APPENDIX

THE STUDY ON ELECTRIFICATION PROJECT OF MAIN RAILWAY LINES IN JAVA IN THE REPUBLIC OF INDONESIA (MASTER PLAN)

FINAL REPORT

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY
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Appendix 1.1 Conditions of Indonesia

The Republic of Indonesia is the world's largest insular country having population of about 150 million on an area of $1,920,000m^2$. It has about 14,000 islands, large and small, over a vast area about 1,900km from north to south by about 5,100km from east to west on both sides of the Equator.

Its climate is of the tropical monsoon type and the seasons can be divided into rainy and dry seasons. The annual mean temperature is about 27°C and the annual temperature range is extremely small, but the temperature drops to some extent in the rainy season.

The Java Island stretches about 1,260km east to west and about 200km north to south and covers an area of about $130,000km^2$ and includes the adjacent island of Madura. The volcanic soil of this island is fertile, precipitation is great and because of these natural features, agriculture in Java has been prosperous since long ago to develop as the core of Indonesian politics and culture. At present, it has a population of about 97,000,000 or 65% of the national population and accounts for about 7% of the area of Indonesia.

About 80% of its population is in the rural areas, where job opportunities have decreased due to modernization and labor-saving efforts. For this reason, the populations of Jakarta and Surabaya have increased at a rapid pace in recent years. Coupled with industrialization in recent years, questions on housing, urban transit and inter-city transport have come to the fore.

The Republic of Indonesia is blessed with abundant underground resources. The main resources include crude oil, natural gas, coal, bauxite, nickel, copper, tin and others. In particular, crude oil is the most important export item. A check of the output of crude oil in the past several years indicates there are signs of a drop with 615 million barrels in 1977 as a peak. In the domestic energy consumption, Indonesia's reliance on oil was estimated at 90% in real terms in 1978. Of this percentage, diesel oil and gasoline for vehicles accounts for 46%.

In conjunction with the economic development, domestic oil consumption is expected to increase to the extent that the Indonesian Government is stepping up the construction of additional thermal power plants and practical geothermal power plants. Great attention is being focused on railway electrification, as oil consumption can be greatly reduced by changing from road transport having a poor energy coefficiency to transport by electrified railways having a good energy coefficiency.

Appendix 1.2 History of Railways

Historically, Indonesia's railway service made its debut when a railway line of about 26 kilometers was laid between Semarang and Tanggung some 120 years ago or on June 17, 1868.

Following in the steps of development of railways in Europe, the NISM (Nederlandsch Indische Spoorweg Maatschappy: Netherland Indies' Railway Company) held a ceremony in Semarang on June 7, 1864, in commemoration of the laying of the Semarang-Surakarta line. This line was completed and put into business operation on February 18, 1870. On the other hand, construction work was started for a line between Jakarta and Bogor in April 1869 and put into business operation in 1873. This line was constructed by the NISM but its management was later handed over to the SS (Spoorwegen: State Railways Company).

On the Sumatra, the oldest railway line is the one which was put into operation between Ulele and Banda Aceh on November 12, 1876. In West Sumatra, a line linking Pulu, Aer and Padang was opened in 1891. In North Sumatra, a line was opened between Labuan and Medan on July 25, 1886. In South Sumatra, the laying of a railway line was started between Telukbetung and Prabumlih in 1912 and between Makasar and Takalar on July 1, 1923.

In those years, the contributions made by private railways were indeed great. There were 11 private railways on the Java and one on the Sumatra, owing 1,022 kilometers of railway lines as against the 4,350 kilometers owned by the SS. These private railway lines were constructed to transport farm produce to ports in a smooth manner in sharp contrast to those of the Dutch Government which were designed for the full control of its colony.

With the establishment of so many railway firms, four different gauges of 0.80, 0.75, 1.067 and 1.435m were in use, each firm had its own railway laying rule.

Under instructions from the Dutch Government, low wages were forced on the employees. The command and supervision of the business also rested with the home government.

The end of World War II witnessed the birth of the Republic of Indonesia. After the declaration of its independence, all railways were incorporated into the Indonesia State Railway Service on 1950. The railways were begun to be operated in accordance with the Indonesian Enterprise Law. From 1963 to 1971, the Law No.19 "State Enterprise" (1960) was in force. At present, Indonesia's railway transportation is carried out by Perusahaam Jawatan Kereta Api (Indonesian State Railways) in accordance with a 1971 government regulation under the supervision of the General Manager for Land Transport, Ministry of Transportation.

Appendix 1.3 Present Situation of PJKA

Organization and Personnel

As stated earlier, the railways of the Republic of Indonesia is placed under the control and management of its government, as all private railways were nationalized in 1950. The authority for the nationalization is the Indonesian Enterprise Law (1927). Under the Government Regulation No.61 (1971), all state railways have been called Perusahan Jawatan Kereta Api (PJKA) as a public enterprise service.

The PJKA is placed under the supervision of the Minister of Transportation and Communications, to whom the president of the PJKA is fully accountable. The determination of railway fares, one of the important measures in terms of management of the state railways, rests entirely with the Government, and the decision-making power of the PJKA president is confined to, among others, the determination of the number of workers who are to be newly employed and the revision of the timetable (see Appendix 1.3.1, 1.3.2).

Organization of the PJKA headquarters is shown in Appendix 1.3.3. It encompasses the entire management of the state railways with its headquarters situated in Bandung. There are five major bureaus -- personnel, facilities, construction, business and accounting. Education and training centers are separated from the Personnel Bureau for an improvement of the productivity of personnel, suggesting that the PJKA is enthusiastic about its management.

Organization of the PJKA's local agencies are shown Appendix 1.3.4 and they are made up of the following six branch offices.

Name	Location
Western Java	Jakarta
Central Java	Semarang
Eastern Java	Surabaya
Southern Sumatra	Palembang
Western Sumatra	Padang
Northern Sumatra	Medan

Each branch is made up of several managerial departments, which are organized as follows:

Western Java		
Managerial Department	1	Jakarta
Managerial Department	2	Cirebon
Managerial Department	3	Bandung
Central Java		
Managerial Department	4	Purmokerto
Managerial Department	5	Semarang
Managerial Department	6	Yogyakarta
Managerial Department	7	Semarang
Western Java		
Managerial Department	8	Madium
Managerial Department	9	Surabaya
Managerial Department	10	Malang
Managerial Department	11	Jember
Southern Sumatra		
Managerial Department	12	Tanjungkarang
Managerial Department	13	Kertapati
Western Sumatra		
Managerial Department	14	Paddang
Northern Sumatra		
Managerial Department	15	Ache
Managerial Department	16	Medan
Managerial Department	17	Medan

As of the end of fiscal 1981, 50,700 personnel were on the payroll of the PJKA as indicated in Appendix 1.3.5. which was prepared by line of duty. Additionally, there were about 10 percent of "non-active" personnel, who correspond to workers laid off in the ordinary enterprises. They are standing by at their homes. By age, personnel at the age of 39 and under account for 51 percent, those at 40 ∿ 50 44 percent and those at 51 and above four percent. Moreover, there have in the last several years been signs of an increase in the number of younger personnel.

The qualifications for employment by the PJKA are determined in accordance with Paragraph 3 of the Government Regulation No.6 (1976) entitled "Government and Public Officials." The main qualifications include, among others, ① persons who are at the age of 18 ∿ 40, ② persons who have never been dishonorably discharged either as staff officials of government agencies or as employees of private businesses, and ③ persons who neither are public servants nor have any intention of becoming public servants. There is no need to point out that the applicants must be Indonesian nationals.

Outline

At present, the PJKA has about 700 stations with about 5,900 route kilometers (with a narrow gauge of 1,067mm). With 51,000 personnel on the payroll, the PJKA carries about 40 million passengers or 6,300 million passenger-kilometers and about 4,500,000 tons of freight or 950 million ton-kilometers a year. (See Appendix 1.3.6 for the actual records of fiscal 1981.)

By island, the Java shares 4,442 route kilometers and the Sumatra 1,464 route kilometers. In addition, 505 kilometers of railway lines with a gauge of 750mm are laid on the Sumatra. Eighty-five route kilometers of railway lines in and around Jakarta have been electrified, including a 40-kilometer double-track section. The single-track section accounts for 98 percent.

In the business sector, earnings from passenger transport accounted for about 64 percent of the total incomings in fiscal 1981. Passengers are divided into first, second and third classes. A check of the actual records of fiscal 1981 for the Java, which shared the greater part of the total transport volume, indicates that the transport of first, second and third classes accounted for 1, 6 and 93 percent in passengers carried, or 4, 15 and 81 percent in passenger-kilometers. As is discernible from Appendix 1.3.8, an average of kilometers travelled by class reveals that it is the longest for the first class. Presumably, this is an outcome of the use of limited sleeper express.

The fare system is so arranged that the longer the distance, the lower the average fare per kilometer. Fluctuations in the fares for the major trains in the major sections are indicated in Appendix 1.3.9. The fares were revised at an annual average rate of 8 ∿ 10 percent from 1973 to 1981, and the higher the class, the higher the revision rate.

A check of trend in the transport volume for the Java indicates that there has been a steady rise in the past several years but the increase rate has slowed down, as indicated in Appendix 1.3.8. The number of passengers carried and that of passenger-kilometers increased by 5.8 and 9.2 percent, respectively, a year from 1973 to 1981 primarily because they rose by 6.6 and 12.7 percent, respectively, for the third class. The leveling-off or decrease of passengers in the higher classes accelerated the aggravation of the revenue.

On the other hand, a check of freight transport in terms of its incomings indicates that its share in the total revenue is on the downturn. It accounted for a mere 30 percent in fiscal 1981. This rate was used in the compilation of a budget for fiscal 1982.

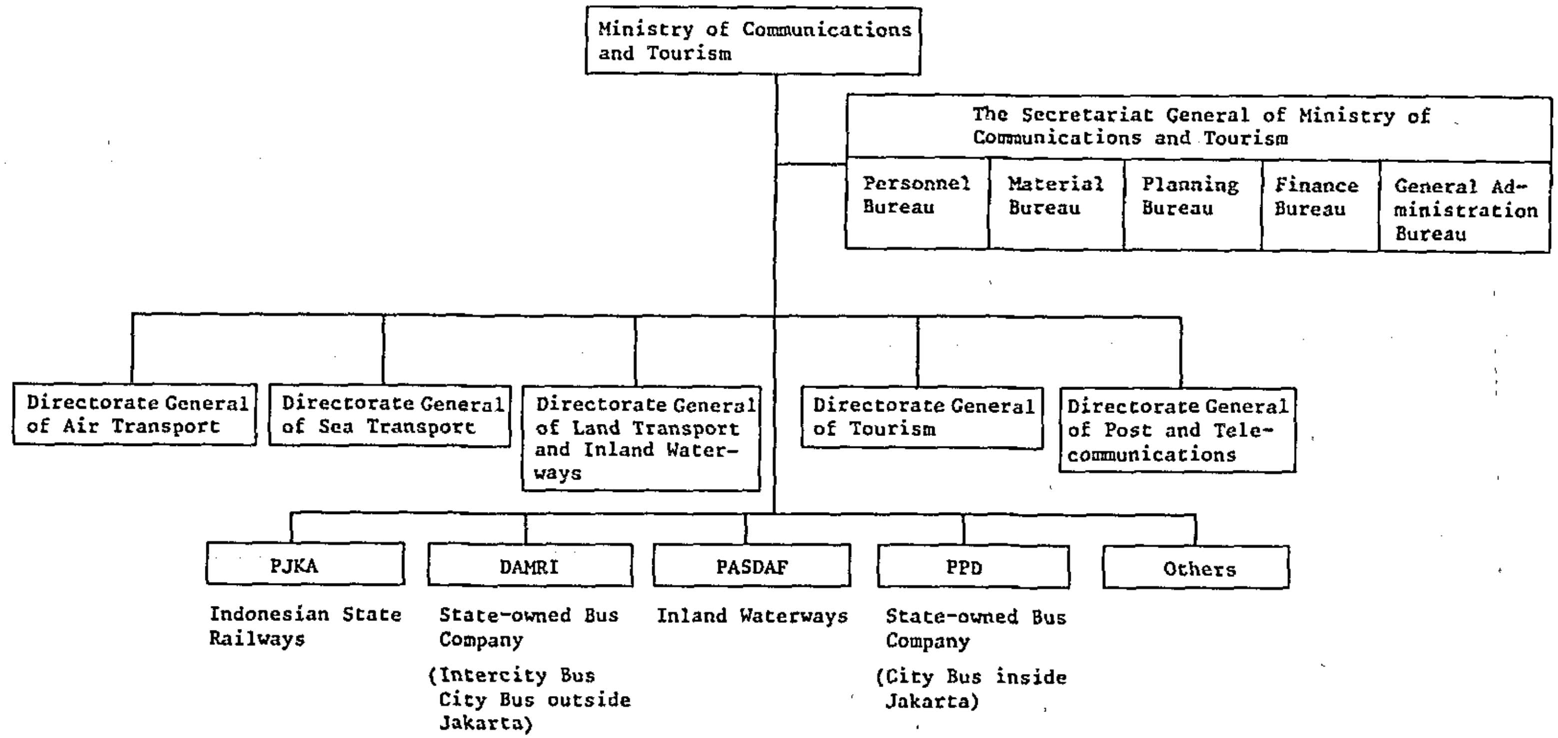
Examples of the freightage are given in Appendix 1.3.10. The freightage has been divided into five classes since 1974. There is not much change in freightage between classes, as the fifth class stands at 79 with the first class at 100. In terms of volume, the transport of freight is shown in Appendix 1.3.11.

In general, freight transport is at a low ebb presumably because facilities and trains are put to excessive use without adequate maintenance, a partial shortage in the track capacity and a resultant limit to the train speed.

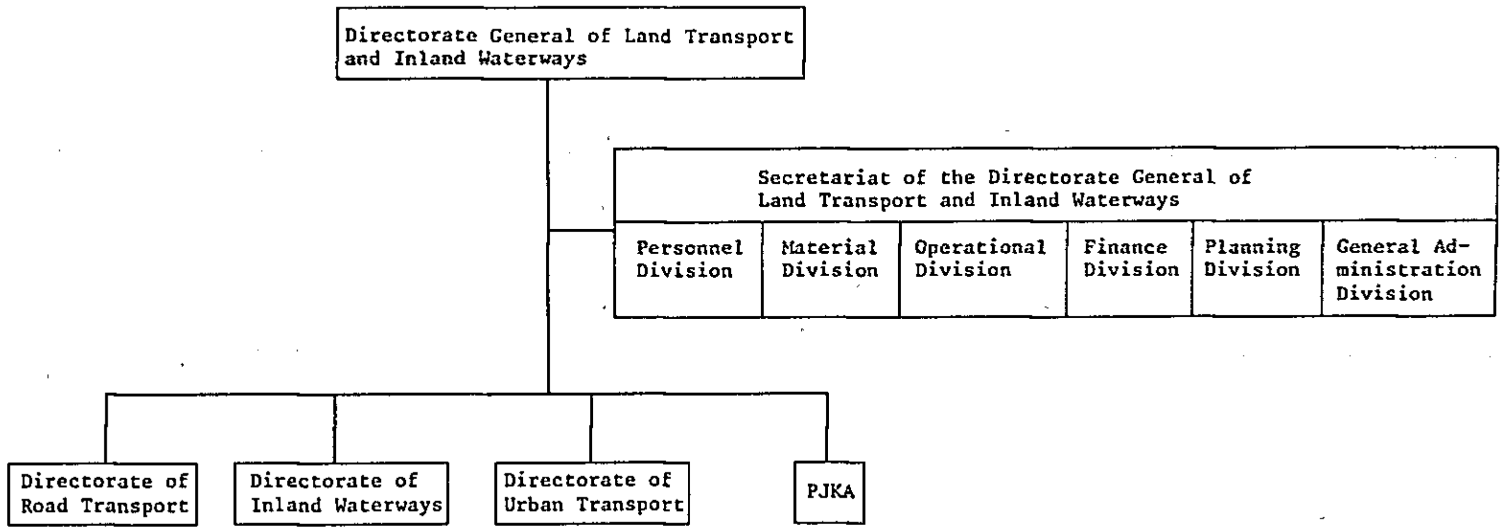
However, the economic power of Indonesia is such that the real growth rate of the gross domestic product averages slightly higher than seven percent (Appendix 1.3.12). By carrying out a variety of development projects and coming out with a system fully responsive to demands from the clients, or by concentrating efforts on the offer of elaborate services as a means of public transport, it is presumable that the transport volume may easily be increased.

Next, let us check the financial status of the PJKA. The incomings may be divided into those from railway transport, those from ferryboat transport and those from restaurants and other sources. Incomings from railway transport have remained at 86 ∿ 90 percent each year (Appendix 1.3. 13). As indicated in Appendix 1.3.9 and 1.3.10, the railway fares have been revised every several years, but they are pegged at low levels for the sake of price policy because they are public charges, so that hopes cannot be put on a quick equilibration of incomings and outgoings. For example, the incomings from railway transport are just good enough to offset the personnel cost and the operating ratio is estimated at 186 according to the fiscal 1982 budget.

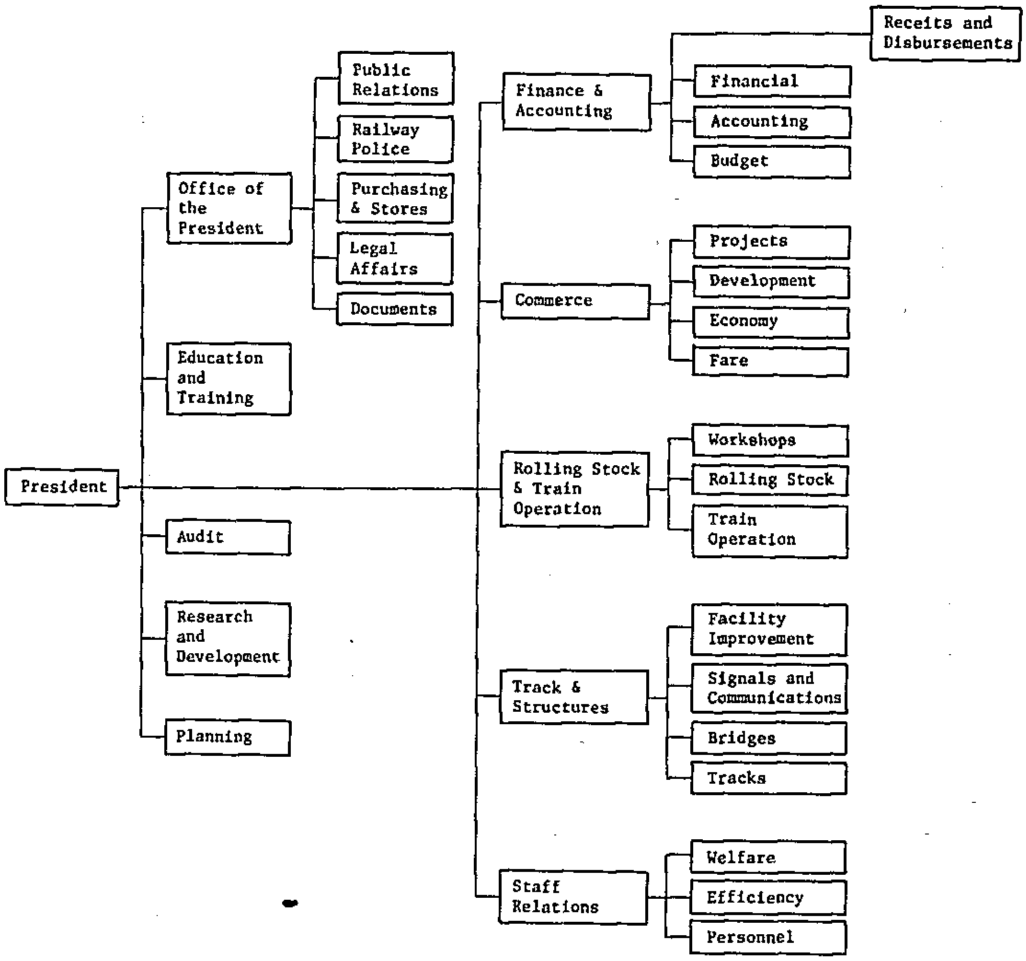
On the other hand, in the expenditure sector, the personnel outlay rose by 36 percent in fiscal 1979, 38 percent in fiscal 1980 and 47 percent in fiscal 1981, and the increase is estimated at 43 percent for fiscal 1982 (Appendix 1.3.13). But it seems quite difficult to realize this increase. Consequently, the amount of investments in facilities incorporated from the PELITA fund is great, amounting to eight billion Rupiahs, to say the least of five billion Ruphiahs (according to the actual records for fiscal 1980 in Appendix 1.3.15).



