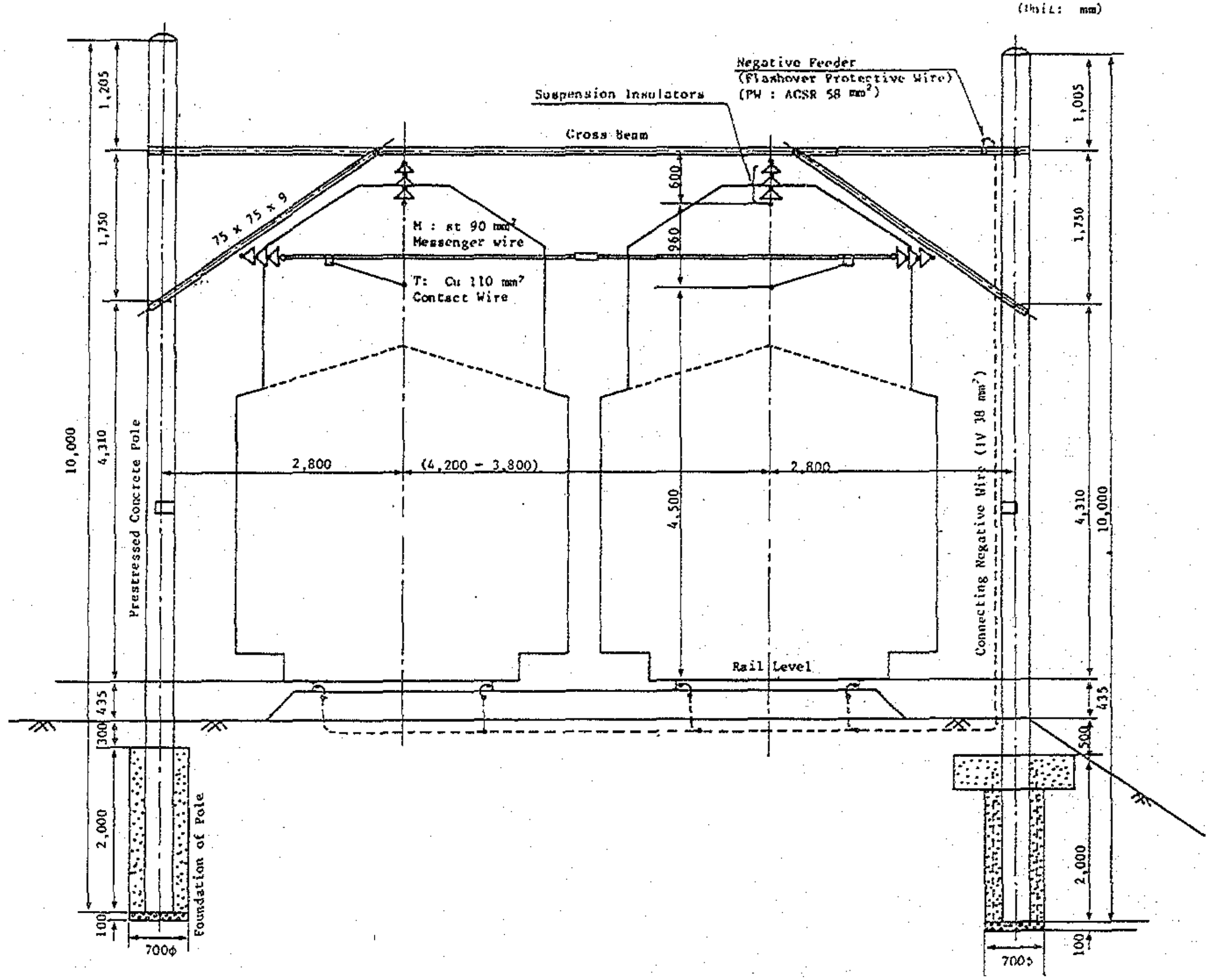


Fig. 8.3.7 Standard Supporting Structures

Source: Study draws

(4) Overhead contact wire special equipment

(a) Overhead contact wire is installed under road overbridges using two parallel wires consisting of contact wires only.

(b) The dead sections are provided at a substation and a sectioning post (section insulator: about 8 metres long).

(5) Protective equipment for overhead contact line

The following equipments are provided to protect the overhead contact line and to prevent electrocution accidents.

(a) Protective metal net designed at both side of road overbridges and passenger overbridges.

(b) Warning signs installed at level crossings.

8-3-4 Maintenance, Organization and Education

(1) Maintenance system and organization of power equipment after electrification

Different countries and railways have different concepts about the maintenance system and organization. One such concept is outlined here.

a. Maintenance system

The idea of preventive maintenance is applied for facilities such as substations and overhead contact lines, which directly affect the train operation. Breakdown maintenance is considered sufficient for other facilities.

b. Organization

An organization is established to jointly maintain the new electrification facilities and existing electrical facilities, which will increase the experience of the maintenance crew in the electrical field.

Electrical maintenance depots are strategically located at the Mahlwagon Substation and Insein Sectioning Post. Power dispatchers are stationed at the substation.

(2) Education and Training

Railway electrification requires a composite system of many technical areas including civil engineering, rolling stock, electrical engineering and operation. The exhaustive effort to acquire the expert techniques and skills such as planning, design, construction and maintenance, is the key to the success of electrification.

Also, high-level training for instructors will be given through programmes including studying abroad.

Modern electric railways are reliable as a whole. This means that there are fewer occasions where the equipment needs to be directly touched. However, prompt repair is required once faults develop and so staff members must be thoroughly trained in routine techniques and skills.

It is important that maintenance crews be regularly trained to acquire practical experience through the use of training facilities such as full-size panels comprising reserve substation equipment and overhead contact facilities.

Needless to say, a public relations campaign must be conducted to make the general public aware of the danger of the 25 kV high-voltage wires, and to make them appreciate the need for safety.

8-4 Modification of Structure and Facilities for Electrification

8-4-1 Track

(1) Removal of rail line level crossings

The number of diamond crossings and turnouts between Rangoon and Pazundaung stations is reduced through removal. This track layout change is made so that independent train operation can take place on the six routes. The track layout sketch is given in Fig. 8.4.1.

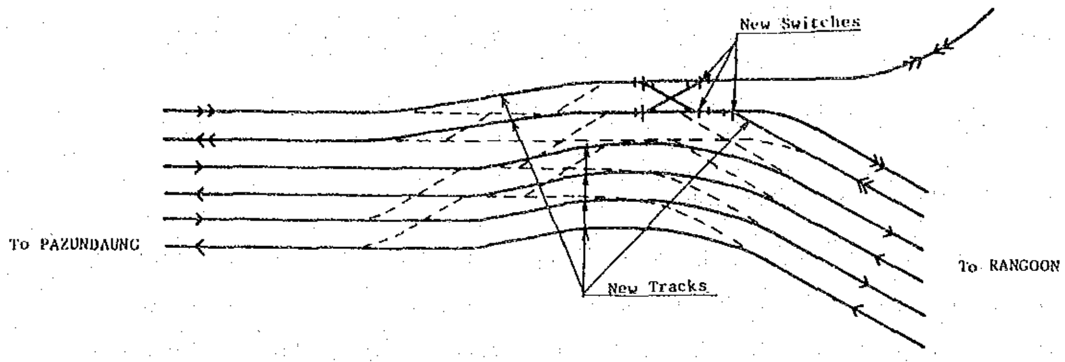


Fig. 8.4.1 Track Layout Modification (RANGOON-PAZUNDAUNG)

Source: Study draws

With the above track layout changes, Rangoon station must have its train arrival-departure tracks changed, the tracks repaired and turnouts newly installed as shown in the track layout sketch is given in Fig. 8.4.2.

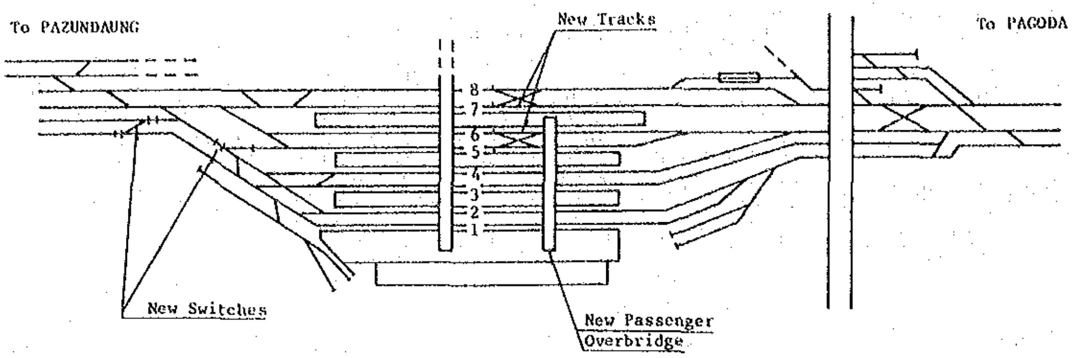


Fig. 8.4.2 Track Layout Modification (RANGOON)

Source: Study draws

(2) Shuttle operation facilities

To secure the train headway and increase efficiency of shuttle train operation, there are new shuttle operation facilities constructed at the Mingaladon Bazaar and Togyaunggale stations. Emergency shuttle operation facilities are constructed at Tadagale station. The track layout sketch is given in Fig. 8.4.3, Fig. 8.4.4 and Fig. 8.4.5.

(3) Test run track

The seventh track in Insein station yard is extended by 0.7 kilometres to Gyogon for use as a 1.5 kilometres test run track (cf. Fig. 8.4.6).

(4) Sufficient clearance beneath road overbridges

The rail level is lowered to secure the necessary clearance beneath road overbridges. There are three sections with a total length of about 7.0 kilometres and which require their roadbeds to be lowered (cf. Fig. 8.4.7). This lowering is performed by dividing the track into several work sections to enable single track operation so that the work can then be sucessively carried out for each work section.