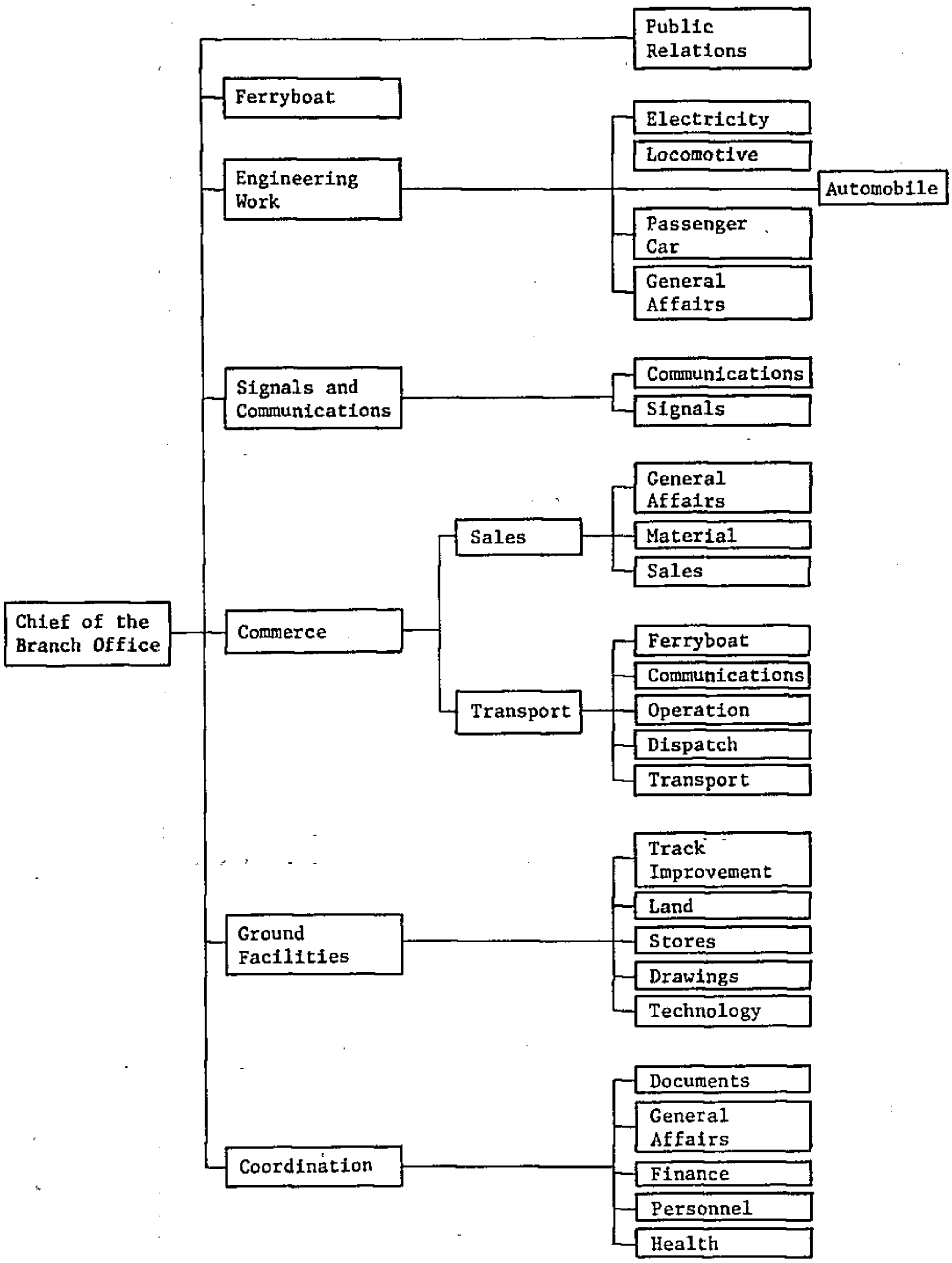
Appendix 1.3.1 Ministry of Communications and Tourism and PJKA



Appendix 1.3.2 Directorate General of Land Transportation and Inland Waterways and PJKA



Appendix 1.3.3 Organization of PJKA



Appendix 1.3.4 Organization of PJKA's Branch Office

Appendix 1.3.5 Number of Staff Officials

As of March 31, 1982

Line of business	Number of personnel
Personnel and accounting	3,858
Welfare	295
Tracks and buildings	13,618
Signals and communications	1,568
Bridges	846
Operation and rolling stocks	13,109
Workshops	3,452
Purchasing & stores	257
Business and sales	12,657
Railway police	617
Ferryboat	403
Total	50,710

Excluding 1,714 part-time employees (690 for tracks and buildings, 731 for business and sales and 293 for others).

Appendix 1.3.6 Traffic Volume

Year	Passenger			Freight		
	Passengers carried (1,000)	Passenger-kilometers (1,000)	km/passenger	Tons carried (1,000)	ton-km (1,000)	km/ton
1979	38,575	5,894,769	153	4,419	1,001,269	227
1980	39,951	6,029,939	151	4,440	976,215	220
1981	40,241	6,269,740	156	4,485	948,230	211

Appendix 1.3.7 Route Kilometers

Unit: km

Branch	1,067mm			750mm
	Main lines	Others	Total	
Western Java Branch Office	947	311	1,258	
Central Java Branch Office	860	778	1,638	
Eastern Java Branch Office	950	596	1,546	
Southern Sumatra Branch Office	639	4	643	
Western Sumatra Branch Office	222	56	278	
Northern Sumatra Branch Office	445	98	543	505
Total	4,063	1,843	5,906	505

Unit: km

	Single track	Double track	Total
Electrified	45	40	85
Non-electrified	5,731	90	5,821
Total	5,776	130	5,906

Appendix 1.3.8 Railway Passenger Transport Volume (Java Island)

Unit: 1,000

Year	1st class			2nd class			3rd class			Total		
	Passengers carried	Passenger-kilometers	km/passenger	Passengers carried	Passenger-kilometers	km/passenger	Passengers carried	Passenger-kilometers	km/passenger	Passengers carried	Passenger-kilometers	km/passenger
1973	436	202,216	464	2,479	790,517	319	20,780	1,744,855	84	23,695	2,737,588	116
1974	277	155,400	562	1,085	282,816	261	21,560	2,679,771	124	22,922	3,117,987	136
1975	275	162,941	593	1,217	293,675	241	18,368	2,651,462	144	19,860	3,108,078	157
1976	273	161,768	593	1,236	326,494	264	17,164	2,723,020	159	18,673	3,211,282	172
1977	313	179,950	574	1,285	366,842	286	17,260	2,913,304	169	18,858	3,460,096	184
1978	340	210,289	618	1,581	501,917	318	25,254	3,593,813	142	27,175	4,306,019	159
1979	312	198,346	638	2,082	730,936	351	32,171	4,212,399	131	34,565	5,141,681	149
1980	314	204,797	653	2,104	726,136	345	34,102	4,479,575	131	36,520	5,410,508	148
1981	298	197,450	662	2,319	803,485	346	34,668	4,535,871	131	37,285	5,537,806	149

Appendix 1.3.9 Trends in Passenger Fares

(In Rupiahs)

Year	Jakarta - Surabaya (830km)			Jakarta - Semarang (444km)			Jakarta - Bandung (175km)		
	Limited sleeper express	Night limited express	Night limited express	Night limited express			Rapid service	Express	Special rapid service
	1st class	2nd class	3rd class	1st class	2nd class	3rd class	3rd class	2nd class	3rd class
1973	6,900(100)	4,700(100)	1,700(100)	2,800(100)	1,850(100)	1,300(100)	850(100)	1,250(100)	650(100)
1974	6,900(100)	4,700(100)	1,700(100)	2,800(100)	1,850(100)	1,300(100)	850(100)	1,250(100)	650(100)
1975	9,700(141)	6,500(138)	2,200(129)	4,200(150)	2,500(135)	1,600(123)	1,100(129)	1,700(136)	700(108)
1976	9,700(141)	6,500(138)	2,200(129)	4,200(150)	2,500(135)	1,600(123)	1,100(129)	1,700(136)	700(108)
1977	9,700(141)	6,500(138)	2,200(129)	4,200(150)	2,500(135)	1,600(123)	1,100(129)	1,700(136)	700(108)
1978	9,700(141)	6,500(138)	2,200(129)	4,200(150)	2,500(135)	1,600(123)	1,100(129)	1,700(136)	700(108)
1979	12,100(175)	7,700(164)	3,050(179)	5,500(196)	3,300(178)	2,050(158)	1,450(171)	2,050(164)	825(127)
1980	15,600(226)	9,600(204)	3,650(215)	6,400(229)	4,100(222)	2,400(185)	1,650(194)	2,500(200)	900(138)
1981	15,600(226)	9,600(204)	3,650(215)	6,400(229)	4,100(222)	2,400(185)	1,650(194)	2,500(200)	900(138)

Appendix 1.3.10. Trends in Freightage (per Ton between Semarang and Surabaya)

(In Rupiahs)

Year	Class I	Class II	Class III	Class IV	Class V	Class VI
1973	2,040(100)	1,864(100)	1,666(100)	1,494(100)	1,221(100)	1,065(100)
1974	2,220(109)	2,104(113)	1,988(119)	1,872(125)	1,756(144)	
1975	2,442(120)	2,315(124)	2,187(131)	2,059(138)	1,932(158)	
1976	2,442(120)	2,315(124)	2,187(131)	2,059(138)	1,932(158)	
1977	2,442(120)	2,315(124)	2,187(131)	2,059(138)	1,932(158)	
1978	2,442(120)	2,315(124)	2,187(131)	2,059(138)	1,932(158)	
1979	2,745(135)	2,603(140)	2,459(148)	2,314(155)	2,173(178)	
1980	3,268(160)	3,099(166)	2,927(176)	2,755(184)	2,587(212)	
1981	3,268(160)	3,099(166)	2,927(176)	2,755(184)	2,587(212)	

The figures in brackets represent annual rates with 1973 at 100.

Appendix1.3.11 Railway Traffic Volume of Main Cargoes (in Java Island)

(Unit: 1,000)

Year	Fertilizer			Cement			Oil products			Maize		
	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton
1973	176	45,347	258	220	91,992	418	1,230	212,468	173	49	27,363	558
1974	164	48,301	295	226	96,903	429	1,170	179,239	153	28	19,448	695
1975	179	39,409	220	201	76,891	382	1,145	172,896	191	22	14,020	637
1976	96	23,428	244	196	96,903	494	1,178	204,024	173	18	10,088	560
1977	176	41,278	235	244	76,611	314	1,053	181,415	172	30	19,434	648
1978	547	135,377	247	360	108,500	301	997	172,124	173	25	15,672	627
1979	422	93,778	222	533	116,084	218	910	150,081	165	26	16,373	630
1980	413	85,954	208	392	99,106	253	691	125,292	181	38	28,788	758
1981	471	83,852	178	318	83,571	263	777	117,336	151	82	60,317	736

Year	Theriac			Rice			Sugar			Steel		
	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton
1973	172	24,146	152	98	27,654	282	61	23,767	390	21	8,604	410
1974	161	25,084	156	73	4,765	65	43	17,357	404	13	5,854	450
1975	142	22,018	155	31	9,402	303	29	12,543	433	12	8,705	725
1976	109	17,048	156	25	4,752	190	28	10,717	383	6	2,498	416
1977	73	11,048	151	66	18,623	282	29	11,101	383	6	2,965	494
1978	90	16,096	179	52	13,271	255	19	6,612	348	6	2,987	498
1979	72	13,999	194	63	22,220	353	39	10,558	271	5	2,228	446
1980	55	11,798	215	40	17,719	443	53	21,322	403	4	1,744	436
1981	63	14,067	222	32	13,024	407	17	5,984	352	8	5,448	681

Year	Salt			Paper		
	Tons	Ton-km	km/ton	Tons	Ton-km	km/ton
1973	34	16,395	482	6.7	4,877	733
1974	41	23,381	570	5.7	3,909	691
1975	15	8,705	580	1.2	852	698
1976	8	4,024	503	1.8	953	541
1977	21	11,703	557	1.4	774	553
1978	26	15,843	609	0.8	409	524
1979	34	21,451	631	0.3	189	675
1980	36	23,496	653	0.6	275	466
1981	20	11,346	567	0.2	63	274

Appendix 1.3.12 Gross Domestic Product (in 1973 Prices)

(In billion Rupiahs)

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980*
1. Agriculture, forestry and fisheries	2,263.0	2,356.0	2,441.0	2,479.0	2,710.0	2,811.0	2,811.2	2,943.7	2,981.3	3,134.8	3,259.9	3,438.5
a. Edible crops	1,373.0	1,402.0	1,436.0	1,415.0	1,573.0	1,681.0	1,696.1	1,755.5	1,734.2	1,835.8	1,908.8	2,093.7
b. Others	890.0	954.0	1,005.0	1,064.0	1,137.0	1,130.0	1,115.1	1,188.2	1,247.1	1,299.0	1,351.1	1,344.8
2. Mining	452.0	522.0	551.0	674.0	831.0	859.0	828.1	952.3	1,070.0	1,048.8	1,046.9	1,034.6
3. Other industries	399.0	435.0	490.0	564.0	650.0	755.0	847.7	930.0	1,057.7	1,176.5	1,295.1	1,568.9
4. Electricity, gas and water	19.6	22.5	24.7	26.2	30.4	37.0	41.2	46.3	49.0	56.9	68.6	77.9
5. Construction	114.0	143.0	171.0	222.0	262.0	320.0	364.8	384.5	463.8	528.9	562.8	628.5
6. Transport and communications	158.0	165.0	210.0	229.0	257.0	288.0	302.7	342.6	427.6	490.1	541.4	595.5
7. Wholesale, financing, service	1,414.9	1,538.5	1,657.0	1,873.0	2,013.0	2,199.0	2,434.9	2,556.9	2,821.5	3,047.3	3,215.1	3,610.0
Total	4,820.5	5,182.0	5,544.7	6,067.2	6,753.4	7,269.0	7,630.8	8,156.3	8,870.9	9,483.3	9,989.8	10,953.9
1. Agriculture, forestry and fisheries	46.9	45.5	44.0	40.8	40.1	38.7	36.8	36.1	33.6	33.1	32.6	31.4
a. Edible crops	28.5	27.1	25.9	23.3	23.3	23.1	22.2	21.5	19.5	19.4	19.1	19.1
b. Others	18.4	18.4	18.1	17.5	16.8	15.6	14.6	14.6	14.1	13.7	13.5	12.3
2. Mining	9.4	10.1	9.9	11.1	12.3	11.8	10.9	11.7	12.1	11.0	10.5	9.5
3. Other industries	8.3	8.4	8.8	9.3	9.6	10.4	11.1	11.4	11.9	12.4	13.0	14.3
4. Electricity, gas and water	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.7	0.7
5. Construction	2.4	2.7	3.1	3.7	3.9	4.4	4.8	4.7	5.2	5.6	5.6	5.7
6. Transport and communications	3.3	3.2	3.8	3.8	3.8	4.0	4.0	4.2	4.8	5.2	5.4	5.4
7. Wholesale, financing, service	29.3	29.7	29.9	30.9	29.8	30.2	31.9	31.3	31.8	32.1	32.2	33.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* Provisional figure Financial Notes 1981/1982 and Budgets Plan for 1982/1983 - Spoken by President Soeharto.

Appendix 1.3.13 Statement of Profit and Loss

(In tousand Rupiahs)

	1979.4 ~ 1980.3	1980.4 ~ 1981.3	1981.4 ~ 1982.2 (Provisional)	1982.4 ~ 1983.3 (Budget)
Incomings				
Railways	37,971,838	46,388,080	49,030,950	59,502,000
Ferryboats	1,808,128	1,760,618	1,657,463	1,619,000
Others	4,598,069	5,624,307	3,095,940	3,530,000
Total	44,378,035	53,773,005	53,784,353	64,651,000
Outgoings				
Personnel outlay	25,164,202	35,764,218	46,088,870	52,040,000
Outlay for goods	29,433,314	41,486,052	32,285,430	43,300,000
Others	4,311,215	6,467,441	6,133,350	11,779,640
Interest, depreciation	10,322,444	11,463,372	12,631,501	12,826,895
Total	69,231,175	95,181,083	97,139,151	119,946,535
Balance	Δ24,853,140	Δ41,408,078	Δ43,354,798	Δ55,295,535

Appendix 1.3.14 Balance Sheet

(In thousand Rupiahs)

	Mar.31,'80	Mar.31,'81
Assets		
Cash	14,062,140	19,644,686
Accounts receivable	4,816,215	6,019,380
Goods in stock	8,855,596	6,471,523
Fixed assets	197,392,067	220,218,025
Rolling stocks	78,349,609	88,372,567
Ground facilities	92,859,101	102,648,951
Building	6,947,551	7,044,740
Autos	1,023,444	1,079,456
Electric facilities	17,026,889	19,873,612
Ferryboats, etc.	1,185,473	1,198,699
Total assets	225,126,018	252,353,614
Liabilities and capital		
Liabilities	9,812,865	15,656,161
Capital	159,037,624	175,437,006
Depreciation reserve	38,354,443	44,781,019
Capital	8,855,596	6,471,523
Government capital account	9,065,490	10,007,905
Total liabilities and capital	225,126,018	252,353,614

Appendix 1.3.15 Investments in PJKA with PELITA Fund

(In thousand Rupiahs)

	1979.4 ~ 1980.3	1980.4 ~ 1981.3
Rolling stocks	2,410,569	797,977
Ground facilities	2,981,992	5,112,287
Building	101,782	2,990
Autos	6,124	16,740
Electric facilities	1,185,584	2,123,441
Total	6,686,051	8,053,435

Appendix 1.4 Roads in General

The total length of roads in the Republic of Indonesia is 123,715 km as indicated in Appendix 1.4.1. Of the total length, 46 percent or 59,029 km is paved with asphalt and the remaining 70,000 km or so is not paved.

The asphalt roads increased by about 78 percent for three years from 1975 to 1978. In spite of no significant rise in the total length, the length of asphalt roads increased presumably because the Indonesian Government concentrates its efforts on an improvement of the road specifications, rather than the construction of new roads.

In general, it has been pointed out that the drainage of roads in Indonesia has yet to be improved and the road shoulders are narrow. In addition, the fact that the load of bridges is excessively small is also taken up as an issue. These factors result in reducing the road capacity. In an overall aspect, it might be said that the road network is sparse. On the national average, 67 m of roads available per square kilometer or 870 m per 1,000 population.

On Java, 62 percent of the national population are concentrated. Nevertheless, Java shares only 31 percent of roads, or as low as about 440 m of roads per 1,000 population. This factor constitutes a major cause to an acceleration of traffic snarls witnessed at all times.

The Indonesian Government is striving hard to construct new roads and maintain and improve existing roads. Under PELITA (five-year plan), a huge amount of money is invested in roads as indicated in Appendix 1.4.2. In 1980, a total of 238,300 million Rupiahs was invested. In the following year, a budget of 298,100 million Rupiahs was earmarked.

Next, the number of autos was indicated in Appendix 1.4.3. In 1980, the number of registered autos throughout the nation stood at about 3,850,000 (including 2,650,000 bicycles). This total figure includes 640,000 four-wheelers. From 1971 to 1980, the annual increase rate stood at 10.5 percent for four-wheel passenger cars, 15.8 percent for buses, 17.0 percent for trucks and 19.8 percent for bicycles, indicating that the rate is highest for bicycles.

Sixty-seven percent of the national total of autos or about 2,600,000 autos are registered in Java. Of them, passenger cars account for 78 percent, going far ahead or other vehicles.

Next, let us see the recent business conditions of DAMRI (State-owned Bus Company). The transportation program for fiscal 1982 is given in Appendix 1.4.4. The buses owned by this company include 264 for inter-city transport, 588 for urban transport (including 65 double-deck buses), 144 for new line and feeder transport and 57 for tourism, totaling 1,053. The personnel consists of 216 at the central and local offices, 1,120 for inter-city transport, 99 for urban transport, 481 for new line and feeder transport, 73 for tourism and 273 at workshops and transfer offices, totaling 5,562 persons. In this fiscal year, plans are afoot for the education of 646 workers in various lines of business, with drivers and conductors sharing the greatest number with 472. There also plans for the development of 1,500 buses in this fiscal year or fiscal 1983, so that an additional 1,680 workers are scheduled to be educated. These buses include 1,000 for inter-city transport and 500 for new line and feeder transport. The investments are $29 million and $13 million respectively. As regards the employment of workers, it is made a practice to hire four per bus for inter-city transport, six for urban transport, 4.5 for new line and feeder transport and 2.5 for tourism.

The conditions of this company's incomings and outgoings are shown in Appendix 1.4.4. The management records are relatively good with the operating ratio standing at 106.0 in fiscal 1981. With the predepreciation one standing at 85, the incomings are in excess of the outgoings. One of the major reasons for this favorable account is that the share of the personnel outlay is relatively small with 27 percent.

According to the company's long-range plan extending to 2,000, the population increase rate is estimated at 2.5 percent. On this estimate, the number of buses required is estimated at 3,460, 9,550 and 1,900 vehicles for inter-city, urban and new line and feeder.

Appendix 1.4.1 Length of Roads

(in kilometers)

Year	National					Java				
	Asphalt	Gravel	Earth and Sand	Others	Total	Asphalt	Gravel	Earth and Sand	Others	Total
1975	33051	21372	23484	26774	104681	17383 (53)	8631 (40)	2681 (11)	7116 (27)	35811 (34)
1976	48961	26012	40557	7811	123341	25380 (52)	6265 (24)	7441 (18)	1043 (13)	40129 (33)
1977	49319	23962	41055	8458	122794	25900 (53)	5015 (21)	7360 (18)	955 (11)	39230 (32)
1978	59029	21662	40424	7600	128715	28593 (48)	4929 (23)	5340 (13)	1017 (13)	39879 (31)

Note: Directorate or General Road Traffic and Transportation. The figures in brackets represent the Java's share in the national total.

Appendix 1.4.2 Road Investment

Year	Maintenance and Rehabilitation	Improvement	New Construction	Maintenance	Bridges	PLPT
	KM	KM	KM	KM	M	KK
1974	12,257	546	230			
1975	9,716	757	145			
1976	10,168	916	148			
1977	11,071	1,165	110			1,005
1978	13,281	1,365	108			1,105
1979	900	935	68	21,074	5,537	49,000
1980	1,582	1,684	221	18,528	6,510	70,400
1981	2,395	1,750	185	20,702	11,520	80,425

	$Rp \times 10^3$	$Rp \times 10^3$	$Rp \times 10^3$	$Rp \times 10^3$	$Rp \times 10^3$	$Rp \times 10^3$
1974	10,643,725	42,889,350	12,376,944			
1975	10,032,329	32,305,794	12,742,155			
1976	12,678,329	46,435,782	13,911,102			
1977	12,769,592	69,768,193	14,485,758			14,005,427
1978	15,306,775	85,944,830	21,635,467			36,622,000
1979	922,023	40,716,522	13,976,017	18,108,367	15,014,984	30,654,615
1980	1,935,393	77,460,881	47,672,779	33,847,806	22,458,447	54,947,221
1981	3,572,902	73,018,000	17,081,441	69,185,553	25,831,200	109,424,196

Note: Director General of Highways, 1981

Appendix 1.4.3 Number of Vehicles by Type

Year	National Total					Java				
	Passenger Cars	Buses	Trucks	Bicycles	Total	Passenger Cars	Buses	Trucks	Bicycles	Total
1971	259282	22797	115082	522069	925230	195425 (75)	11663 (51)	65311 (57)	358185 (69)	630584 (68)
1972	277210	26488	113175	615220	1050093	208022 (75)	13370 (50)	78832 (60)	433691 (70)	733915 (70)
1973	307739	30388	144060	720056	1202223	228507 (74)	15440 (51)	87467 (61)	495990 (69)	827404 (69)
1974	337789	31439	166457	944733	1480418	254563 (75)	17121 (54)	108191 (65)	652099 (69)	1031974 (70)
1975	383061	35103	196416	1191771	1806351	290862 (76)	19406 (55)	130263 (66)	816748 (69)	1257279 (70)
1976	420945	40001	223062	1419375	2103383	328099 (78)	21567 (54)	146007 (65)	956352 (67)	1452025 (69)
1977	479335	48089	278979	1704964	2511367	378295 (79)	25921 (54)	182930 (66)	1142661 (67)	1729807 (69)
1978	535442	58389	336753	1990250	2920834	412209 (77)	32723 (56)	214588 (64)	1326184 (67)	1985704 (68)
1979	581757	67230	364553	2308133	3321672	453624 (78)	40082 (60)	248938 (68)	1510831 (65)	2253475 (68)
1980	636867	85571	472095	2655889	3850422	496760 (78)	51340 (60)	321020 (68)	1726330 (65)	2595450 (67)

Notes : —— 1. The national totals are based on the number of motorized vehicles all over Indonesia. (Directorate of Road Traffic and Transportation)

2. The number of vehicles on Java is based on Jumlah Kendaran Bermotor Tahun 1966~1979 Seluruh Indonesia (ibid).

3. The figures in brackets represent shares of Java (%) in the national total in each year by type of vehicle.

Appendix 1.4.4 DAMRI Actual Record and Plan (in thousand Rupiahs)

	Planned 1981	Actual Record 1981	Planned 1982
Incomings			
Incomings from transport	10,814,390	10,540,341	13,871,211
Incomings from kiosks	103,873	115,297	193,700
Incomings from transfers	251,858	257,692	269,060
Others	111,446	103,517	126,600
Total	11,281,567	11,016,847	14,460,571
Outlays			
Personnel outlay			
Transport	2,237,766	1,739,005	2,391,496
Technology	332,075	383,382	492,369
Control	571,604	545,597	717,755
Others	289,390	298,613	358,693
Total	3,430,835	2,966,597	3,960,313
Operation			
Wheels	914,941	981,344	1,597,345
Diesel oil	1,197,548	1,184,342	1,639,275
Lubricant	457,718	469,523	743,177
Terminals	133,714	161,240	161,635
Total	2,705,291	2,796,449	4,141,432
Maintenance			
General transport equipment	1,571,370	1,607,491	1,894,217
Others	47,926	62,248	120,000
Total	1,619,296	1,669,739	2,014,217
Depreciation			
General transport equipment	1,969,934	1,990,983	2,916,181
Others	286,014	339,841	208,340
Total	2,255,948	2,330,824	3,124,521
Insurance			
General transport equipment	106,915	84,832	126,607
Buildings	482	2,080	500
Total	107,397	86,912	127,107
Sales	354,756	356,962	454,499
Business tours	189,033	173,155	217,880
General control	973,168	951,626	1,035,450
Taxes	135,131	130,210	136,225
Interest	210,562	218,261	199,182
Total	11,982,047	11,680,735	15,410,826
Balance	Δ 700,480	Δ 663,888	Δ 950,255
Operating ratio	106.2%	106.0%	106.6%

	Planned 1982	Actual Record 1981	Planned 1982
Number of Buses			
Inter-city	264	246	264
Urban	559	549	588
New lines and feeders	138	144	144
Tourism	50	57	57
Total	1,011	996	1,053
Transport Record			
Operation (1,000 vehicle-km)			
Inter-city	25,925	25,752	33,056
Urban	31,168	29,089	35,378
New lines and reeders	5,128	4,511	6,302
Tourism	890	847	1,040
Total	63,111	60,199	75,776
Traffic volume (1,000)			
Inter-city (passenger-km)	849,042	862,619	1,098,381
Urban (passenger-carried)	154,045	143,081	169,045
New lines and feeders (passenger-km)	106,418	94,043	138,013
Freight (ton-km)	771	561	314
Tourism (passenger-km)	32,018	32,931	34,464
Number of staff officials (passenger-carried)			
Head and branch offices	220	216	216
New lines and feeders	433	481	481
Urban	3,049	3,309	3,399
Inter-city	1,117	1,120	1,120
Kiosks	130	136	136
Transfer offices	127	137	137
Tourism	125	73	73
Total	5,201	5,472	5,562

Source: Legalization of the Expenditures and Revenues Budget for P.N. DAMRI 1982.

Appendix 1.5 Aviation in General

The demand for air transport has remarkably increased in conjunction with the development of the national economy. As it were to follow this trend, the Government has invested huge amounts of money in air transport to increase its supplying capacity.

Appendix 1.5.1 shows the amounts of money invested by the Indonesian Government in the development of airports and the purchase of equipment and material. About 394,500 million Rupiahs had been invested from the first five-year plan to the end of fiscal 1981.

A check of the volume of transport indicates, as is discernible from Appendix 1.5.2, that passenger transport increased at an annual rate of about 19 percent in terms of passenger-kilometers and cargo transport registered an annual average rise of 19 percent in terms of tonkilometers from 1971 to 1981. In particular, the latter showed an annual average rise of 21 percent in terms of tonnage. When this percentage is compared with the rate of increase in ton-kilometers, it is discernible that the rise in the short-distance transport of cargoes was high.

Garuda Indonesian Airways, the national airline, which forms the core of civil air transport in Indonesia has a share of 94∿95 percent in both passenger and cargo transport. The number of incoming and outgoing passengers by major city on the Java has in the last several years increased at a high annual rate of 20 percent with the exception of Jakarta and Yogyakarta.

Appendix 1.5.1 Investments in Civil Air Transport

(in million Rupiahs)

Long-range plan	National fund		Foreign fund		Total		Rate of foreign fund (%)	
	Planned	Actual	Planned	Actual	Planned	Actual	Planned	Actual
PELITA I	19767	19674	15047	19241	34814	38915	43	49
" II	78333	78333	180930	125975	259263	204308	70	62
" III (1981 ∿ 1982)	138607	75839	138565	75415	277172	151254	50	50
Total	236707	173846	334542	220631	571249	394477	59	56

Note: Directorate of General of Air Communications

Appendix 1.5.2 Domestic Air Transport Volume

Year	Flying distance (1,000km)	Flying hours (1,000hr)	Number of passengers transported (1,000 persons)	Passenger transport			Cargo transport			
				Passenger-kilometers transported (1,000km)	Seat-kilometers (1,000 seat-km)	Load factor (%)	Transport tonnage (1,000 ton)	Transport ton-kilometers (1,000 ton-km)	Load ton-kilometers (1,000 ton-km)	Load factor (%)
1971	20458	61	993	731095	1045712	70	7.015	68051	102494	66
1972	26942	74	1235	881112	1412575	62	11.094	82209	125502	66
1973	33194	85	1649	1197196	2100763	57	13.790	115062	213952	54
1974	42448	106	2126	1593990	2779464	57	19.252	114401	264461	43
1975	46972	116	2323	1786404	3125450	57	22.619	164955	302570	55
1976	56138	136	2732	2118572	3801312	56	28.781	196602	370925	53
1977	59142	151	3372	2578953	4160492	62	32.908	233290	396509	59
1978	65958	166	3979	2688525	4531113	59	35.822	263716	422400	62
1979	69324	174	4192	3042558	4972793	61	38.532	275513	456247	60
1980	71352	188	4449	3356971	5226647	64	44.480	306189	492160	62
1981	87456	212	5588	4187869	6351887	66	50.459	373166	616433	61

Note:—Directorate General of Air Communications

Appendix 1.5.3 Passengers (Air Transport)

Airport	Year	Arrival	Departure	Total	Rate of increase
Jakarta	1977	1,635,438	1,614,186	3,249,624	1.00
	1978	1,937,741	1,933,761	3,871,502	1.19
	1979	2,023,707	2,035,096	4,058,803	1.25
	1980	2,298,360	2,313,063	4,611,424	1.42
	1981	2,703,505	2,640,313	5,343,818	1.64
Bandung	1977	16,087	18,936	35,023	1.00
	1978	38,031	43,823	81,854	2.34
	1979	48,431	57,005	105,436	3.01
	1980	37,396	44,328	81,724	2.33
	1981	40,651	47,205	87,856	2.51
Semarang	1977	126,792	129,345	256,137	1.00
	1978	159,489	164,052	323,541	1.26
	1979	155,192	154,211	309,403	1.21
	1980	166,888	166,902	333,790	1.30
	1981	183,485	177,493	360,978	1.41
Yogyakarta	1977	117,555	124,774	242,329	1.00
	1978	116,471	128,123	244,594	1.01
	1979	114,545	125,157	239,702	0.99
	1980	121,444	132,753	254,197	1.05
	1981				
Solo/Surakarta	1977	16,333	17,637	33,970	1.00
	1978	29,008	31,675	60,683	1.79
	1979	36,055	39,095	75,150	2.21
	1980	36,721	40,841	77,562	2.28
	1981	48,500	50,009	98,509	2.90
Surabaya	1977	210,525	292,692	503,217	1.00
	1978	292,777	437,925	730,702	1.45
	1979	482,585	526,152	1,008,737	2.00
	1980	614,464	627,425	1,241,889	2.47
	1981				

Appendix 4.1 Trial Calculation of Impedance of Feeding Circuit

1. Estimation of earth conductivity

Earth conductivity is roughly estimated from geological maps. Since the western Java area is primarily composed of layers of lime and layers of volcanic rock, its earth conductivity is estimated to be less than 0.001 - 0.01 S/m, and the central and eastern Java areas are alluviums with an earth conductivity of about 0.01 to 0.1 s/m. Consequently, a trial calculation is carried out by using an earth conductivity of 0.01 s/m.

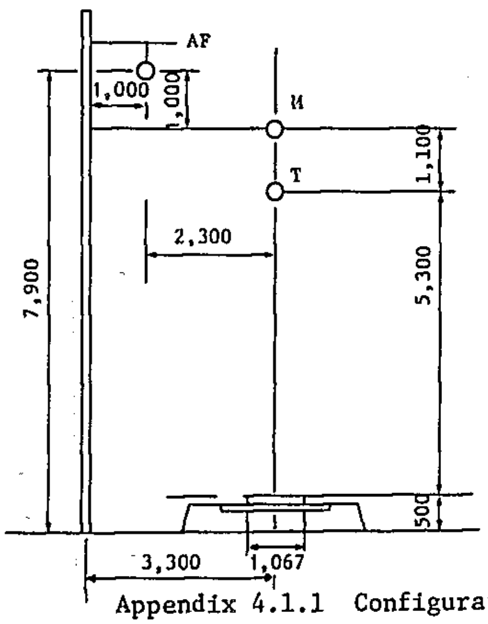
2. Frequency 50 Hz

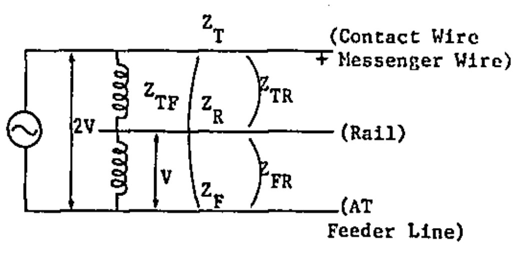
3. Rail

PJKA uses several kinds of rail, but we selected the R-14 type rail since it is used in the greatest amount.

4. Arrangement of electric wires and kind of wire

AF: Al 200 mm^2
M : St 135 mm^2
T : Tr 110 mm^2





Appendix 4.1.1 Configuration of Overhead Contact System

5. Results of trial calculation

Self impedance

Contact wire + messenger wire $Z_T = 0.132 + j\ 0.642$

AT feeder wire $Z_F = 0.196 + j\ 0.740$

Rail $Z_R = 0.110 + j\ 0.604$

Mutual impedance

Between contact wire · messenger wire and rails

$Z_{TR} = 0.049 + j\ 0.319$

Between contact wire and AT feeder wire

$Z_{TF} = 0.049 + j\ 0.366$

Between AT feeder wire and rail $Z_{FR} = 0.049 + j\ 0.301$

Line impedance:

Line impedance is calculated by a simplified formula

$$Z = \frac{Z_T + Z_F - 2Z_{TF}}{4} = 0.056 + j\ 0.163$$

Appendix 4.2 Trial Calculation of Voltage Drop

1. Estimation of impedance

(1) Impedance of power source

	Three phase fault level (Ps)	Impedance of power source (at 25 KV)
Double track section	1,500 MVA	j 0.84 Ω
Single track section	800 MVA	j 1.56 Ω

(2) Transformer impedance (at 25kV)

Double track section .. It is assumed 30MVA and %Z=10(%);

$$Z = \frac{10 \times 25^2 \times 10}{30,000} = j\,2.08\ \Omega$$

Single track section .. It is assumed 20MVA and %Z=10(%);

$$Z = \frac{10 \times 25^2 \times 10}{20,000} = j\,3.12\ \Omega$$

(3) Line impedance

$$Z = 0.056 + j\,0.163\ \Omega/\text{km}$$

2. Voltage drop per unit (Cos θ = 0.8)

(1) Power source

Double track section	0.84 × 0.6 = 0.504 V/A
Single track section	1.56 × 0.6 = 0.936 V/A

(2) Transformer

Double track section	2.08 × 0.6 = 1.248 V/A
Single track section	3.12 × 0.6 = 1.872 V/A

(3) Line $0.056 \times 0.8 + 0.163 \fallingdotseq 0.150$ V/A-Km

3. Composition of circuit and loading condition

(1) Feeding distance 100 km

(2) Whether a series condenser (SrC) for compensating the impedance of a transformer for feeding at SS is used or not.
Whether an ACVR for relieving a voltage at extended feeding is installed at SP or not.

(3) Number of train

Single track line	Normal feeding	5 trains
	Extended feeding	10 trains
Double track line	Normal feeding	8 trains
	Extended feeding	16 trains

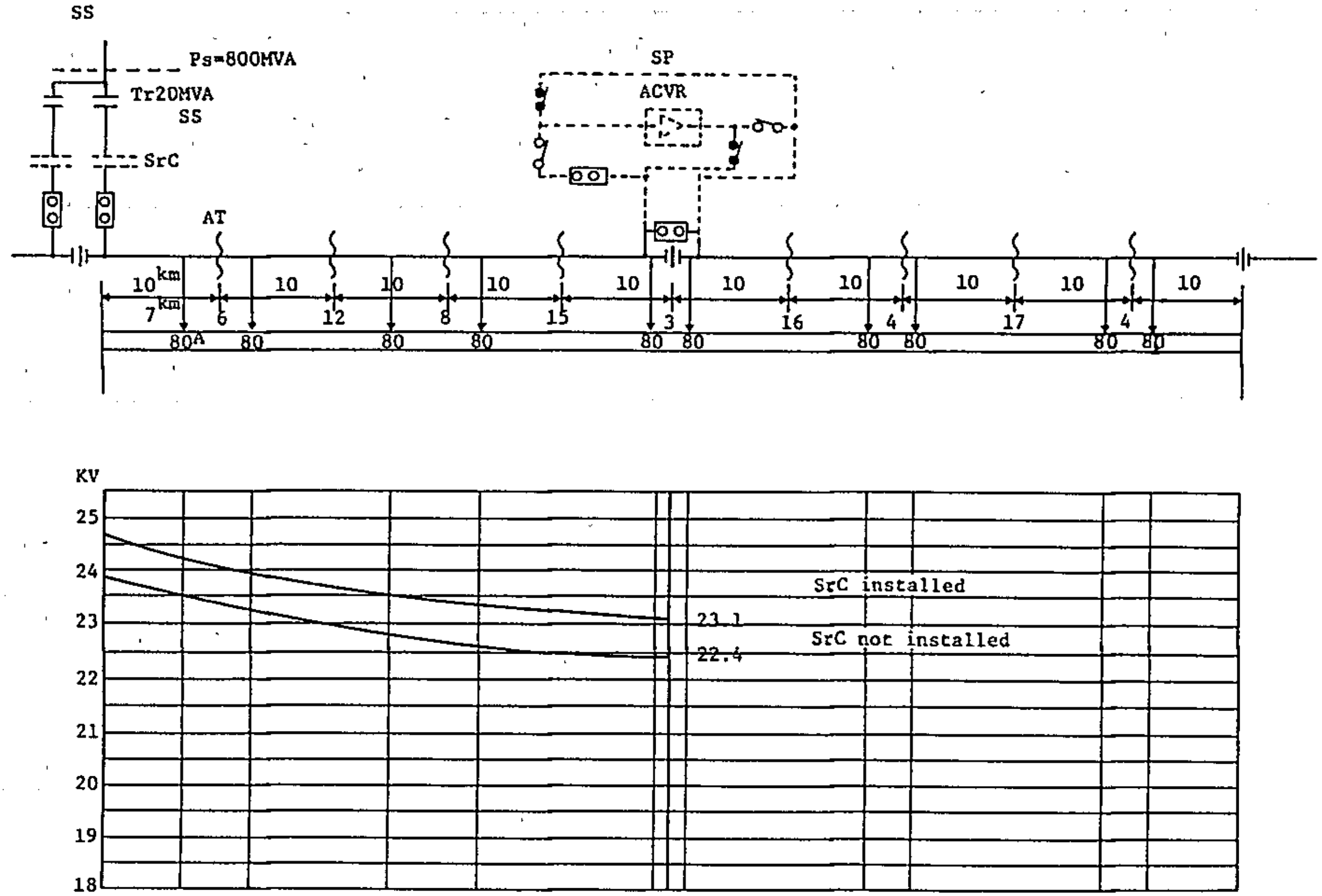
A train is applied with a uniform load of 80A.