A concrete bed is partially adopted to prevent substructure deformation resulting from the rail lowering and the underground depth of the existing road overbridge abutments.

(5) Countermeasure against track circuits not working

Ballast is supplemented to prevent mulfunction of the track circuits in the rainy season. This work is required for six stations on the Circular Line and for two stations on the Suburban Line.

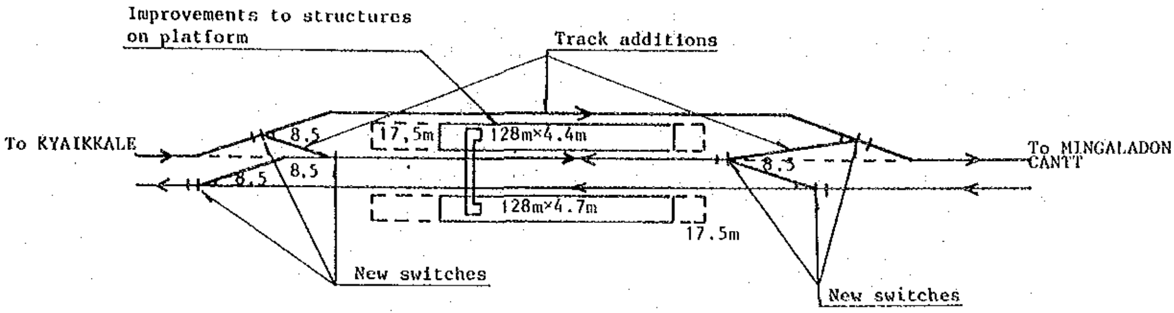


Fig. 8.4.3 Track Layout Modification (MINGALADON BAZAAR)

Source: Study draws

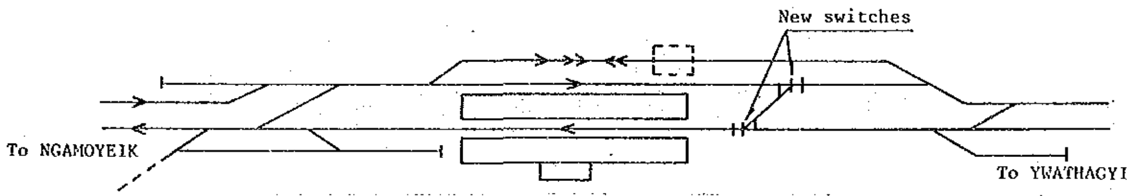


Fig. 8.4.4 Track Layout Modification (TOGYAUNGGALE)

Source: Study draws

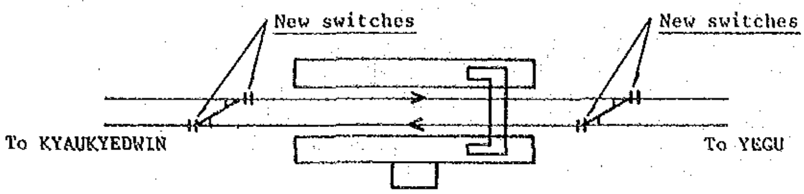


Fig. 8.4.5 Track Layout Modification (TADAGALE)

Source: Study draws

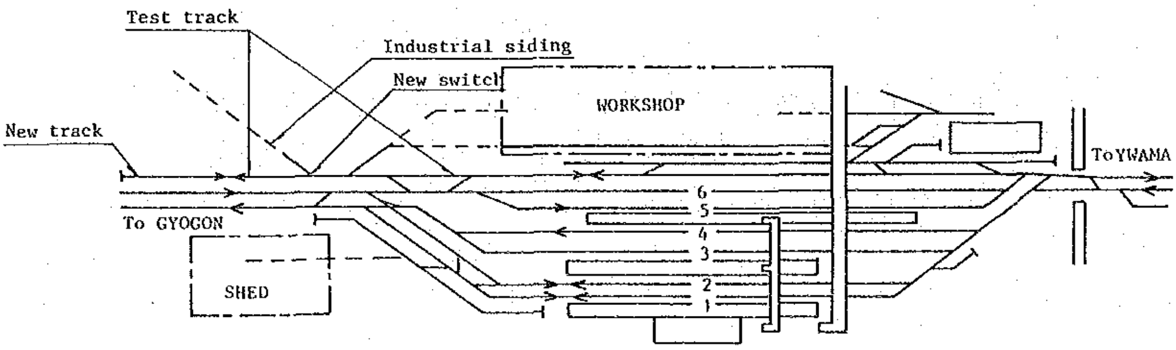


Fig. 8.4.6 Track Layout Modification (INSEIN)