4. Results of trial calculation

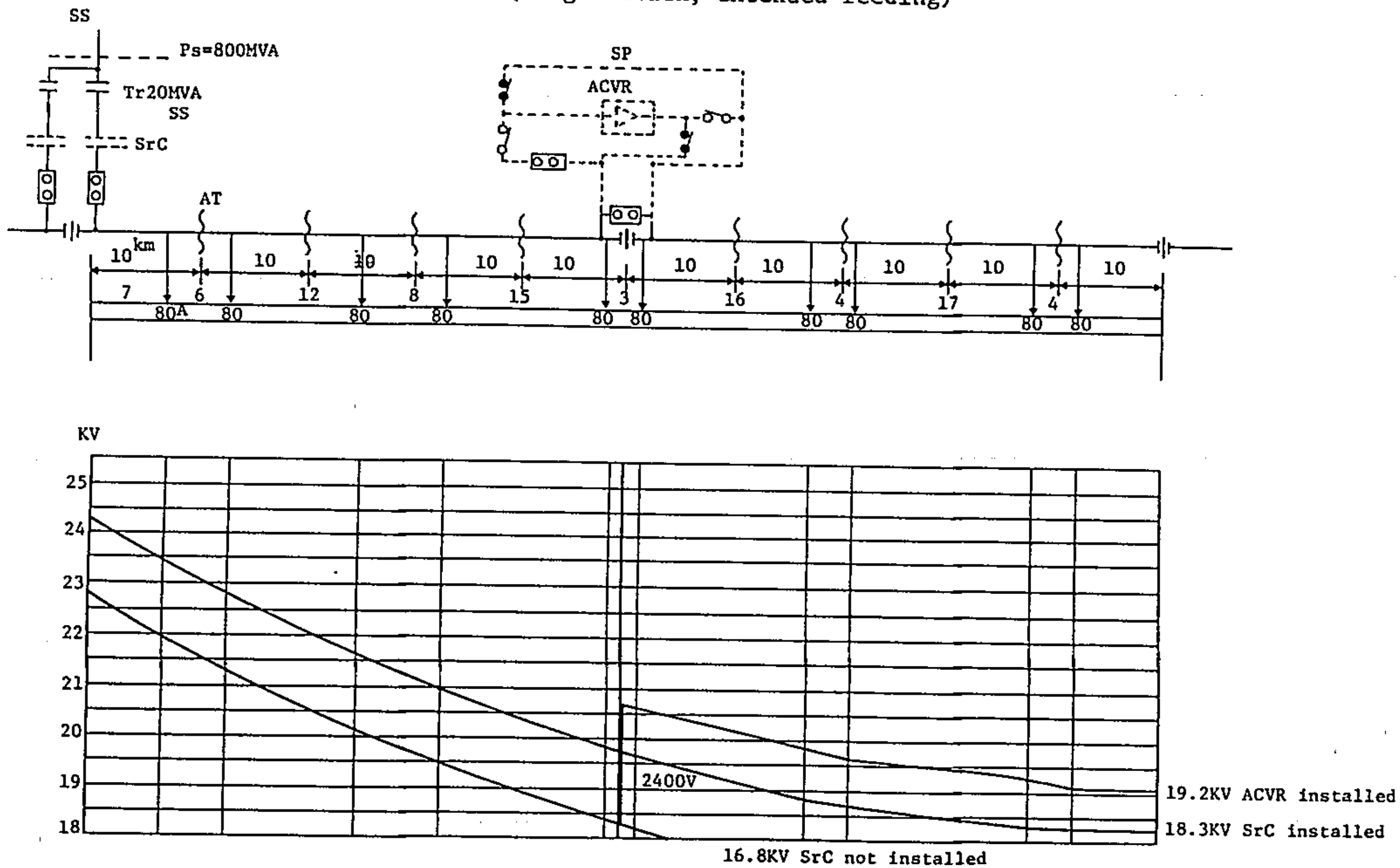
Results are shown in Appendix 4.2.1 to 4.2.4.

Appendix 4.2.1 Example of Trial Calculation of Volatage Drop

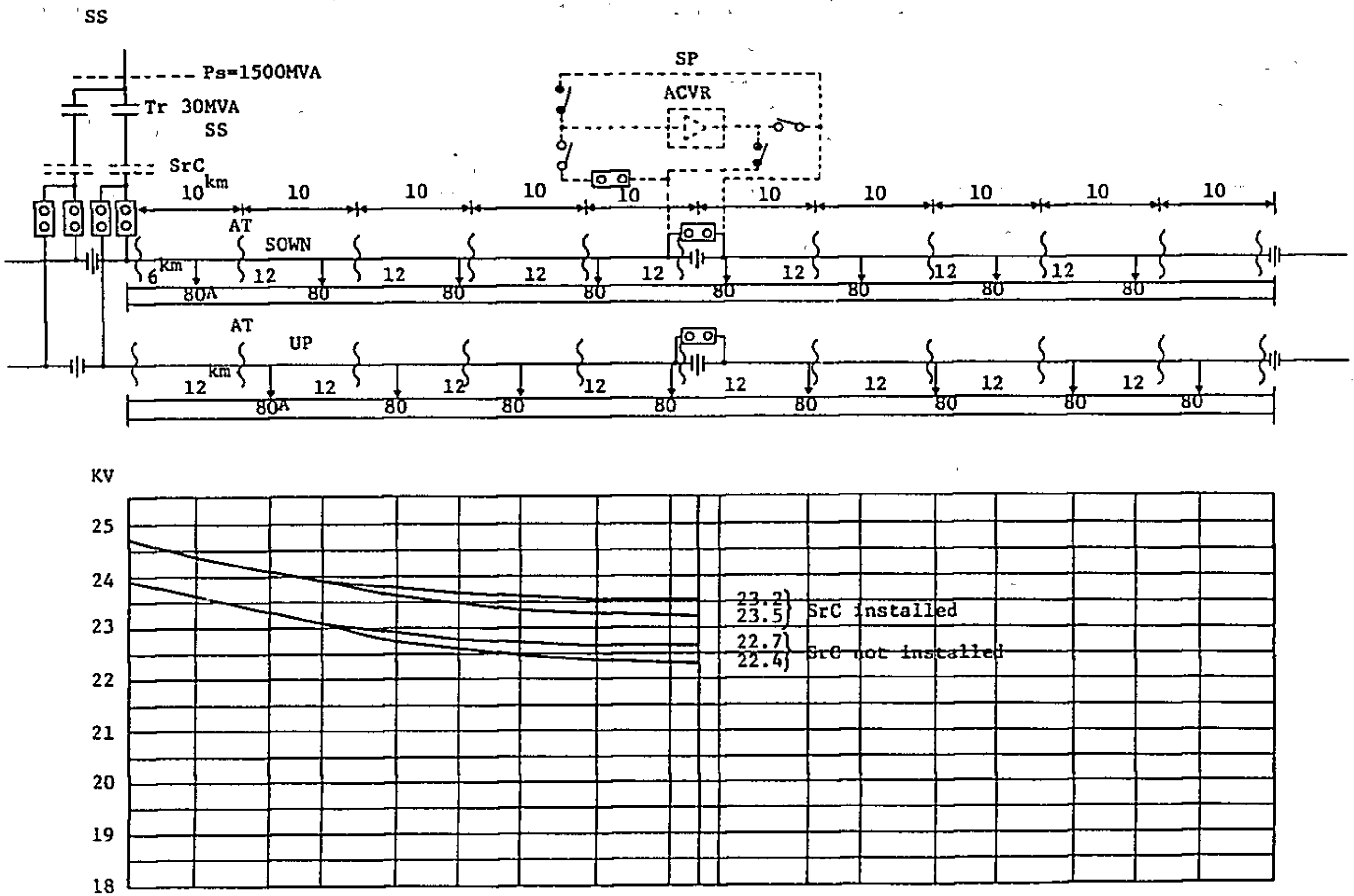
(Single track, normal feeding)



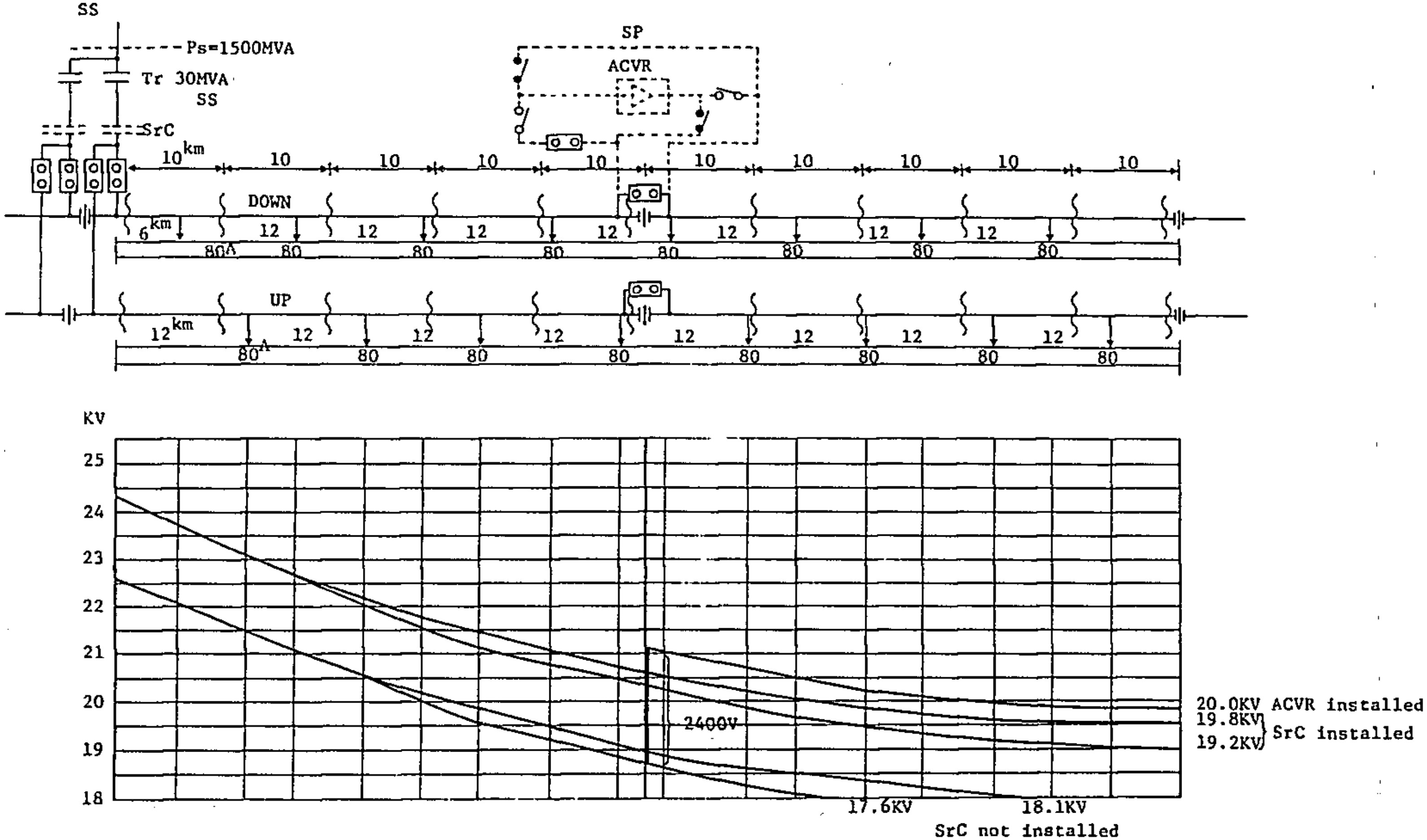
Appeendix 4.2.2 Example of Trial Calculation of Voltage Drop
(Single track, extended feeding)



Appendix 4.2.3 Example of Trial Calculation of Voltage Drop
(Double track, normal feeding)



Appendix 4.2.4 Example of Trial Calculation of Voltage Drop
(Double track, extended feeding)



Appendix 4.3 Trial Calculation of Feeding Transformer Capacity

1. Prerequisites

(1) No. of train

It is assumed as foolows:

Single track section: 80/day

Double track section: 230/day

(2) No. of train per hour

Single track: $80/\text{day} \times \frac{3}{4} \times \frac{1}{12} = 5/\text{h}$

Double track: $230/\text{day} \times \frac{3}{4} \times \frac{1}{12} \fallingdotseq 14/\text{h}$

- The number of effective hour per day is assumed 24.
- It is assumed that $\frac{3}{4}$ of all trains are operated during half of the effective hours.

(3) No. of ton to be hauled

Freight car: 1,060 t

Passenger car: 460 t

- The ratio of PC trains and FC trains shall be 9 to 1.
- Schedule speed shall be 70 km/h.

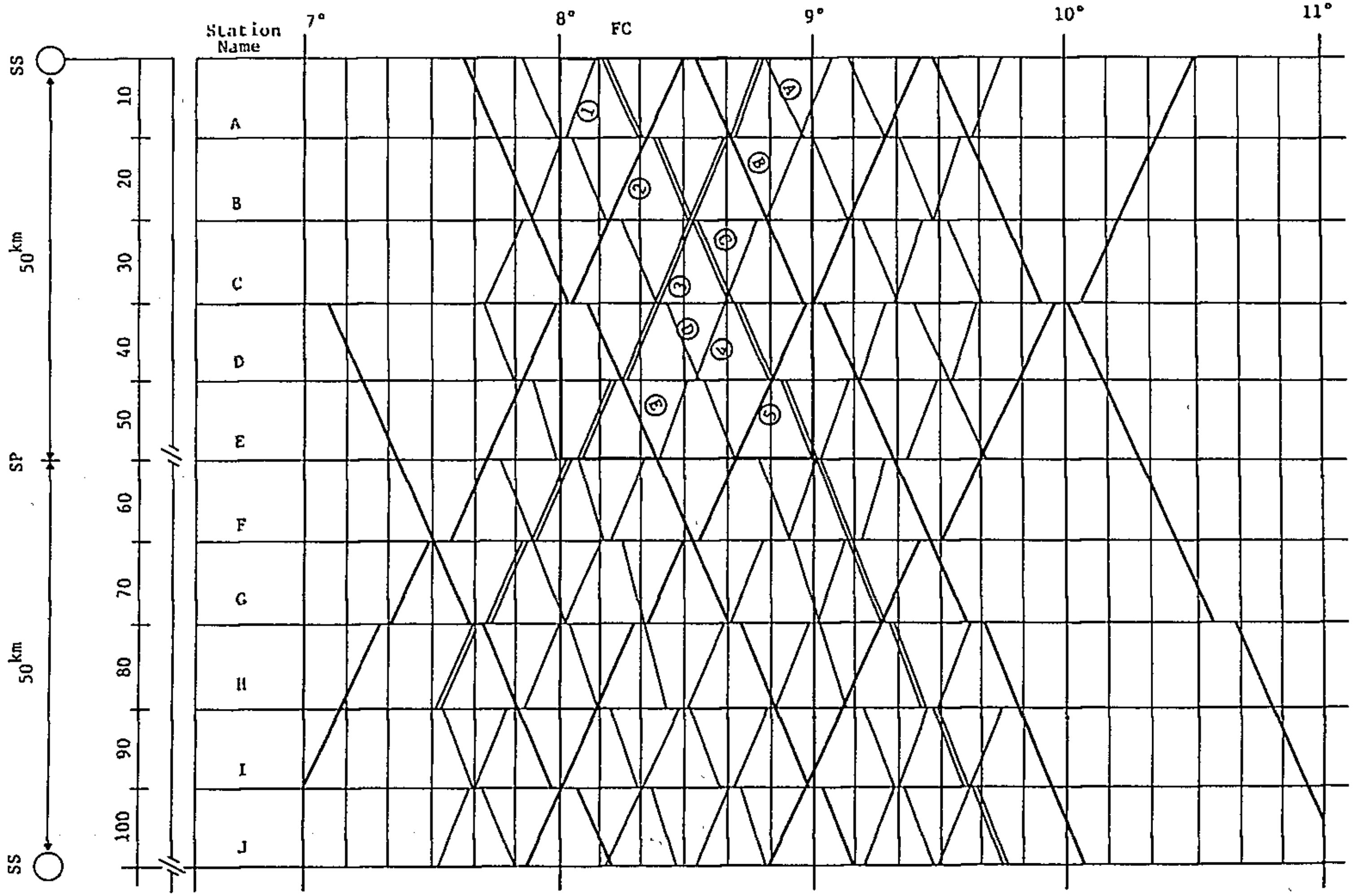
(4) Estimation of rate of electric power consumption

FC: 25KWh/1,000 t-km

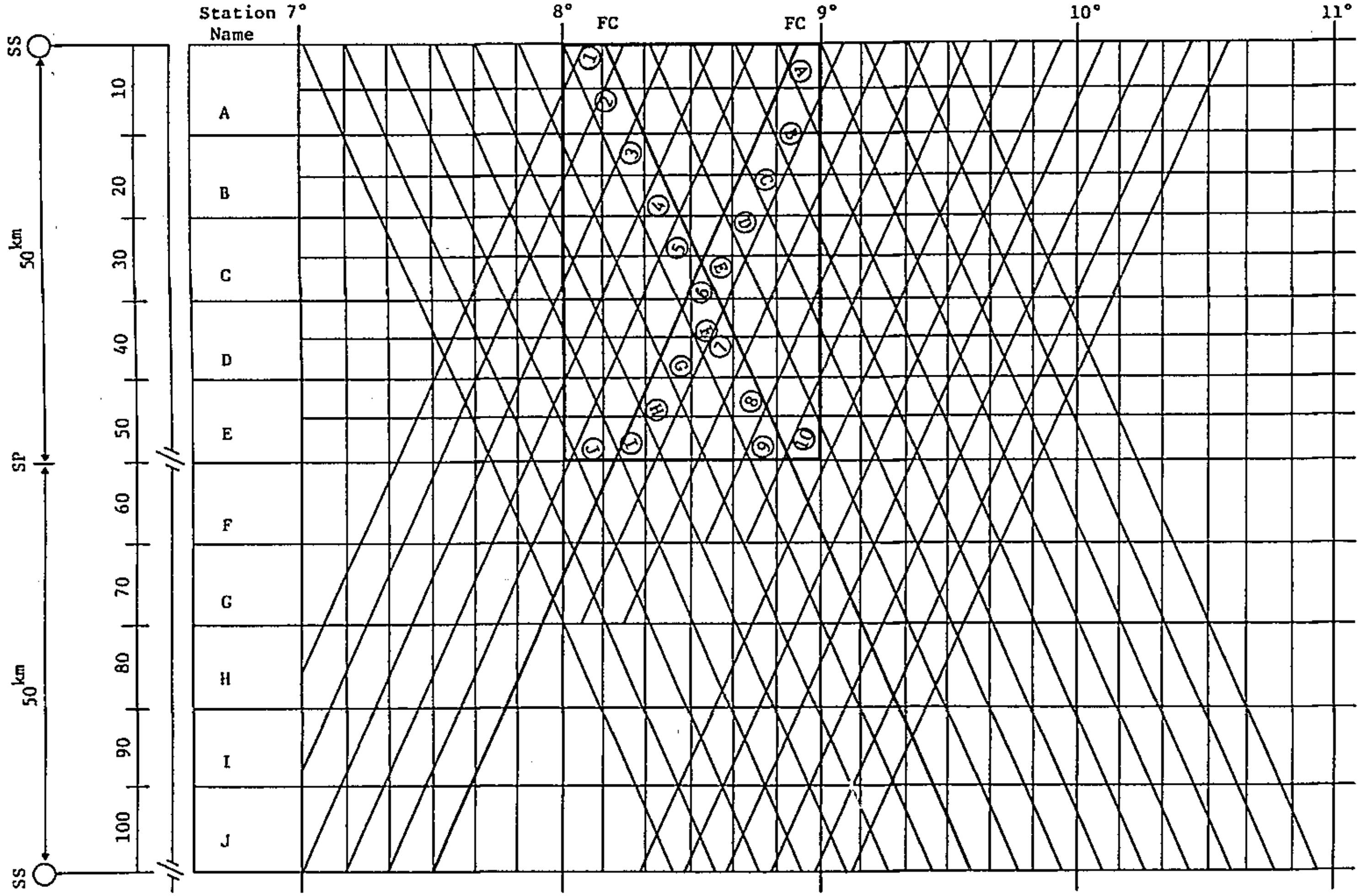
PC: 30KWh/1,000 t-km

(5) Tentative train diagrams are shown in Appendix 4.3.1 and 4.3.2.