Source: Study draws

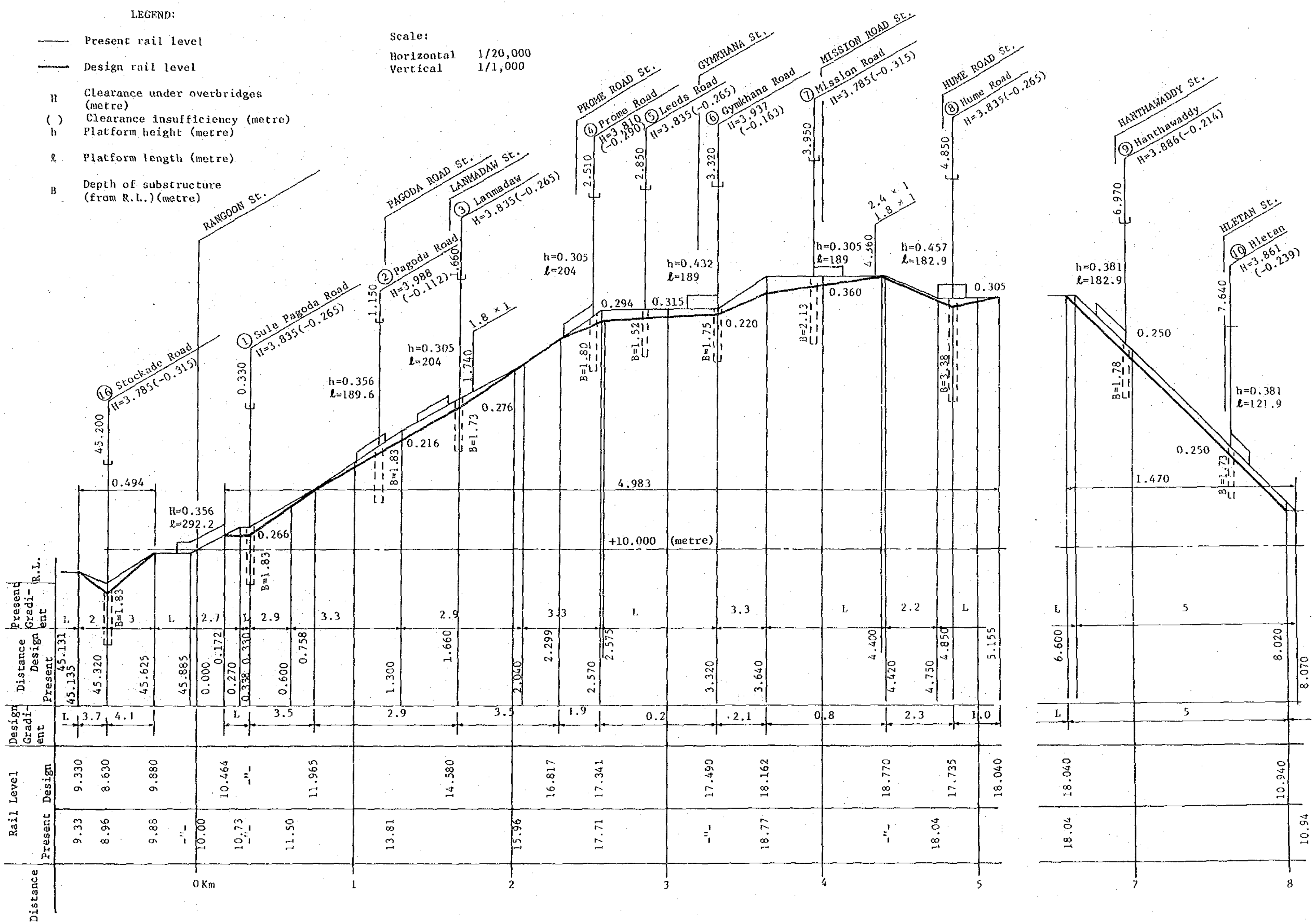


Fig. 8.4.7 Profile of Lowered Track

Source: Study draws

8-4-2 Structure

(1) Roadbed construction

In relation to the above section 8-4-1 (4), a retaining wall and side-drain are newly provided.

A standard cross section is given in Fig. 8.4.8.

Furthermore, the track layout change and the additional test run track require embankments and ground levelling work.

(Unit: mm)

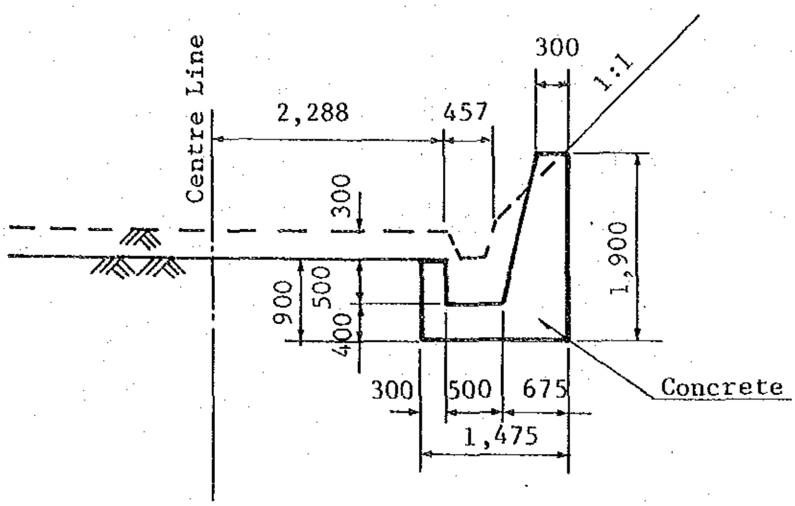


Fig. 8.4.8 Rail Level Lowering (Standard Cross Section)

Source: Study draws

(2) Raising passenger overbridges

Ten of the 40 passenger overbridges are to be raised to secure a 4,550 mm under the passenger overbridges (cf. Table 8.4.1).

A passenger overbridge is newly constructed at Rangoon station for changes in the train arrival-departure tracks (cf. Fig. 8.4.2).

Table 8.4.1 Raising Passenger Overbridges

Name of Bridges	Height of Bridges from Rail Level (metre)	Height of Raising (metre)	Length (metre)	Road Width (metre)	Structure
Short Street	4.293	0.257	14.427	1.83	Steel
Kemmendine Station	4.115	0.435	71.780 (19.942 × 1, 21.641 × 2, 8.534 × 1)	2.80	Steel
Thantada	4.216	0.334	32.919 (17.374 × 1, 15.545 × 1)	1.98	Steel
Kamayut Station	4.445	0.005	14.478	1.68	Steel
Okkyin Station	4.343	0.207	14.630	1.68	Steel
Thamaing Station	4.369	0.181	14.630	1.68	Steel
Gyogon Station	4.267	0.283	14.630	1.83	Steel
Insein Station	4.115	0.435	31.600 (15.800 × 2)	1.83	Steel
Insein Station to Workshop	4.039	0.511	81.229 (24.689 × 1, 9.906 × 1, 27.127 × 1, 19.507 × 1)	1.83	Steel
Thingangyun	4.343	0.207	30.640 (16.924 × 1, 13.716 × 1)	2.314	Steel

Source: Study estimates

(3) Improvement of railway bridges

Improvements are made for four truss-portal structures of Ngamoyake bridge on the Suburban Line and some small bridges are improved along with the rail level lowering.

(4) Rainwater drainage

Track in the cut region and some other regions is flooded whenever there is heavy rain, and so concrete drains are constructed along both sides of the track in the region for rail level lowering, and the track graded where it is flat. In Rangoon station, two side-drains on the west side of Sule Pagoda Road overbridge are connected with a culvert, and rain water from west side and Rangoon station yard is discharged to the creek on east side of Rangoon station through a newly constructed

1.6 kilometres conduit having both an open earth structure, and a rigid-frame box structure under the station platform.

It is advisable that the drainage system between Stockade road overbridge and Hletan road overbridge be studied in detail during design stage in cooperation with the organizations concerned, including investigation of seasonal tidal flooding of the trench in the east side of Rangoon station.

(5) Buildings related to electrification:

New construction:

Substation	one
Sectioning post	one
Electric power depot	one
Electric power sub-depot	two

Enlargement of buildings:

Workshop	one

Reconstruction:

Structures on the platform

8-4-3 Rolling Stock Shed

(1) Insein shed

Insein shed is equipped with facilities for the operation, inspection and repair of electric locomotives. Six diesel electric locomotives operated on the Prome line are transferred to the Mahlwagon locomotive shed, while Insein shed has electric locomotives only.

a. Inspection work

Daily Grade-A inspections to assure operation of electric locomotives, and Grade-B, Grade-C and Grade-D inspections on a running time/kilometerage basis are carried out at the shed, along with light repairs.

b. Inspection shed

The existing inspection shed for diesel electric locomotives is used after equipment reorganization as follows.

(a) Overhead contact wires in the shed

(b) Inspection stand for pantographs (40 metres × 1 line)

(c) Switches to disconnect overhead contact lines for the six lines

(d) One set of testing machines

(e) Improvement of shops

Workshops such as a repair shop for electric parts, etc., must be provided to effectively inspect and maintain the electric locomotives.

(f) Removal of disused fuel oil tanks

(2) Rangoon shed

Rangoon shed will be used for carriages after electrification, and requires no additional equipment for carriage inspection.

8-4-4 Workshop

(1) Inspection and repair of electric locomotives

a. Premises

(a) Inspection system and places

The inspection system and places for electric locomotives are as follows. Table 8.4.2 gives the kinds of inspection and their respective descriptions. Periodic inspections are as shown in Fig. 8.4.9.