Appendix 4.3.1 Tentative Train Diagram of 5 Train/H for Single Track Section



Appendix 4.3.2 Tentative Train Diagram of 14 Train/H for Double Track Section



Appendix 4.3.3 Preparation of Load Calculation Table

Based on the Tentiave Train Diagram, the Load Power per Hour is Shown Below:

Single-track section 5 trains/h

Hour (h)	Power consumption rate (KWh/1000t-km)	Houling capacity (t)	Running distance of train (km)	Power 1000 (KWh)	Total power (KWh)	Train No.
	30	460	10	138		①
	30	460	30	414		②
	25	1,060	50	1,325		③
	30	460	44	607		④
	30	460	20	276		⑤
					2,760	
	30	460	10	138		Ⓐ
	30	460	30	414		Ⓑ
	25	1,060	50	1,325		Ⓒ
	30	460	40	552		Ⓓ
	30	460	22	304		Ⓔ
					2,733	

Double-track section 14 trains/h

Hour (h)	Power consumption rate (KWh/1000t-km)	Houling capacity (t)	Running distance of train (km)	Power 1000 (KWh)	Total power (KWh)	Train No.
	30	460	5	67		①
	30	460	16	221		②
	30	460	28	386		③
	30	460	40	552		④
	30	460	50	690		⑤
	25	1,060	50	1,325		⑥
	30	460	44	607		⑦
	30	460	32	442		⑧
	30	460	20	276		⑨
	30	460	8	110		⑩
					4,678	
	30	460	12	166		Ⓐ
	30	460	18	248		Ⓑ
	30	460	34	469		Ⓒ
	30	460	47	649		Ⓓ
	25	1,060	50	1,325		Ⓔ
	30	460	50	690		Ⓕ
	30	460	38	524		Ⓖ
	30	460	26	359		Ⓗ
	30	460	15	207		Ⓘ
	30	460	3	41		Ⓙ
					4,678	

2. Trial Calculation of Feeding Transformer Capacity

(1) Single track 5 trains/H diagram

One hour output = 2,760 + 2,733 = 5,493 KW

Assuming a power factor of 0.8; One hour output; 7,000 KVA

Capacity of transformer: 7,000 KVA × 1.2 ≒ 9,000 KVA

Margin rate of facility: 1.2

In consideration of 100 km of extended feeding;

9,000 × 2 = 18,000 KVA

In consideration of standardization of transformers;

Transformer capacity: 20,000 KVA

(2) Double-track 14 trains H diagram

One hour output = 4,678 × 2 = 9,356 KW

Assuming a power factor of 0.8, one hour output; 12,000 KVA

Capacity of transformer: 12,000 KVA × 1.2 = 15,000 KVA

In consideration of 100 km of extended feeding;

15,000 × 2 = 30,000 KVA

Transformer capacity: 30,000 KVA

Appendix 5.1 Optical Fiber Cable

The information transmission system in railway transportation systems is composed of the radio system and the cable system. In the cable system of information transmission, communication cables (paired cables, coaxial cables) has been used generally and electrical signals used as the media of this method of communication. In this communication cable system, however, there are technical restrictions as to transmission band width and transmission distance and, furthermore, countermeasures are necessary against potential rises due to inductive interference and grounding accidents in the substation or feeder line in the railway electrification section.

On the other hand, optical fiber cables, the development of which has been progressing as a low loss cable, possess various features suitable to the electromagnetic environment of the electrified section previously mentioned, in addition to their low loss feature and, with rapid technological advances in recent years, their reliability has also improved. Optical fiber cables have now reached the stage at which they can be introduced into the railway transportation system.

Here we shall summarize the fiber optics communication system and the problems in introducing this into the railway field.

5.1.1 Features of the Optical Fiber Communication System

As optical fiber insulating material are used as the signal transmission media in optical fiber communication systems, high quality communications can be carried out in the electromagnetic environmental conditions previously mentioned. It also possesses the following features over conventional communication cables.

(1) Low loss and wide band

As transmission loss is currently very low at 3 to 5 dB/Km at a wave length of 0.85 μm, long distance transmissions (up to 10∿15 Km at 5 dB/Km) without relays are possible. Also, as the transmission band is wider than conventional communication cables, not only will it be possible to transmit general voice signals but wide-band transmissions of video signals, PCM signals and other high speed digital signals are also possible.

(2) Noninductive and high insulating characteristics

As electromagnetic and electrostatic induction is not generated in optical fibers since they are insulators, no inducted voltages or noises are generated. Also, as there will be no fear of the cable being wighted with surge voltages due to lightning, there will be no need for protective devices such as arrestors or for insulating coordination. In addition, it will no longer be necessary to consider shielding the cable itself, its voltage withstanding characteristics, or its distance from high tension lines.

(3) No crosstalk and no noise characteristics

There is practically no crosstalk between lines and no external noises so there will be no signal errors during transmission nor will there be any mixing in of abnormal voltages.

(4) Fine core and light in weight

Even after a nylon coating, the outside diameter of the optical fiber is only about 1mm and it is also extremely light in weight at less than 1/50 of the weight of conventional cables.

(5) Flexibility and corrosion resistant characteristics

The permissible ratio of curvature of single-core optical fibers is extremely small at 3mm and these fibers are highly flexible. Also, as they are made of glass material, there will be practically no cases of electrolytic corrosion or metallic corrosion arising as in the case of metallic wires.

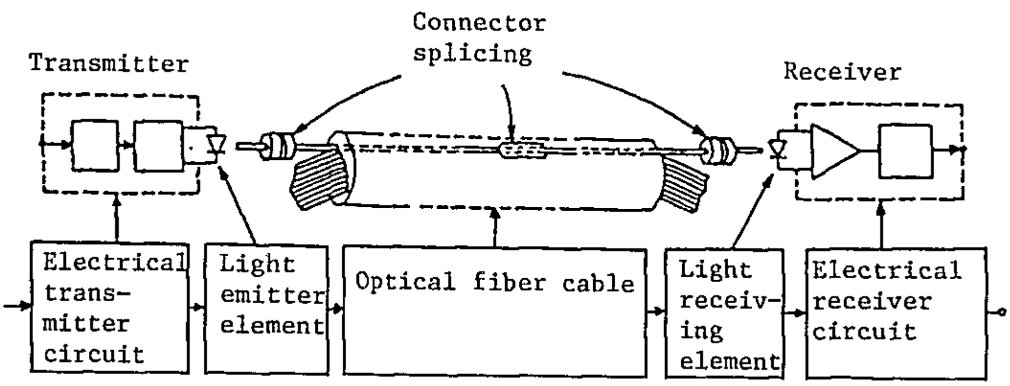
(6) Construction characteristics

Optical fiber systems possess various advantages as explained in the foregoing and one of the major advantages is from the standpoint of construction since, not only is the cable easy to lay, it can be used compositely with high voltage lines and can be laid in the same conduit line.

5.1.2 Optical Fiber Communication System

(1) Basic composition of optical fiber communication

As shown in Appendix 5.1.1, the optical fiber communication system is composed of the optical emitter transmitter (E/O) to convert electrical signals to light signals, the optical receiver (O/E) to convert the light signals back into electrical signals, the optical fiber cables and the terminal equipment.



Appendix 5.1.1 Optical Fiber Communication System

(2) Optical fiber communication system

Transmission can be roughly divided into the analog system and digital system depending on the type of signals to be sent.

1) Analog system

The analog system can be divided into direct modulation and premodulation according to the modulation system.

a) Direct modulation

This is a system of modulating the amount of light directly with the input electrical signals. It has the advantages of simplicity in equipment composition and nonwidening of the transmission band. On the other hand, linearity will be required in the photoelectric conversion element.

b) Premodulation

This is a system of carrying out light modulation by initially modulating the carrier signal with the input electrical signals, so it will not be easily subjected to the effects of linearity. A typical premodulation system is the PFM (pulse frequency modulation) in which the strength of the input will be made proportional to the repeated frequency of the pulse. Although improvements in signal to noise ratio can be obtained in this system by increasing the degree of modulation, wide-band fibers will be required.

2) Digital system

This is a modulation system in which the information to be transmitted is expressed with pulse codes and this is substituted by flashing the light output. Compared to the analog system, equipment composition is complex. This system is suitable for transmission of PCM signals and data where the information to be transmitted is originally digital signal.

(3) Types of optical fiber communication equipment

Optical fiber communication equipment may be classified as follows according to the wavelength band of the light used and the photoelectric conversion element.

1) Classification by wavelength band

The light used in optical communication is near infrared rays and the wavelength band may be divided into the 0.85μm band, 1.3μm band and the 1.5μm band. The 0.5μm band is currently becoming popular and is the most economical. The 1.3μm band has already entered the practical use stage and, utilizing the low loss characteristics of fiber (1dB/Km), will be suitable for long distance transmission. On the other hand, the 1.5μm band is still in the research stage.

2) Classification by photoelectricity conversion element

The transmitters and receivers used in optical communications can be classified as follows according to the photoelectric conversion element used.

a) Transmitter

The transmitters can be classified into the LD transmitter using a laser diode as its light emitting element and the LED transmitter using an LED (light emitting diode). As losses at the connections to the optical fiber are low in the LD transmitter, this transmitter is suitable for long distance transmission as light output is high. However, its reliability is slightly inferior compared to the LED transmitter. At present, reliability has been improved by doubling the LD's and this transmitter is being widely used in the field of digital transmission.

Although the LED transmitter is inferior in transmission distance to the LD type as its connection loss is great, it is superior in reliability and economic characteristics, and its linearity is also superior. This transmitter is therefore suitable for analog transmissions as well as digital transmission.

b) Receiver

The receivers can be classified into the APD receiver using an avalanche photodiode as its light receiving element, and the PIN-PD receiver using a PIN photodiode.

Since the APD receiver possesses a degree of multiplication with the diode itself, even very low light levels can be received.

The PIN-PD receiver is very easy to handle circuit-wise compared to the APD receiver and can be used for either digital or analog short distance communications. Its range of application is wide.

(4) Structure of optical fibers

The optical fiber is composed of a core (quartz) with a comparatively high refractive index and an enveloping cladding (glass) with a comparatively low refractive index. Light is trapped in the optically low loss core portion and transmitted through the inside of the fiber. The optical fibers can be classified into the following 2 types according propagation mode.

1) Multimode fiber

The core diameter of multimode fibers is large at several tens of μm and the light beam entering one end of the fiber is totally reflected between the core and the cladding. Propagation is carried out by a great number of modes and they can be roughly divided into the stepped type and graded type.

a) Stepped type fiber

Stepped type fiber possessing a stepped type refractive index has the limited transmission band width due to propagation mode dispersion, but manufacturing is easy because its structure is simple.

b) Graded type fiber

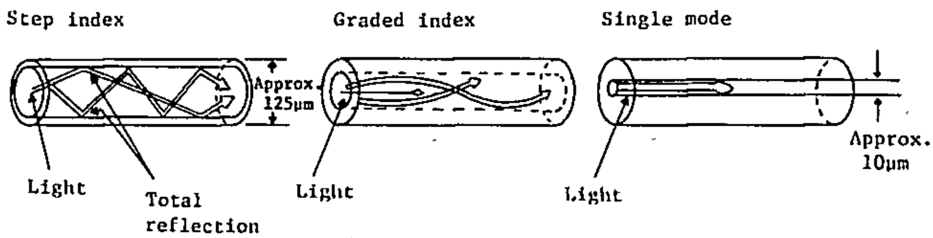
This is a fiber possessing a parabolic refractive index and its transmission band width is at least several times greater than that of the stepped type fiber. As this transmission band width will be influenced by the distributed refractive index, a high degree of refractive index control will be required during the manufacturing process.

2) Single mode fiber

The core diameter of a single mode fiber is normally small at only a few μm and, since it has only one propagation mode, its transmission band is wide and it is expected to serve as large capacity communication circuits in the future.

However, as a number of problems still exist, it is still in the research and development stage.

The structures of the various optical fibers are shown in Appendix 5.1.2.



Appendix 5.1.2 Structures of the optical fiber

5.1.3 Use of the Optical Fiber Communication System in Railways

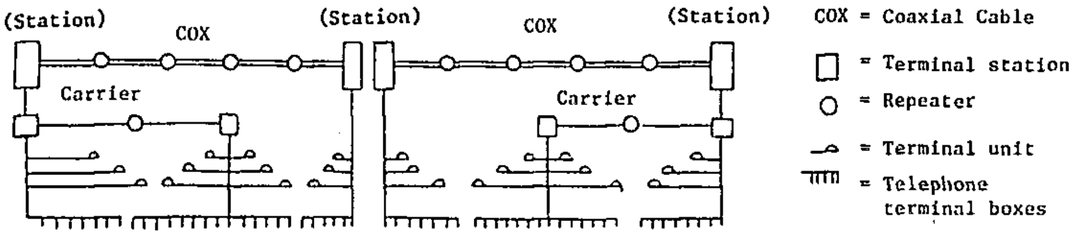
From the various features explained in 5.1.1, the optical fiber communication system is adaptable as a replacement system to the conventional communication cables in the railway fields indicated below and progress is being made in its practical use.

(1) Application to long distance circuits

When configuring a long distance circuit network with cable systems as the basic transmission path, coaxial carrier systems are generally employed. If this is replaced by an optical fiber communication system, a highly reliable and stable transmission system will be possible because the interval between repeaters will be greatly extended compared to the situation with coaxial cables.

(2) Application to short and medium distance circuits

Although FDM carrier circuits and PCM carrier circuit have been overlapped on communication cables for use as short and medium distance circuit systems, if an optical fiber communication system is employed here, high quality transmission paths free from crosstalk and external noises and with a digital transmission capacity of about 24ch. to 480ch. (voice channel converted) and repeater spacing of 10 to 15 Km will be possible. An example of a layout of a PCM multiple communication system is shown in Appendix 5.1.3.



Appendix 5.1.3 PCM Multiple communication system

(3) Application to metallic circuits

In AC electrified sections, aluminum shielded cables are used and insulating coordination to cope with problems in electromagnetic environments such as inductive interference caused by the train traction current, potential rises due to grounding faults in substations and feeder circuits and surge currents due to lightening are also provided. However, from a technical standpoint, these problems can all be resolved by using optical fiber cables.

(4) Application to video transmission

Video transmission in railway systems is used for monitoring passengers within the station-yard and supplying information in relation to operating conditions. However, there is a limit to the transmission distance without repeaters with coaxial cables used from the past and transmission was easily affected by power cables. On one hand, with its wide band characteristics, optimum system configuration is possible with optical fibers for video transmission with wide band requirements.

5.1.4 The Problem of Introducing Optical Fiber Communication Systems into the Railway System

The optical fiber communication system possesses various advantages over conventional cables and this system is now entering a period in which it will be introduced into the railway system. However, thorough study is still required in actual application, in relation to the economic factors of optical fiber system as well as trends in technical development, and the uniqueness and maintenance characteristics of the communication system in the railways.

(1) Trends in technological development of optical fiber communication systems

In the development of the optical fiber communication system, development of the optical fiber itself reached earlier a stage of practical usage but development of the connecting means such as fiber cables, light receiving and transmitting elements, and light switches, and also the transmitter and receiver, was delayed due to various problems. However, as marked progress in technological development of the optical fiber communication system was observed these past several years, this system has now reached the stage of practical use.

It is believed that progress in miscellaneous technical developments will be made at a rapid tempo on low-loss fibers for use in the long wave band, stabilization of light transmitting and receiving elements, improvements in long life characteristics and connecting methods, and also improvements in the economics and reliability of the overall system.

(2) Peculiarity of railway telecommunication systems

The following items must be taken into consideration due to the peculiarity of railway telecommunication systems.

a) Withstanding characteristics in relation to special environmental conditions

Cable laying methods in railways consist of underground cabling along the tracks, road bed troughs and bridge girder cabling. However, stability of high quality transmission, reliability and durability will be demanded of the cable under the severe environments that these methods involve such as stress and train vibrations and the effects of temperature and humidity.

b) Adaptability to communication circuit composition

The communication circuits in the railway system consist of long distance circuits, medium distance circuits and short distance circuits. As the greater part of the information will be required by the various stations, a terminal unit will be required at each station. Branchings will also be required of the level crossings and miscellaneous facilities between stations.

Although the major feature of the optical fiber communication system is long distance transmission using low-loss fiber, this superiority is lost when there are a great number of branch circuits as these branches will increase transmission losses in the overall transmission path. When introducing optical fiber communication systems in the railway communication system, it will therefore be necessary to closely study the adaptability to the respective communication circuits.

Especially when applying to circuits in sections where transmission volume is small, the conventional communication cables will probably be used at this stage due to economic factors. Also, since metallic type transmission paths can be easily configured for medium distance circuits by employing the short distance circuits, thorough study will be necessary on optical fibers in relation to economic factors.

c) Maintenance characteristics

As photoelectric circuit equipment will become newly necessary in addition to the conventional electrical circuit facilities when introducing the optical fiber communication system, maintenance facilities will increase.

Also, when using the optical fiber communication system for the communication circuits which directly affect train operational safety, it will be necessary to assure absolute safety by providing a reserve system as, under the current situation, the optical fiber system has only a short proven record.

As explained above, although optical fiber communication systems excel in transmission volume, wide band characteristics and transmission quality as compared to conventional metallic cable communication systems, it will be necessary to advance practical usage in adaptable areas by selecting the system suitable for each applicable field, by taking into consideration economic and safety characteristics, and by observing the trends in development and progress of miscellaneous technologies in relation to the optical fiber communication system in the midst of the recent remarkable technical revolution.

Appendix 5.2 Promotion of Modernization of Signalling and Telecommunication Systems

For the stabilization at railway management, it is necessary to carry out positive railway modernization measures of which the following is considered to be the objective.

- o Advancing safety
- o Increasing efficiency of train operation control
- o Modernization of passenger and freight business

To achieve these measures, the modernization of signalling and telecommunication systems is required.

Among these measures, those advancing safety must be given top priority following the electrification. Other measures must be undertaken one by one in consideration of the situation of the railway, the condition of its management and technical background, etc.

5.2.1 Advancement of Safety

In compliance with the high speed and congestion of trains due to the electrification and increasing demand, to secure safe and accurate operation of trains which is the main purpose of the railway, it is necessary to undertake mostly such modernization measures of signalling system as the installation of automatic block signal system, relay interlocking and ATS devices and reinforcement of level crossing safety devices, etc.