Table 8.4.2 Inspection for Electric Locomotives (by type and place)

	Name of Inspection	Places in charge of inspection
Daily Inspection	Visual inspection conducted in accordance with the usage of the train	Depot
Regular Inspection	Inspection conducted at fixed intervals (60 days, 25,000 km)	Depot
Intermediate Inspection	Inspection of traction motors, brake equipment, control equipment and other important components, conducted at fixed intervals	Workshop
General Inspection	Complete disassembly inspection conducted at fixed intervals	Workshop
Occasional Inspection	Partial disassembly inspection, conducted according to necessity	Workshop or depot

Source: Study estimates

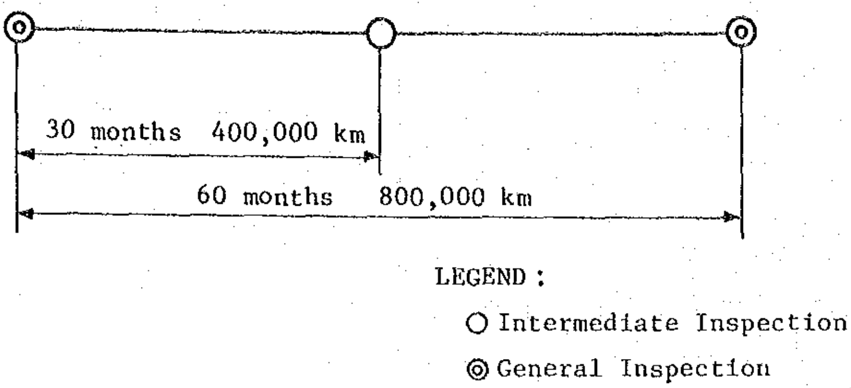


Fig. 8.4.9 Inspection Cycle for Electric Locomotives

Source: Study draws

(b) Number of electric locomotives

The number of electric locomotives is planned to be 19 in 1990 and 31 in 2010.

(c) Standard process

The workshop inspection for both diesel electric, and electric locomotives takes eight weeks (five days/week) as a standard. However, it is hoped that modernization of the inspection and repair work planned by B.R.C. and increased proficiency in electric locomotive inspection will shorten this period to within six weeks in the near future in order to improve the operation efficiency for electric locomotives. Table 8.4.3 shows the two standard processes of general inspection of eight weeks (A draft) and six weeks (B draft) duration.

Table 8.4.3 Standard Electric Locomotive Inspection and Repair Schedule (Draft)

Item \ Weeks	1	2	3	4	5	6	7	8	Remarks
A draft	Entry inspection; Parts removal; Body lifting	Inspection & repairs		Painting & signs	Parts attachment & adjustment		Body elections Adjustments	Leaving inspection (Test operation & adjustments)	5 days/ week
B draft	Entry inspection; Body lifting	Inspection & repairs	Painting; Parts attachment & adjustments		Body elections Adjustments	Leaving inspection (Test operation & adjustments)			

Source: Study draws

(d) Number of electric locomotives under inspection

The yearly number of electric locomotives inspected and the average daily number of electric locomotives in the workshop for intermediate and general inspection at any one time, are given in Table 8.4.4.

Table 8.4.4 Number of Locomotives in Workshop for Inspection

Item	At Start-up	In future
Number of locomotives per year	9.5	15.5
Intermediate Inspection	3.8	6.2
General Inspection	3.8	6.2
Occasional Inspection	1.9	3.1
Daily number at any one time	1.7	2.7
Intermediate Inspection, General Inspection	1.6	2.5
Occasional Inspection	0.1	0.2

Source: Study estimates

b. Outline of improvement plan for Insein workshop

(a) Reason for selecting workshop

After electrification, the electric locomotive intermediate and general inspections will be conducted at the Insein workshop for the following reasons.

- Suitable scale and location of the workshop.
- Space in the workshop for repair of electric locomotives is available because of reduced number of steam locomotives.
- Engineers are easily secured. And they are experienced in the repair of electrical parts of diesel electric locomotives.
- The existing inspection and repair equipment enables new equipment investment to be minimized.

(b) Improvement of layout

The process for inspecting and repairing electric locomotives is to the same as that for existing steam locomotive. The reasons are as follows.

- The presently used diesel electric locomotives will be replaced (by electric locomotives) and transferred to other railway divisions, but the Insein workshop will perform major repairs to electrical parts and bogies of diesel electric locomotives as usual because the Ywataung workshop performs heavy repairs for diesel hydraulic locomotives.
- Rehabilitation work for diesel electric locomotive is now being performed, and is assumed to continue.
- Inspection and repair of carriages used on the Circular Line is assumed to be concentrated into the Insein workshop for the future, instead of the carriages being transferred to the Myitnge workshop.

An equipment and supply room is newly constructed adjacent to the body repair shop so that the layout for body and parts repair shops can remain as it is at present.

The building location and work process are given in Fig. 8.4.10.

The track layout is unchanged and the minimum overhead contact lines are laid. There are many electric machine parts for inspection and repair, and which are used in common by electric locomotives and diesel electric locomotives, and so partial expansion of the existing electric shop can meet the demand for electric locomotives.

c. Equipment plan

Electric locomotives make the best use of the existing equipment for inspection and repair, to which only necessary test-machines and equipment are added, as shown in Table 8.4.5.