These serve not only for advancing safety but permit increases of the track capacity, which in effect delays the time for additional installation of tracks and achieves improvement of the railway management.

However, for carrying out these measures, as mentioned in 5.2.1(1), improvement of outer environmental conditions is required. Therefore, the improvement plan of tracks, bridges to be undertaken in the future is required to be promoted before the modernization of signalling systems.

5.2.2 Increasing Efficiency of Train Operation Control

Following the increased traffic demand, the train operation becomes more complicated due to increased traffic and more varieties of train type the speeding up and rationalization of data transmission with regard to train operation will become necessary.

The CTC system which controls signal devices and points machines at stations on the whole line and centrally controls trains thereby simultaneously carries out train operation dispatch business and operation of signal devices, etc., advancing safety and increasing the track capacity as well as saving manpower and so greatly contributes to the modernization and rationalization of railways.

Especially since train operation dispatch business is complicated and operation crews at each station are large in the single-track section, CTC achieves a high rate of rationalization.

5.2.3 Modernization of Passenger and Freight Business

As a measure to promote active business operation the automation of seat reservations and freight yards and other such modernizationary eats are considered to promote sales business of railway for passengers and freight.

In the modern management of railway, it will be required to use computers, instantly process abundant data and provide basic materials for management decision.

For computerization of railway management, the following subjects are considered.

- o Modernization of clerical work .... personnel control, accounting, material control, safety of rolling stock, passenger and freight statistics.
- o Work and maintenance control .... cost calculation, process control, maintenance control, etc.
- o Others .... automation of seat reservation and freight yard.

As mentioned above, for modernizing railway, signal and communication systems must be modernized.

Therefore, it is necessary to promote improvement of telecommunication systems by clearly establishing their priority in future railway modernization.

Appendix 5.3 Inductive Interference and its Countermeasures

Where there are telecommunication lines running parallel to power lines and electrified rail track, the telecommunication line statically responds to the energy of the power side and electromagnetically to the high voltage, large load current and grounding current, etc. on the power side of the power line and electric railway. This phenomenon is called induction effect.

This induction effect causes a risk of struck by high voltage generated on telecommunication lines, maloperation of equipment and communication trouble by noise on telecommunication circuits etc. This phenomenon is called inductive interference.

To remove this inductive interference, appropriate technical and economical measures must be simultaneously enforced on the power side generating induction (called 'inducer' side) and the communication side receiving induction (called 'induced' side).

5.3.1 Type of Inductive Interference and Restricting Value

The induction phenomena comprise electrostatic induction caused by the static combination of the inducer side (power line) and induced side (telecommunication line) and electromagnetic induction caused by electromagnetic combination.

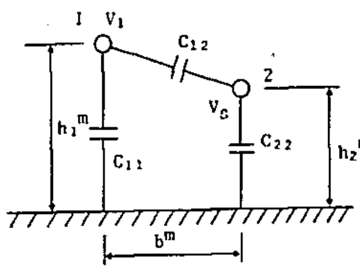
(1) Electrostatic induction

When power line (1) and telecommunication line (open-wire) (2) are installed in parallel on the ground as shown in Appendix 5.3.1, the following electrostatic inductive voltage Vs is generated on the communication line by the electrostatic capacity C_{12} between the power line (1) and the telecommunication line (2) and the electrostatic capacity (C_{22}) between the telecommunication line (2) and the ground.

$$Vs = \frac{C_{12}}{C_{12} + C_{22}} V_1 \quad [V] \quad \cdots\cdots\cdots\cdots (5.3.1)$$

In the above formula, V_1 denotes the potential to ground of the power line.

Also, where the radius of the power line is r_1[m], and its height from the ground level is h_1[m], the height of the telecommunication line from the ground level h_2[m] and the horizontal distance between the power line and the telecommunication lines b[m], the following formula is obtained.



Appendix 5.3.1 Electrostatic Induction

$$Vs = \frac{\log \frac{b_2 + (h_1 + h_2)^2}{b_2 + (h_1 - h_2)^2}}{2 \log \frac{2h_1}{r_1}} \cdot V_1 [V] \quad \ldots\ldots (5.3.2)$$

Electrostatic induction voltage Vs becomes larger in proportion to the voltage of the power line V_1 and there is no correlation with the length of the power line parallel to the telecommunication line.

Discharge current (Is), however, will be as follows.

$$Is \fallingdotseq \omega \cdot C22 \cdot Vs \cdot \ell \quad \ldots\ldots (5.3.3)$$

Where, ω is angular frequency.

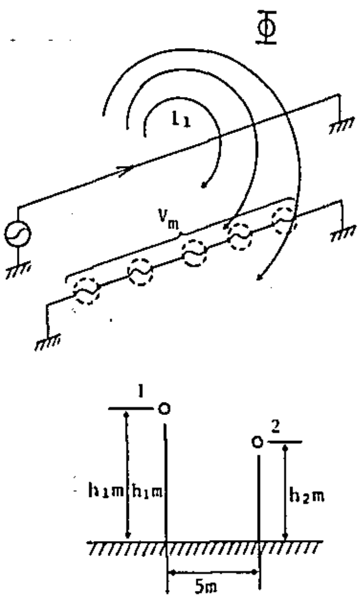
It increases in proportion to the length ℓ.

(2) Electromagnetic induction

When the power line (1) is energized with current I_1 returning to the ground and with frequency f, electromagnetic induction voltage Vm is generated in the communication line by mutual induction between the power line and the telecommunication line.

Vm is given in the following formula.

$$V_m = -j\omega M I_1 \ell \quad [V] \quad \text{.................................} \quad (5.3.4)$$



Appendix 5.3.2 Electromagnetic Induction

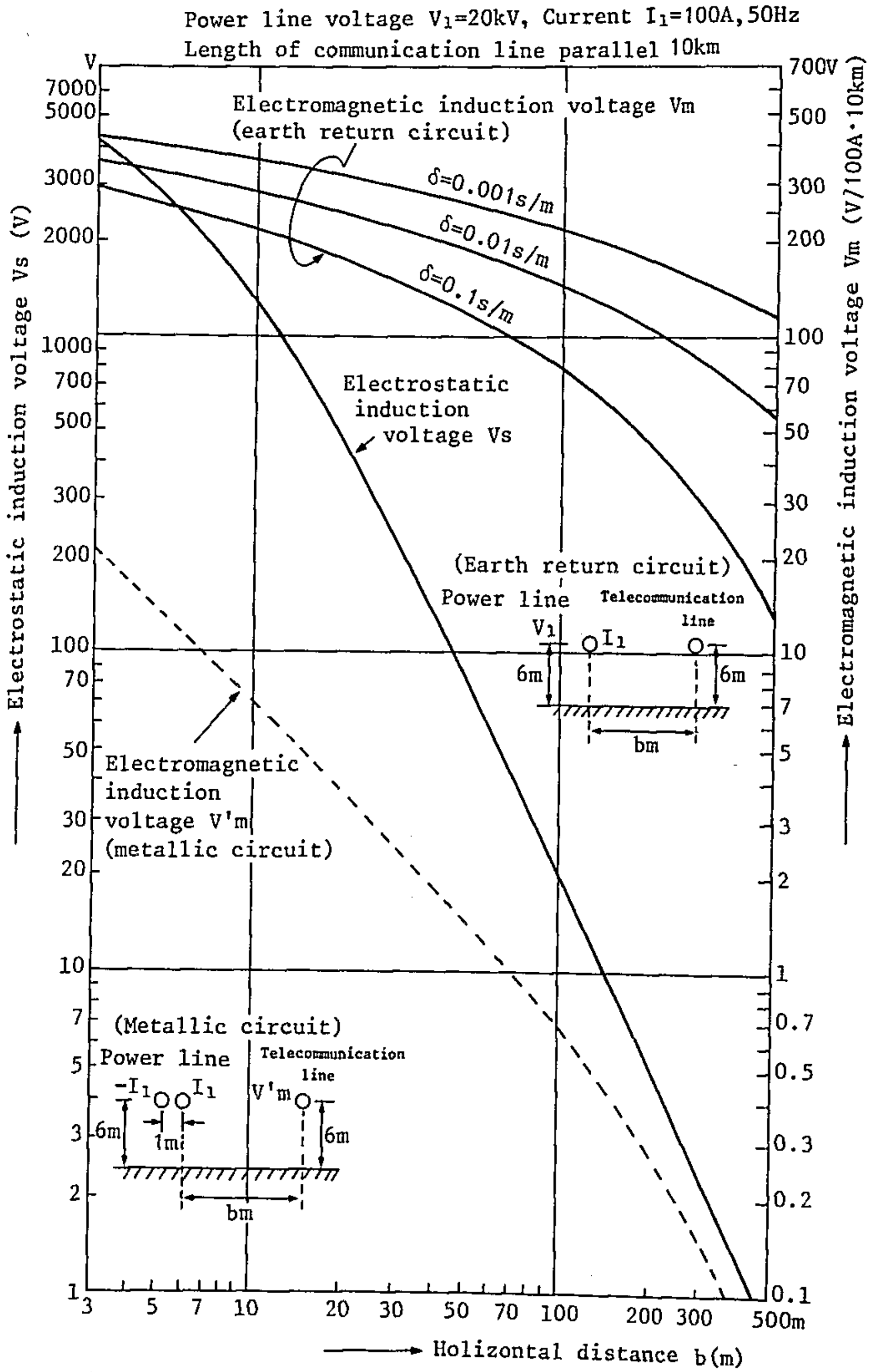
Where, ω: angular frequency

M: mutual inductance between power line and communication line [H/km]

I_1: Current of power line [A]

ℓ: Parallel length [km]

Electromagnetic induction voltage Vm increases in proportion to frequency f, current of power line I_1, parallel length ℓ and mutual inductance M.



Appendix 5.3.3 Electrostatic Induction Voltage and Electromagnetic Induction Voltage

Mutual inductance M where current is returning to the round largely varies depending on the earth conductivity and when the earth conductivity σ is large, M becomes smaller and when σ is small, M becomes larger and also the electromagnetic induction voltage becomes larger. The earth conductivity σ is generally large in fertile plains and small in rocky ground in hills, being roughly around 0.001-0.1 s/m.

Mutual inductance M between power lines and telecommunication lines forming the earth return circuit as shown in Appendix 5.3.2 is popularly calculated with the formula of Carson-Pollaczeck which coincides with the actual situation.

The formula is:

$$M_{12} = \left[2\log\frac{2}{K\sqrt{b^2+(h_1-h_2)^2}} + \frac{4}{3\sqrt{2}}K(h_1+h_2) - 0.1544 - j\left\{\frac{\pi}{2} - \frac{4}{3\sqrt{2}}K(h_1+h_2)\right\}\right] \times 10^{-4} \quad [H/km] \quad \text{........} \quad (5.3.5)$$

Where $K = 2\pi\sqrt{2\sigma f \times 10^{-7}}$

σ : earth conductivity (s/m)

b: horizontal distance (m)

h_1: height of power line (m)

h_2: height of telecommunication line (m)

$K\cdot\sqrt{b^2+(h_1-h_2)^2} \leq 0.5$

$$M_{12} = \frac{4}{Kb}\left[kei'(Kb) - j\left\{\frac{1}{Kb} + ker'(Kb)\right\}\right] \times 10^{-4} \quad [H/km] \quad \text{..........} \quad (5.3.6)$$

Where $Kb > 0.5$

ker'(Kb), kei'(Kb) : Kelvin Function (Bessel Function)

$$M_{12} = -j\frac{4}{(Kb)^2} \times 10^{-4} \quad [H/km] \quad \text{.......................} \quad (5.3.7)$$

Where $Kb > 10$

Appendix 5.3.3 shows actually how large the electrostatic induction voltage and electromagnetic induction voltage are.

When metallic circuits are used as return circuits, the current return circuit gives substantially smaller electromagnetic induction voltage compared to that of the earth return circuit.

(3) Restricted value of induction voltage

Appendix 5.3.4 shows restricting values of induction voltage and noise voltage adopted by CCITT and in Japan.

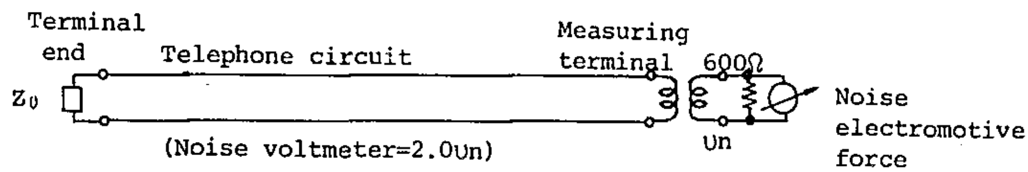
Appendix 5.3.4 Restricting values of induction voltage and noise voltage

	Type	Condition	Allowance	Description
CCITT	Critical voltage (bare communication cable, telecommunication cable)	Abnormal time	430V (electromagnetic induction voltage effective value)	o {General power line (single line grounded) / AC electrified railway}
			650V (electromagnetic induction voltage effective value)	o High reliable power line (single line grounded) o In the case of telecommunication cables with insulated transformers at both ends, the voltage between the cable conductor and the sheath is 60% of the test voltage.
		Normal time	60V (electromagnetic induction voltage effective value)	o No relation with induction line o No condition
			150V (electromagnetic induction voltage effective value)	o No relation with induction line o With condition (1) In case of communication cables, the section induced by insulation transformer is insulated. (2) Special warnings must be given to people working on the cable cores in sections having induction.
	Noise voltage (open-wire, telecommunication cable)	Normal time	1mV (psophometric electromotive force by electrostatic induction and electromagnetic induction)	o No relation to the type of induction line
Japan	Critical voltage (bare communication cable, telecommunication cable)	Abnormal time	300V (electromagnetic induction voltage effective value)	o {General power line (single line grounded) / AC electritied railway}
			430V (electromagnetic induction voltage effective value)	o High reliable power line (single line grounded) (within 0.1 sec. of continuous time)
		Normal time	60V (electromagnetic induction voltage effective value)	o No relations to the type of induction line
		Normal time (Misoperation of equipment)	10-15V (electromagnetic induction voltage effective value)	o No relations to the type of induction line o Misoperation of exchange

Appendix 5.3.4 Restricting values of induction voltage and noise voltage (Cont'd)

	Type	Condition	Allowance	Description
	Noise voltage (open-wire, telecommunication cable)	Normal time	1mV (psophometric electromotive force)	o In case of transmission and distribution line
			2mV	o In case of AC electrified railway 2mV: Telecommunication cable 5mV: Open-wire
			5mV (psophometric electromotive force)	

Note : * Psophometric electromotive force
Psophometric electromotive force is terminated at characteristic impedance Z_0 at the terminal end and terminated at 600Ω pure resistance through matching transformers at the measuring end of the two terminals of the telephone circuit (between lines).
The noise electromotive force of the circuit is twice as large as the evaluated noise voltage of 600Ω terminal.



5.3.2 Inductive Interference in the Electrified Section

There are two types of electrification of railways, ie: DC electrification and AC electrification. For the AC electrified type, the direct feeding system, booster transformer (BT) feeding system and auto transformer (AT) feeding system are put into practical use.

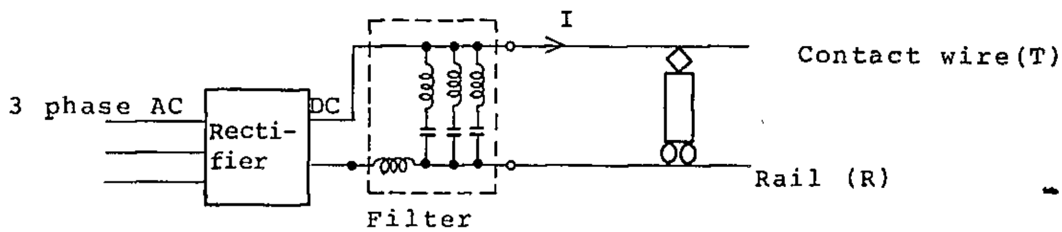
The rails of electric railways are generally used as return load current circuits. Since the rail resistance to leakage to ground is small and the return current of the rail leaks to the ground, an earth return circuit will be composed. Since the induction voltage becomes larger for this reason, BT feeding circuit and AT feeding circuit are used in AC electrification to reduce the earth return current.

(1) Inductive interference due to DC feeding system

In DC feeding systems, AC 50Hz is converted to DC at DC substations (rotary converter, mercury-arc rectifier, silicon rectifier, etc.) and DC is fed to contact wires and rails.

Recently, silicon rectifiers (6-phase rectifier) are generally used, so output current on the DC side includes harmonic 6·n times (n = 1,2,3....) of the fundamental wave. When this harmonic current (eg: 300 Hz, 600 Hz, 900 Hz, 1200 Hz .... when power source is 50 Hz) energizes the feeding circuit, noise interference occurs on the telecommunication lines which run in parallel.

For this reason, a filter to remove harmonics of 300 Hz, 600 Hz, 900 Hz, etc. is installed, thereby reducing pulsating current as a countermeasure against inductive interference.



Appendix 5.3.5 DC Feeding System

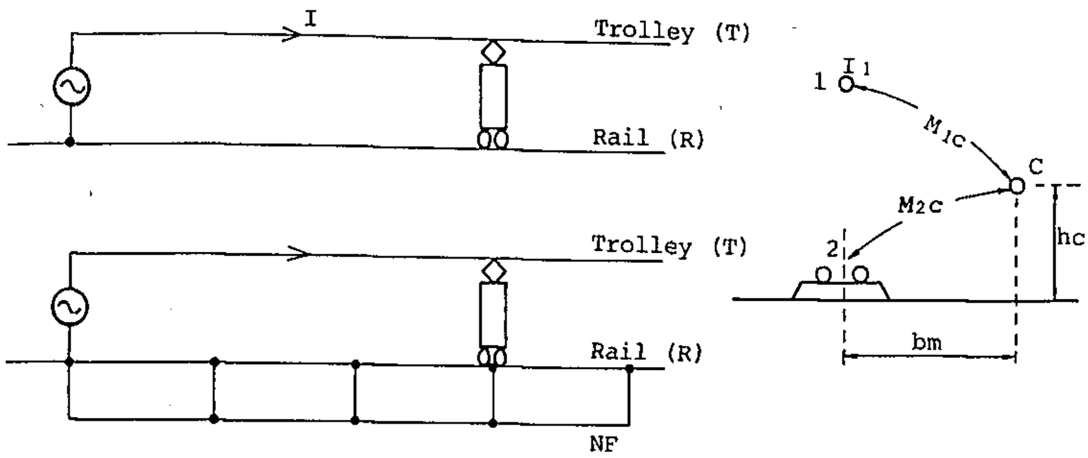
(2) Inductive interference by AC electrification system

(i) Direct feeding system

This is most simple feeding system of all and there may be negative feeders (NF) added to the trolley (T) and the rail (R) when these are precent as shown in Appendix 5.3.6.

This system either reduces induction voltage compared with other BT feeding system and AT feeding system or is comprised of only rail or of rail and NF.

Since the induction voltage is large, it can be used where there is little inductive interference with communication lines.



Appendix 5.3.6 Direct Feeding System

In case the feeding system comprises only trolley wires (T) and rail (R) as shown in Appendix 5.3.6, electromagnetic induction voltage Vm in the telecommunication line (C) is given by the following formula.

$$Vm = -j\omega(M_{1c} - nM_{2c})\ I_1 \cdot \ell \quad [V] \quad \text{...............} \quad (5.3.8)$$

When $n = \frac{Z_{12}}{Z_{22}}$

Z_{12}: mutual impedance between trolley and rail (Ω/km)

Z_{22}: self impedance of rail (Ω/km)

M_{1c}: mutual impedance between trolley and telecommunication line (H/km)

M_{2c}: mutual impedance between rail and telecommunication line (H/km)

ℓ: parallel length (km)

I_1: current of trolley (A)

In case the telecommunication line is located far from feeding circuit,

$$M_{1c} \fallingdotseq M_{2c} = M$$

and

$$Vm \fallingdotseq -j\omega(1 - n)\ I_1 \cdot \ell \quad [V]$$

(1-n) shows reduction of the electromagnetic induction voltage by rail and is considered as shielding coefficient of rail. In case the feeding circuit is a single track, it is about 0.45 - 0.55 depending on the size of rail and the earth conductivity.

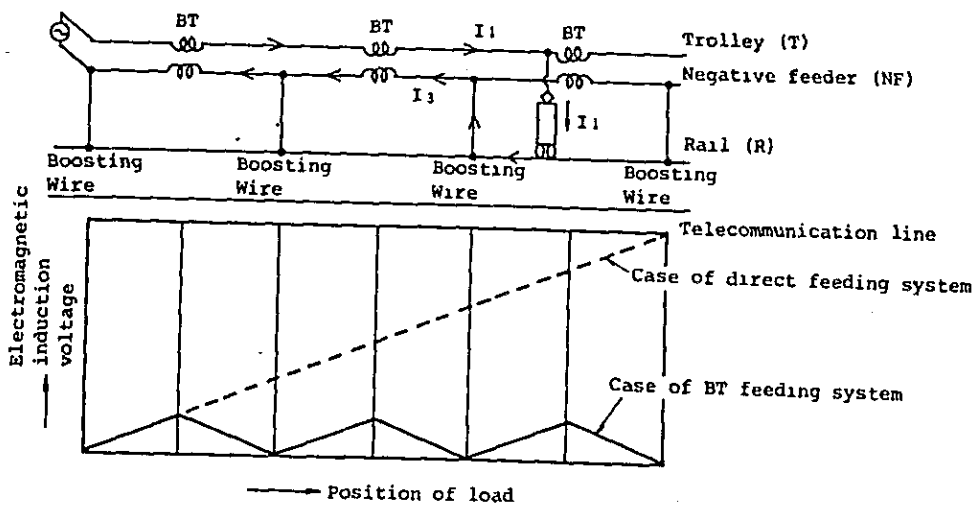
The NF direct feeding system has a shielding effect depending on the NF line and its place of installation, and reduces the induction voltage about 70 ∿ 80% compared to feeding circuits without NF.

Also (1 - n) I_1 is called induction current and (1 - n) $I_1 \cdot \ell$ is called Amp·Km.

(ii) BT Feeding System

In case telecommunication lines in the direct feeding system are long, the induction voltage increases in proportion to the parallel length ℓ.

In the BT feeding system, therefore, a booster transformer is inserted in the feeding circuit as shown in Appendix 5.3.7 so as not to increase the length ℓ (induction exposed length) generating induction and boosts the current energized on the rail to negative feeder (NF) through boosting wire and reduces induction voltage.



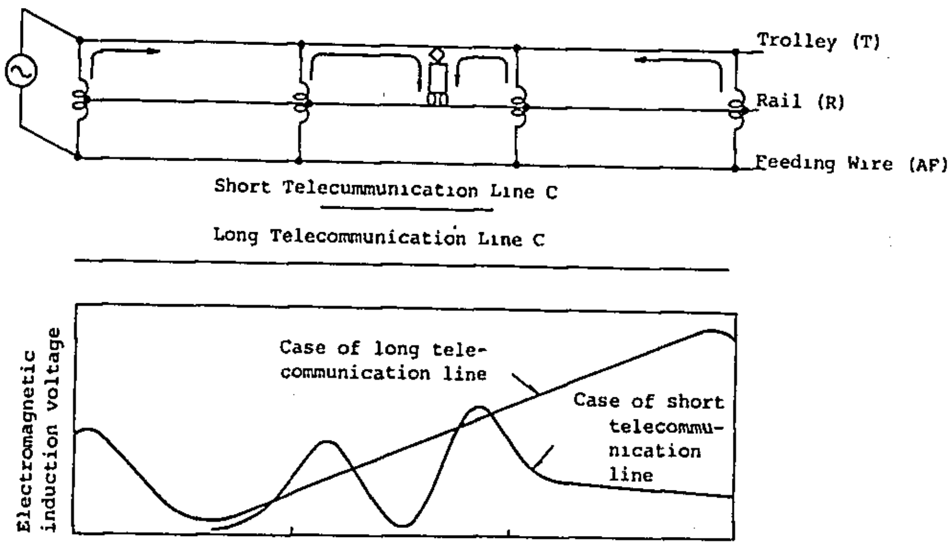
Appendix 5.3.7 BT Feeding System and Induction Voltage

In the case of BT feeding system, the induction voltage is substantially smaller than that of direct feeding system regarding to the distance less than sections between BT and boosting wire (normally 4 km with the general line in JNR).

(iii) AT feeding system

A feeding system using auto transformer feeds load current from AT on both sides of rolling stock load as shown in Appendix 5.3.8.

The electromagnetic induction voltage of telecommunication line, therefore, is mutually offset and the induction voltage is reduced.



Appendix 5.3.8 AT Feeding System and Induction Voltage

This system has a small impedance of feeding circuit and little drop of voltage, so long distance feeding is possible and is generally a good electrical feeding system.

The feature of inductive interference is that it changes according to AT leak impedance, AT distance, and type of contact wire and feeder.

When AT leak impedance is large and AT distance is long electromagnetic induction voltage generally tends to increase.

Also when the length of feeding circuit is long, the induction voltage of long distance telecommunication line increases.

The AT feeding system employed by the general lines of JNR has standard AT distance of 10 km in which case the electromagnetic induction voltage is roughly the same size as that of the BT feeding system.

The AT feeding system has a more complex feeding circuit compared to the direct feeding and BT feeding systems, and it is necessary to use computers in calculating the induction current and voltage.

5.3.3 Countermeasures against Induction Interference

(1) Induction side

In DC electrification system a filter is installed at substations to reduce the component of harmonics in load current.

To reduce the electromagnetic induction voltage, in AC feeding systems, as feeding circuit, BT feeding systems, AT feeding systems or coaxial cable feeding systems are employed to reduce the induction current running to the ground.

Also, shielding wires are installed along the feeding circuit to reduce the induction voltage. To reduce the leakage current from the rail to the ground, sleepers and ballast are improved to increase the ground leakage resistance of the rail.

(2) Motor car side

When the rolling stock is thyrister-chopper controlled cars, minimizing the harmonic current in the feeding circuit is carried out by installing filters in the electric motor vehicle with the number of divisions on the secondary side of main transformer increased and cumulative controls carried out to decrease the harmonic component and to minimize the equivalent disturbance current.

(3) Communication side

Because the induction voltage and noise voltage are very large in the communication circuit with the earth return circuit and so cannot be used, metallic circuits are used.

For reducing the electrostatic induction voltage,

(i) Lines with unshielded wire such as open-wire are turned to cable and the shielded layer is grounded. Sufficient effect is obtained by simple grounding.

(ii) Also, electrostatic induction voltage is reduced by using drainage coil.

(iii) The spacing distance is extended.

For reducing electromagnetic induction voltage,

(i) Cables with electromagnetic shielding sheath and with good balance are used.

(ii) Insulation coils are inserted into the communication line to eliminate accumulation of induction voltage as an induction reducing device.

(iii) A filter drainage coil is used on the telecommunication line energized with DC current.

(iv) A suppression coil is used to advance the balance of exchange etc. connected with the telecommunication line.

(v) Discharge tube such as arrester, etc. is used to discharge high voltage in case of accident.

(vi) Induction voltage is reduced by enlarging the spacing distance. The electromagnetic induction voltage is less effected by spacing than it is by electrostatic induction voltage.

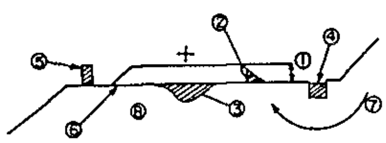
(vii) Carrier transmission system is used.

Appendix 6.1 Disaster Prevention

6.1.1. Mud Pumping

Mud pumping is the phenomenon of mud, formed by the earth mingled in the road bed or in the ballast with rainwater or underground water, spouting out into the ballast or to the surface due to the weight of passing trains. The mud pumping sections require great efforts to repair, it causes damage to the sleepers and ballast. In some cases, it may threaten the safety of operations.

The reason for mud pumping is considered to be the combination of various factors, such as the soil condition of the roadbed, the drainage condition of the ballast and roadbed, the size of the train load, the passing tonnage and the train speeds. The countermeasure for the mud pumping is to remove "Water", "Earth" or "Load". The following are the major causes and their countermeasures:



Appendix 6,1,1 Mud pumping causes

(a) Roadbed mud pumping

Insufficient ballast thickness ①

Defective drainage of ballast ②

Existence of water pockets ③

Defective drainage of the gutter ④

Roadbed obstacles interfering with drainage ⑤

Unsuitable grade of the roadbed ⑥

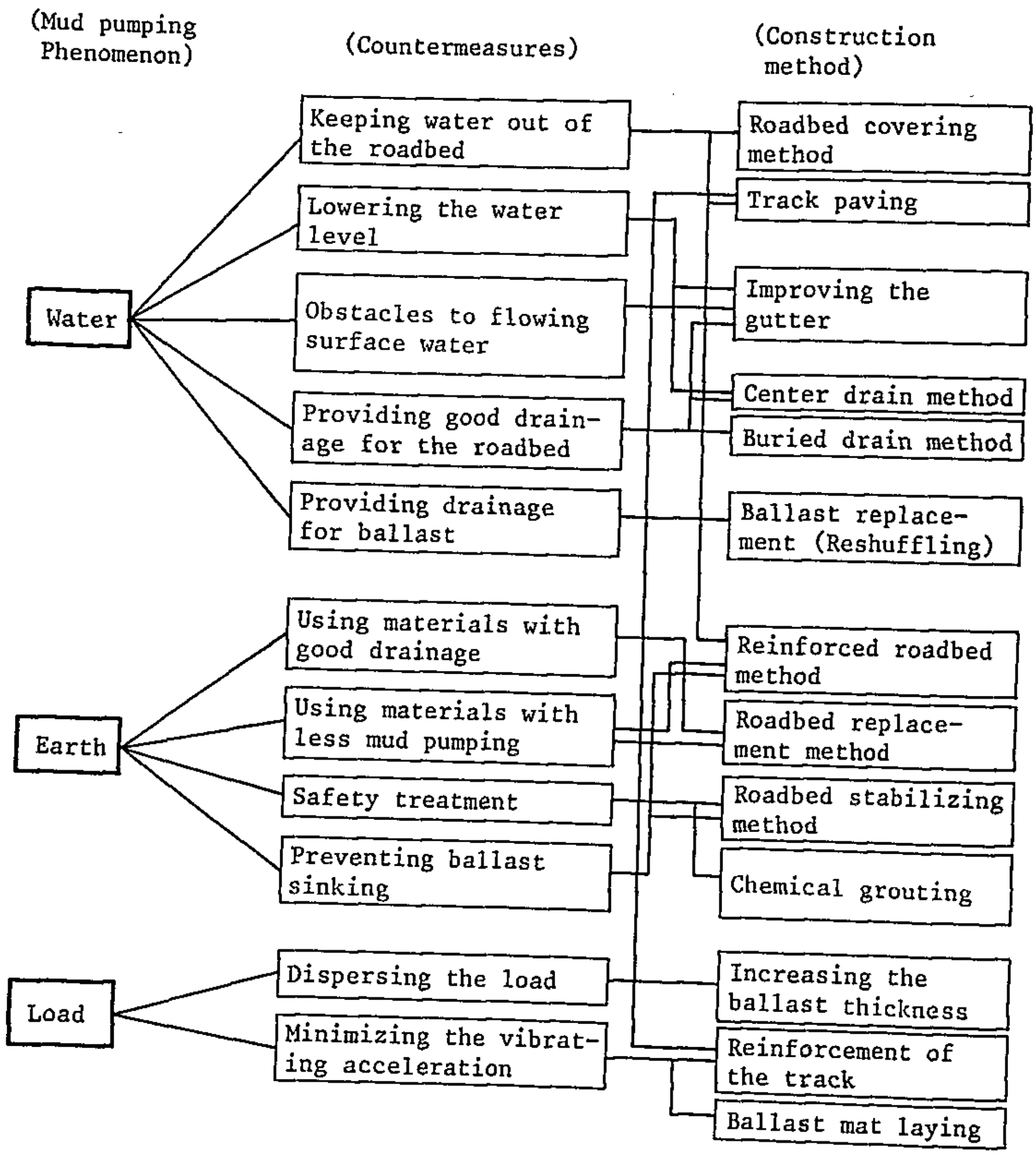
Underground water ⑦

Cohesive soil with high water content ⑧

(b) Ballast mud pumping

Defective drainage in ballast

Unsuitable material of ballast



Appendix 6.1.2 Mud pumping causes and their countermeasures

6.1.2 Subsidence of Roadbed

Subsidence of roadbed is more complicated than mud pumping. The major causes of subsidence are largely found in the ground on which the roadbed is built and in the road bed fill on the natural ground. The factors in these two causes are as follows;

1) In the case that the major cause of Subsidence is in the natural ground

a) Consolidation settlement of the soft strata

b) Subsidence by breaking load of the soft strata

c) Subsidence by shifting due to land slide

2) In the case that the major cause of Subsidence is in the roadbed

a) Subsidence by shrinkage or consolidation due to inapproapriate fill material

b) Subsidence by consolidation settlement due to the axle pressure of the fill being too low

c) Subsidence by the partial breaking or sliding of the fill

d) Subsidence by out flow type due to incomplete filling

e) Lowering by swelling out due to the soaking and softening of the cutting surface.

In these various Subsidence cases, if the main cause is in the natural ground, the reinforcement of the soft layer or replacement of it by the suitable soil is necessary.

If the main cause is in the roadbed, Subsidence is due to the unsuitable execution of the original work, and it is necessary to use suitable fill material and compact it fully.

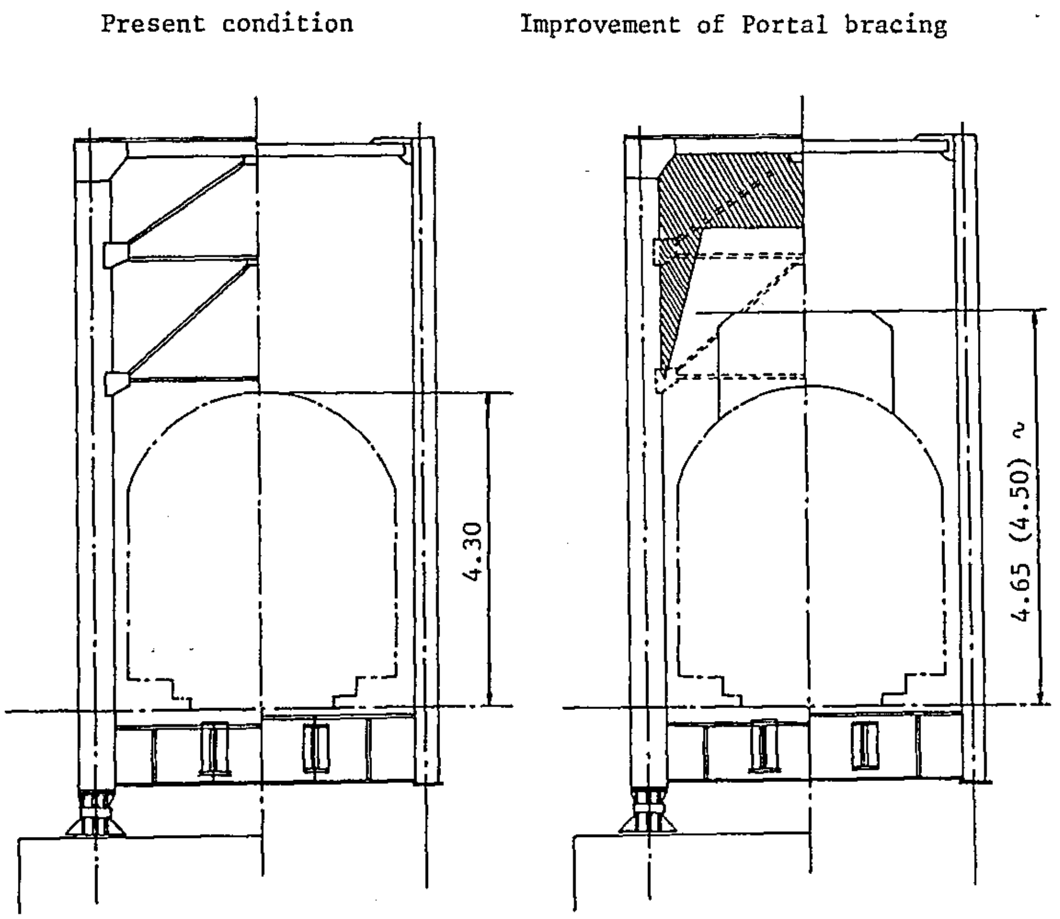
6.1.3 Landslide

Slopes are always affected by gravity and tend to slide down, and a distortion may accumulate around a weak point in the inner slope for a long time. In addition, due to the climatic change, rainfall penetration or underground water, physical and chemical weathering develops and the adhesive strength of the slope becomes less. Especially the accumulation of distortion is affected by this factor. Gradually the weak points expand, and the earth loses the strength to support the slope. Then a landslide occurs. There are two methods to prevent landslides. One is the removal of the cause of the landslide or restoration of balance to prevent landslides. These are called control methods. The other is to construct a structure to bear the land slide strength, which is called the stave off method.

Appendix 6.1.3 Types of land slide preventive methods

- Control method
  - Surface water control method (Channel method, Penetration prevention method)
  - Control of underground water method
    - Control of shallow strata underground water (Open gutter, close gutter, horizontal boring, shut-out of underground water)
    - Deep strata underground water removal (Horizontal boring, concentrated well, drainage tunnel)
  - Earth removal method
  - Compacting fill method
  - River bank structure (Pier construction, river bed compaction, water control method, bank protection)
- Stave off method
  - Pile construct method
  - Shaft construct method
  - Anchor construct method
  - Retaining wall method

Appendix 6.2 Improvement of Portal bracing



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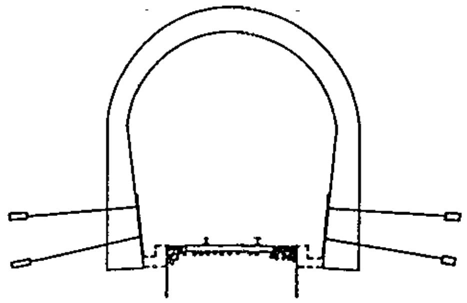
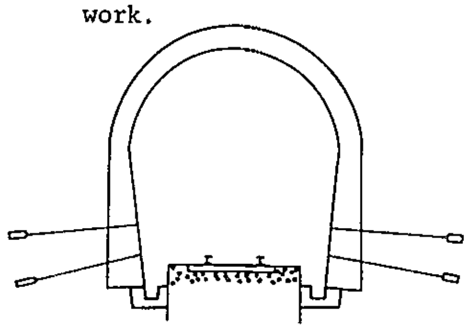
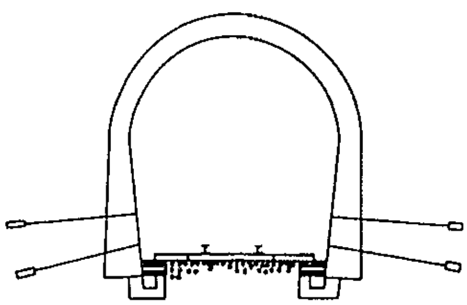
Appendix 6.3 Construction method of the roadbed lowering in the tunnel



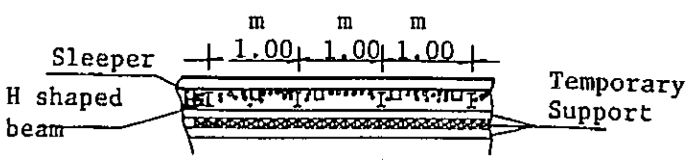
① Reinforcement of the side walls by the plate and rock anchors.
② Temporary sheathing for drain gutter removal with sheathing work.

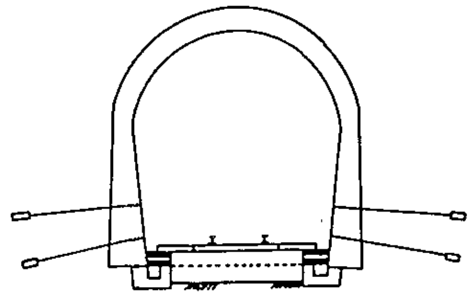


③ Construction of new drain gutter.