Table 8.4.5 Workshop Equipment and Facilities

Item	Quantity	Notes
Track:		
In equipment and supply room	24 metre	track with pit
Overhead contact facilities:		
In workshop yard, supply room and test operation track	approx. 1,600 metre	
Disconnecting switches for overhead power supply	1 set	1 set in supply room
Buildings:		
Equipment and supply room	408 m^2	17 metre × 24 metre
Inspection stand for parts on the roof	17 metre	
Pit:		
In supply room	17 metre	Length of electric locomotive + 3 metre
Inspection and repair equipment:		
Traction motor testing equipment, etc.	1 set	

Source: Study estimates

The main equipment and facilities are as follows.

(a) Track for test run

A track (about 1.5 km) of the station side along the Insein workshop yard is provided for test running.

(b) Equipment and supply room

A shed (24 metre × 17 metre span) is built adjacent to the south side of body repair shop, as an exclusive equipment and supplies room for electric locomotives (cf. Fig. 8.4.10). Only one of the three tracks is a repair track having an overhead contact wire, an inspection stand for devices on electric locomotive roofs and an inspection pit.

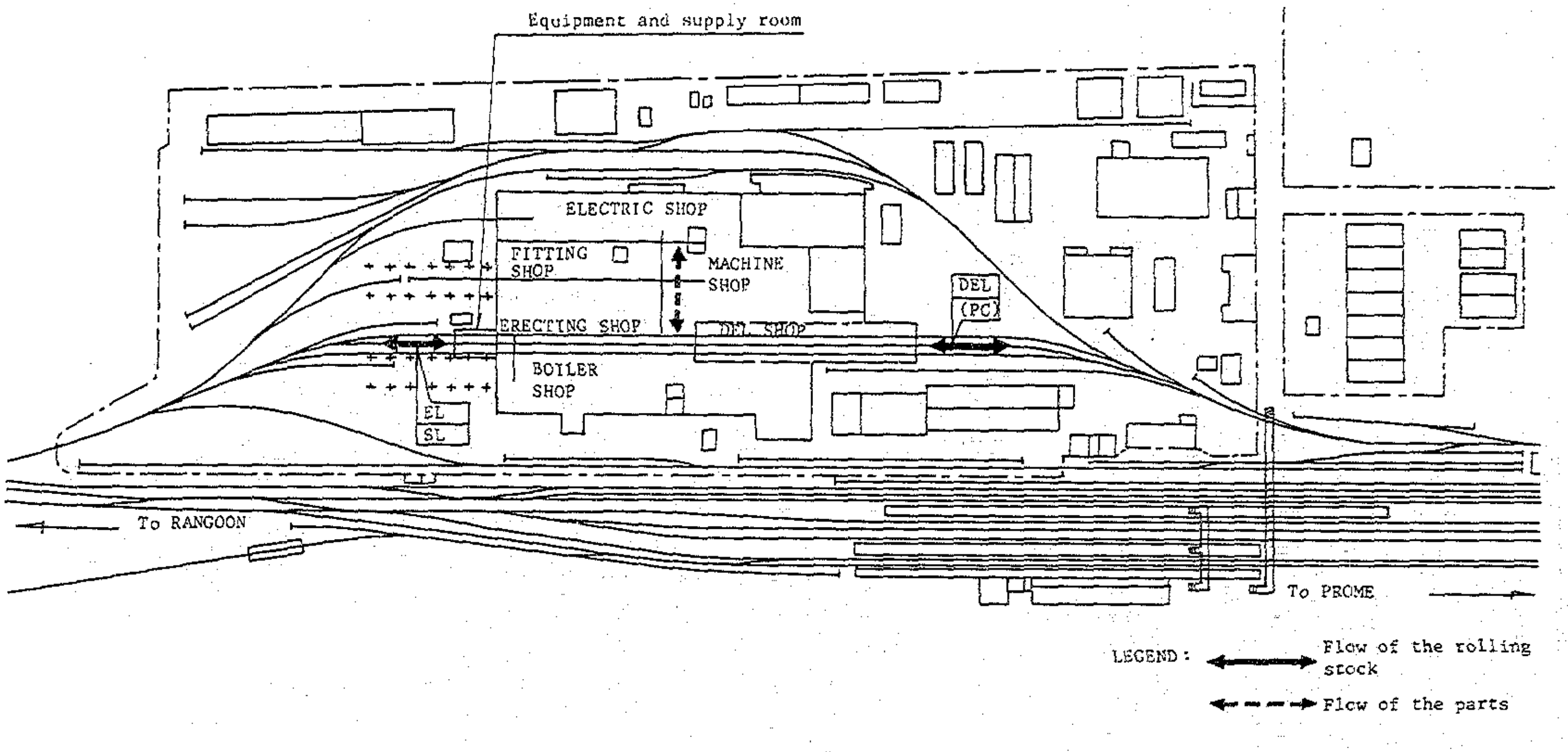


Fig. 8.4.10 Improved Shop Layout and Work Flow (Insein Workshop)

Source: Study draws

(c) Overhead contact wire

The contact wiring over the track is given in Fig. 8.4.11. A disconnecting switch is installed in the equipment and supply room as a preventive measure against electrocution of workers performing work on electric locomotive roofs.

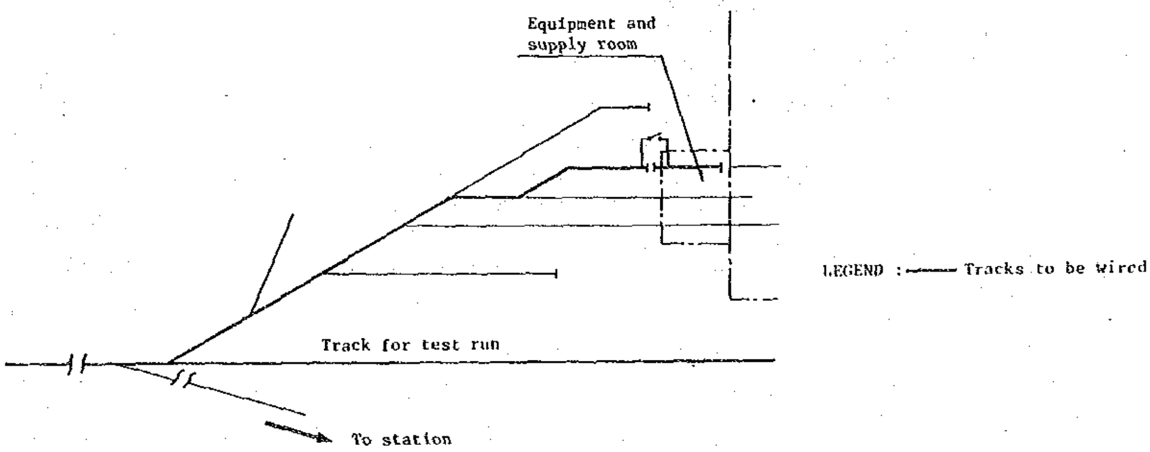


Fig. 8.4.11 Wiring over Tracks

Source: Study draws

(d) Inspection and repair equipment

New electric testing machines, etc. are planned for the workshop to ensure performance. (cf. Table 8.4.6)

Table 8.4.6 Equipment and Facility List

Item	Quantity
Traction Motor Tester	1
Layer Short Circuit Tester	1
Line Breaker Tester	1
Main Controller, Rectifier Tester	1
Pantograph Tester	1
Air Brake Tester	1
Insulating Resistance Tester	1
Insulating Withstand Voltage Tester	1
Armature Lathe	1
Movable Elevated Stand	2
Fork Lift (2 tons)	1
Spare Parts and Tools	1

Source: Study estimates

(2) Inspection and repair for electric locomotives and training for maintenance crew

a. Change in work

The Insein workshop will change its work from the present inspection and repair for steam locomotives to that for electric locomotives. It is therefore necessary to switch over to a new system for electric locomotive maintenance and crew training.

b. Training plan

Repair for electric devices of diesel electric locomotives is performed at the Insein workshop, but there is a fundamental difference in the repair work for diesel electric locomotives and electric locomotives. Thus, when new maintenance of electric locomotives is executed, it is necessary to review the workshop organization and conduct repair technology training for the repair crews and instructors and those who supervise work.

The minimum training should cover the structure and function of electric locomotives, skill for practical working, and knowledge for safety and equipment.

The training must be phased so that the crew is ready for the first delivery of new electric locomotives and for the first inspection in the workshop.

It is possible to conduct training by utilizing the training centre at the Ywataung workshop, but it is desirable for practical training to use an actual electric locomotive. Practical training for instructors is difficult because there will be no electric locomotive available when they are being trained. Also, high-level training for instructors will require other technical training methods such as studying abroad, etc.

(3) Carriage inspection and repair

There is an increasing number of carriages equipped with air brakes. Inspection and repair of air brakes will be performed at the Insein shed. Inspection and repair of these carriages except air brakes is performed as usual in the Myitnge workshop because the Myitnge workshop uses equipment superior to those at the Insein shed at present.

However, it is desirable for the future Circular Line carriages to be inspected at the Insein workshop to eliminate deadhead losses. Furthermore, it is desirable that carriage inspection and repair be conducted at one place such as the Insein workshop in order to maintain a consistent level of quality.

Knock-down production is under preparation in the Myitnge workshop, and this is considered to be an excellent chance to expand the scope of home-produced cars in the future.

8-4-5 Facilities for Power Distribution

(1) Improvement of circuits

All wire crossings over track (cf. Table 5.6.2) except transmission lines are modified as follows.

(a) The B.R.C. distribution lines are changed to the cables and attached to the overhead catenary supporting structures at 71 locations.

(b) The E.P.C. distribution lines are changed to the cables passing under tracks at 25 locations.

(c) The 33 kV E.P.C. power transmission lines are sufficiently high to require no modification.