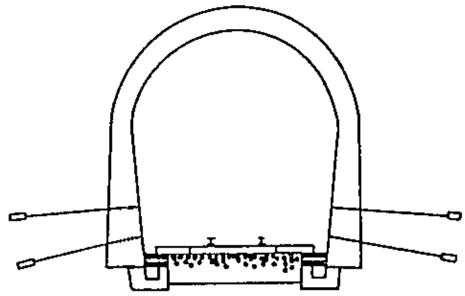


④ Temporary work on the base for an H-shaped structural steel beam (wooden structure)
⑤ Removal of sheathing
⑥ Temporary work of the penetrating H-shaped beam for the base of the track

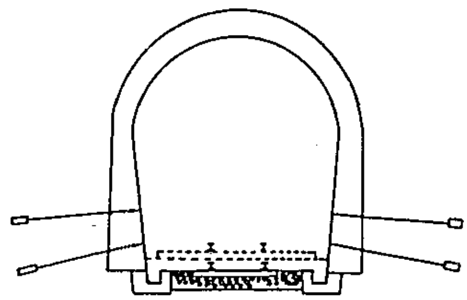




⑦ Existing roadbed gravel to be scraped and carryed out
⑧ Roadbed to be ploughed out and lowered



⑨ New road bed crushed ballast filling and compacted
⑩ Removal of the penetrated H-beam and base for H-beam (wooden)



⑪ Lowering the track (Degree of lowering 100mm per one occasion)
⑫ Even compacting of the entire ballast

Appendix 7.1.1 Survey on Boarding and Alighting Persons, by Station (by Month)

1981 Unit: 1,000

Station \ Month/1981	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
101 JAKARTA	1,917	1,876	1,998	1,949	2,112	2,210	2,054	2,350	1,931	2,041	1,881	1,989	24,316
106 BEKASI	134	144	166	153	141	129	146	156	144	157	162	166	1,798
107 KARAWANG	136	131	125	132	141	156	143	173	143	162	166	178	1,786
108 TANGGERANG	76	74	79	83	86	60	70	78	74	72	75	72	899
109 BOGOR	899	876	967	891	1,012	989	937	1,048	864	923	803	825	11,034
113 LEBAK	105	102	104	105	116	110	94	118	91	103	92	98	1,238
114 PANDEGLANG			1			1	2	3		1		1	9
115 SERANG	301	255	261	279	311	383	346	387	261	292	168	181	3,425
117 CIREBON	69	66	67	72	70	90	75	83	56	92	67	62	869
118 SUBANG	23	28	31	21	16	23	16	16	14	16	12	8	224
119 INDRAMAYU	39	62	71	49	47	53	45	50	38	47	36	30	567
122 BANDUNG	320	295	300	316	320	350	312	366	280	287	280	310	3,736
123 PURWAKARTA	44	45	48	49	51	54	50	62	46	52	50	50	601
124 CIANJUR	75	70	74	77	58	57	76	98	59	82	57	63	846
125 SUKABUMI	127	119	141	129	108	125	142	169	114	140	128	140	1,582
126 GARUT	98	92	94	88	92	93	100	131	81	74	53	71	1,067
127 TASIKMALAYA	36	32	34	33	33	44	34	59	25	31	32	36	429
128 CIAMIS	72	48	53	51	53	74	49	101	45	53	47	66	712
201 BANYUMAS	25	23	24	28	28	38	26	43	22	28	23	29	337
202 BREBES	16	27	31	19	20	25	22	31	17	21	20	16	265
206 KEBUMEN	41	37	38	48	48	58	40	86	41	49	41	50	577
207 PURWOREJO	38	35	35	45	45	67	56	65	39	49	39	49	562
208 CILACAP	84	84	94	101	101	110	87	169	80	92	82	98	1,182
209 PEMALANG	4	3	3	3	4	4	4	7	4	4	4	3	47
210 TEGAL	15	13	14	15	15	19	17	26	11	21	17	13	196
211 PEKALONGAN	16	13	11	13	14	14	12	21	12	14	13	12	165
213 BATANG	5	4	4	4	4	5	4	5	5	5	5	2	52
214 KENDAL	1	1		1	1			2	1	1	1	1	10
216 DEMAK	5	5	6	5	7	2	7	12	7	17	7	5	85
217 PURWODADI	89	92	100	86	64	75	68	110	60	80	65	68	957
218 BLORA	27	27	27	26	25	24	29	40	21	26	22	25	319
219 BOJONEGORO	11	13	17	16	17	22	20	27	14	15	12	12	196
222 REMBANG	9	9	13	12	11	11	10	13	7	8	8	9	120
223 TUBAN	34	36	42	41	45	40	35	44	28	30	29	25	429
224 KULONPROGO	4	4	4	4	4	7	4	9	4	5	4	6	59
225 SLEMAN	141	112	106	125	140	179	159	156	112	131	111	162	1,634

Unit: 1,000

Month/1981 Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
226 KLATEN	10	9	11	8	8	11	11	13	9	7	10	9	116
227 SRAGEN	6	6	13	10	7	7	9	9	5	8	7	7	94
229 KARANGANYAR	3	3	5	3	12	3	2	4	3	3	3	2	46
232 BOYOLALI	8	8	10	10	5	7	8	11	5	9	9	9	99
233 SEMARANG	119	116	118	119	118	136	147	175	108	130	117	120	1,523
235 SURAKARTA	60	41	46	51	51	61	71	82	43	48	42	55	651
238 BANTUL								1					1
303 NGAWI	8	5	10	11	12	13	16	19	11	14	11	14	144
304 MAGETAN				1			1	1		2		2	7
305 MADIUN	28	21	24	25	34	36	32	43	24	29	27	31	354
306 NGANJUK	17	16	13	14	19	22	17	29	14	17	14	16	208
307 JOMBANG	32	30	29	38	44	45	40	63	36	47	41	42	487
308 PONOROGO	2		2			3	3	4	3	2	2	2	23
309 KEDIRI	18	15	12	17	20	27	26	28	18	21	20	21	243
310 TULUNGAGUNG	12	12	9	10	15	16	13	22	11	13	11	14	158
311 BLITAR	42	34	35	41	46	60	58	69	40	51	47	50	573
312 MALANG	54	48	44	51	59	73	66	87	49	60	55	57	703
313 PASURUAN	22	19	18	16	20	19	14	27	18	21	20	20	234
315 SIDOARJO	30	29	29	38	35	28	30	43	37	40	39	39	417
316 MOJOKERTO	15	14	14	20	19	19	18	24	15	19	23	20	220
318 GRESIK	328	284	276	301	333	436	397	436	281	337	313	347	4,069
319 LAMONGAN	16	17	21	17	19	15	19	19	14	16	15	15	203
320 BANGKALAN	2	2	2	2	2	4	8	7	4	6	4	4	47
321 SAMPANG								1					1
324 PROBOLINGGO	3	2	1	1	2	3	2	3	2	1	1	3	24
325 LUMAJANG	7	9	7	7	11	10	10	21	9	9	9	11	120
326 JEMBER	38	38	35	41	41	39	34	55	33	40	35	40	469
327 BONDOWOSO	15	13	18	18	15	14	12	24	15	16	14	11	185
328 SITUBONDO	8	7	8	8	9	9	6	13	9	11	10	7	105
329 BANYUWANGI	45	39	39	46	35	38	32	68	33	43	40	47	505
330 JEMBRANA	4	2		3	1	7	5	5		1	1	8	37
Total	5,988	5,692	6,032	5,996	6,352	6,862	6,398	7,720	5,600	6,250	5,552	5,954	74,396

Appendix 7.1.2 Survey on Boarding Persons, by Station (by Month)

Unit: 1,000

Station \ Month/1981	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
101 JAKARTA	918	912	957	987	1,026	1,040	1,068	1,045	925	997	891	974	11,740
106 BEKASI	69	70	77	80	69	64	76	77	68	74	75	77	876
107 KARAWANG	73	65	68	66	70	87	70	88	70	78	81	86	902
108 TANGGERANG	43	42	44	46	47	30	38	45	40	38	39	38	490
109 BOGOR	470	456	510	417	531	520	490	542	457	482	445	435	5,755
113 LEBAK	49	47	46	49	53	52	45	61	43	48	45	46	584
114 PANDEGLANG			1			1	1	2		1		1	7
115 SERANG	144	127	131	139	155	195	176	195	132	150	87	94	1,725
117 CIREBON	33	34	32	36	33	43	28	44	26	35	30	27	401
118 SUBANG	12	13	18	12	8	13	9	9	7	9	7	5	122
119 INDRAMAYU	18	23	34	24	24	25	21	26	19	23	16	14	267
122 BANDUNG	161	151	155	158	158	178	169	169	142	145	140	155	1,881
123 PURWAKARTA	26	26	29	28	30	33	32	39	28	31	31	32	365
124 CIANJUR	41	38	38	41	30	30	39	52	30	51	30	33	453
125 SUKABUMI	66	63	74	69	55	66	72	90	61	70	67	74	827
126 GARUT	49	46	46	43	45	48	48	67	41	36	26	37	532
127 TASIKMALAYA	21	18	19	18	17	25	14	38	14	18	17	20	239
128 CIAMIS	36	24	30	27	27	37	24	54	22	28	23	33	365
201 BANYUMAS	16	15	16	18	18	24	15	34	15	19	16	19	225
202 BREBES	7	18	12	8	10	13	7	18	8	9	8	6	124
206 KEBUMEN	28	25	25	33	34	42	18	67	27	35	29	35	398
207 PURWOREJO	17	14	15	19	20	29	15	37	17	22	16	19	240
208 CILACAP	44	42	46	51	53	55	38	92	44	48	44	50	607
209 PEMALANG	3	2	2	2	2	3	2	6	3	3	3	2	33
210 TEGAL	7	6	6	6	6	8	6	15	5	9	7	5	86
211 PEKALONGAN	9	7	6	7	8	8	4	15	6	7	7	6	90
213 BATANG	3	2	2	2	2	3	2	3	3	3	3	1	29
214 KENDAL	1	1		1	1			2	1	1	1	1	10
216 DEMAK	2	2	3	2	3	1	3	5	3	6	3	2	35
217 PURWODADI	48	50	52	45	33	40	35	64	33	45	35	36	516
218 BLORA	14	13	13	13	12	12	11	23	10	13	11	12	157
219 BOJONEGORO	6	7	9	9	10	12	11	16	8	8	7	6	109
222 REMBANG	4	4	6	5	5	5	5	5	3	4	4	4	54
223 TUBAN	17	19	21	21	22	18	16	23	13	13	13	12	208
224 KULONPROGO	4	4	4	4	4	6	3	9	4	5	4	6	57
225 SLEMAN	59	42	44	47	52	73	62	69	44	50	45	63	650

Unit: 1,000

Station \ Month/1981	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
226 KLATEN	8	7	8	7	7	9	10	12	8	6	8	8	98
227 SRAGEN	4	3	7	5	4	4	4	6	3	5	4	4	53
229 KARANGANYAR	2	2	4	2	12	2	2	3	2	2	2	2	37
232 BOYOLALI	4	4	6	6	3	4	3	7	3	5	5	5	55
233 SEMARANG	57	56	56	56	57	66	66	85	49	61	55	58	722
235 SURAKARTA	26	18	21	22	23	26	23	36	19	21	18	23	276
238 BANTUL								1					1
303 NGAWI	5	2	6	6	7	8	8	12	7	9	7	9	86
304 MAGETAN				1			1			1		1	4
305 MADIUN	15	11	12	13	15	20	12	27	12	14	14	16	181
306 NGANJUK	9	7	7	8	10	13	6	19	8	10	8	8	113
307 JOMBANG	18	17	16	21	24	24	18	35	21	26	23	23	266
308 PONOROGO	1		1			1	1	2	2	1	1	1	11
309 KEDIRI	9	7	7	8	10	14	12	16	9	11	10	11	124
310 TULUNGAGUNG	7	8	5	6	9	10	7	15	7	8	7	9	98
311 BLITAR	22	18	17	20	25	30	25	38	21	26	24	25	291
312 MALANG	28	24	22	27	29	37	33	44	26	31	28	29	358
313 PASURUAN	11	10	9	8	11	10	7	14	9	11	11	11	122
315 SIDOARJO	16	16	16	20	18	14	16	23	19	21	20	20	219
316 MOJOKERTO	8	7	7	11	10	10	9	13	7	9	9	11	111
318 GRESIK	156	135	122	144	159	218	199	193	132	156	148	162	1,931
319 LAMONGAN	7	8	11	9	10	9	9	10	9	9	9	9	109
320 BANGKALAN	1	1	1	1	1	2	4	3	2	3	2	2	23
321 SAMPANG								1					1
324 PROBOLINGGO	2	1	1	1	1	2	1	1	1	1	1	2	15
325 LUMAJANG	4	5	4	4	6	6	5	11	5	5	5	6	66
326 JEMBER	18	20	18	21	20	20	17	28	17	21	18	21	239
327 BONDOWOSO	8	7	10	9	7	7	6	13	8	9	7	5	96
328 SITUBONDO	4	3	4	4	5	4	3	6	4	5	5	4	51
329 BANYUWANGI	24	20	20	24	20	20	16	37	18	23	21	24	267
330 JEMBRANA	2	1		1		2	3	3		1		2	15
Total	2,994	2,846	3,016	2,998	3,176	3,431	3,199	3,860	2,800	3,125	2,776	2,977	37,198

Appendix 7.1.3 Survey on Boarding Persons, by Station (by Month)

1981 Unit: 1,000

Month/1981 / Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
101 JAKARTA	999	964	1,041	962	1,086	1,170	986	1,305	1,006	1,052	990	1,015	12,576
106 BEKASI	65	74	89	73	72	65	70	79	76	83	87	89	922
107 KARAWANG	63	66	57	66	71	69	73	85	73	84	85	92	884
108 TANGGERANG	33	32	35	37	39	30	32	33	34	34	36	34	409
109 BOGOR	429	420	457	474	481	469	447	506	407	441	358	390	5,274
113 LEBAK	56	55	58	56	63	58	49	57	48	55	47	52	654
114 PANDEGLANG							1	1					2
115 SERANG	157	128	130	140	156	188	170	192	129	142	81	87	1,700
117 CIREBON	36	32	35	36	37	47	47	39	30	57	37	35	468
118 SUBANG	11	15	13	9	8	10	7	7	7	7	5	3	102
119 INDRAMAYU	21	39	37	25	23	28	24	24	19	24	20	16	300
122 BANDUNG	159	144	145	158	162	172	143	197	138	142	140	155	1,855
123 PURWAKARTA	18	19	19	21	21	21	18	23	18	21	19	18	236
124 CIANJUR	34	32	36	36	28	27	37	46	29	31	27	30	393
125 SUKABUMI	61	56	67	60	53	59	70	79	53	70	61	66	755
126 GARUT	49	46	48	45	47	45	52	64	40	38	27	34	535
127 TASIKMALAYA	15	14	15	15	16	19	20	21	11	13	15	16	190
128 CIAMIS	36	24	23	24	26	37	25	47	23	25	24	23	347
201 BANYUMAS	9	8	8	10	10	14	11	9	7	9	7	10	112
202 BREBES	9	9	19	11	10	12	15	13	9	12	12	10	141
206 KEBUMEN	13	12	13	15	14	16	22	19	14	14	12	15	179
207 PURWOREJO	21	21	20	26	25	38	41	28	22	27	23	30	322
208 CILACAP	40	42	48	50	48	55	49	77	36	44	38	48	575
209 PEMALANG	1	1	1	1	2	1	2	1	1	1	1	1	14
210 TEGAL	8	7	8	9	9	11	11	11	6	12	10	8	110
211 PEKALONGAN	7	6	5	6	6	6	8	6	6	7	6	6	75
213 BATANG	2	2	2	2	2	2	2	2	2	2	2	1	23
214 KENDAL													
216 DEMAK	3	3	3	3	4	1	4	7	4	11	4	3	50
217 PURWODADI	41	42	48	41	31	35	33	46	27	35	30	32	441
218 BLORA	13	14	14	13	13	12	18	17	11	13	11	13	162
219 BOJONEGORO	5	6	8	7	7	10	9	11	6	7	5	6	87
222 REMBANG	5	5	7	7	6	6	5	8	4	4	4	5	66
223 TUBAN	17	17	21	20	23	22	19	21	15	17	16	13	221
224 KULONPROGO						1	1						2
225 SLEMAN	82	70	62	78	88	106	97	87	68	81	66	99	984

1981 Unit: 1,000

Station \ Month/1981	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
226 KLATEN	2	2	3	1	1	2	1	1	1	1	2	1	18
227 SRAGEN	2	3	6	5	3	3	5	3	2	3	3	3	41
229 KARANGANYAR	1	1	1	1		1		1	1	1	1		9
232 BOYOLALI	4	4	4	4	2	3	5	4	2	4	4	4	44
233 SEMARANG	62	60	62	63	61	70	81	90	59	69	62	62	801
235 SURAKARTA	34	23	25	29	28	35	48	46	24	27	24	32	375
236 BANTUL													
303 NGAWI	3	3	4	5	5	5	8	7	4	5	4	5	58
304 MAGETAN								1		1		1	3
305 MADIUN	13	10	12	12	19	16	20	16	12	15	13	15	173
306 NGANJUK	8	9	6	6	9	9	11	10	6	7	6	8	95
307 JOMBANG	14	13	13	17	20	21	22	28	15	21	18	19	221
308 PONOROGO	1		1			2	2	2	1	1	1	1	12
309 KEDIRI	9	8	5	9	10	13	14	12	9	10	10	10	119
310 TULUNGAGUNG	5	4	4	4	6	6	6	7	4	5	4	5	60
311 BLITAR	20	16	18	21	21	30	33	31	19	25	23	25	282
312 MALANG	26	24	22	24	30	36	33	43	23	29	27	28	345
313 PASURUAN	11	9	9	8	9	9	7	13	9	10	9	9	112
315 SIDOARJO	14	13	13	18	17	14	14	20	18	19	19	19	198
316 MOJOKERTO	7	7	7	9	9	9	9	11	8	10	14	9	109
318 GRESIK	172	149	147	157	174	218	198	243	149	181	165	185	2,138
319 LAMONGAN	9	9	10	8	9	6	10	9	5	7	6	6	94
320 BANGKALAN	1	1	1	1	1	2	4	4	2	3	2	2	24
321 SAMPANG													
324 PROBOLINGGO	1	1			1	1	1	2	1			1	9
325 LUMAJANG	3	4	3	3	5	4	5	10	4	4	4	5	54
326 JEMBER	20	18	17	20	21	19	17	27	16	19	17	19	230
327 BONDOWOSO	7	6	8	9	8	7	6	11	7	7	7	6	89
328 SITUBONDO	4	4	4	4	4	5	3	7	5	6	5	3	54
329 BANYUWANGI	21	19	19	22	15	18	16	31	15	20	19	23	238
330 JEMBRANA	2	1		2	1	5	2	2			1	6	22
Total	2,994	2,846	3,016	2,998	3,176	3,431	3,199	3,860	2,800	3,125	2,776	2,977	37,198

Appendix 7.2.1 Effective Length at Stations

1. Passenger Train

$$EL = \frac{\ell N}{n} + L + C$$

$$EL = \frac{20.7 \times 400}{45} + 14m + 20m$$

$$= 218m \fallingdotseq 220m$$

EL : Effective length

ℓ : Average length of passenger car (20.7m)

N : EL hauling capacity (400t)

n : Converted number of passenger cars (45t)

L : EL length (14m)

C : Clearance in front and rear of train (20m)

2. Freight Trains

$$EL = \frac{\ell N}{n_1 + n_2} + L + C$$

$$= \frac{8.2m \times 1,000}{(0.633 \times 25) + (0.367 \times 10)} + 14 + 20$$

$$= 454.6 \fallingdotseq 460m$$

n_1 : Converted number of loaded cars (0.633 × 25t)

n_2 : Converted number of empty cars (0.367 × 10t)

ℓ : Average length of freight car (8.2m)

Appendix 7.3.1 Double Tracking and Track Elevating between Jakarta and Manggarai

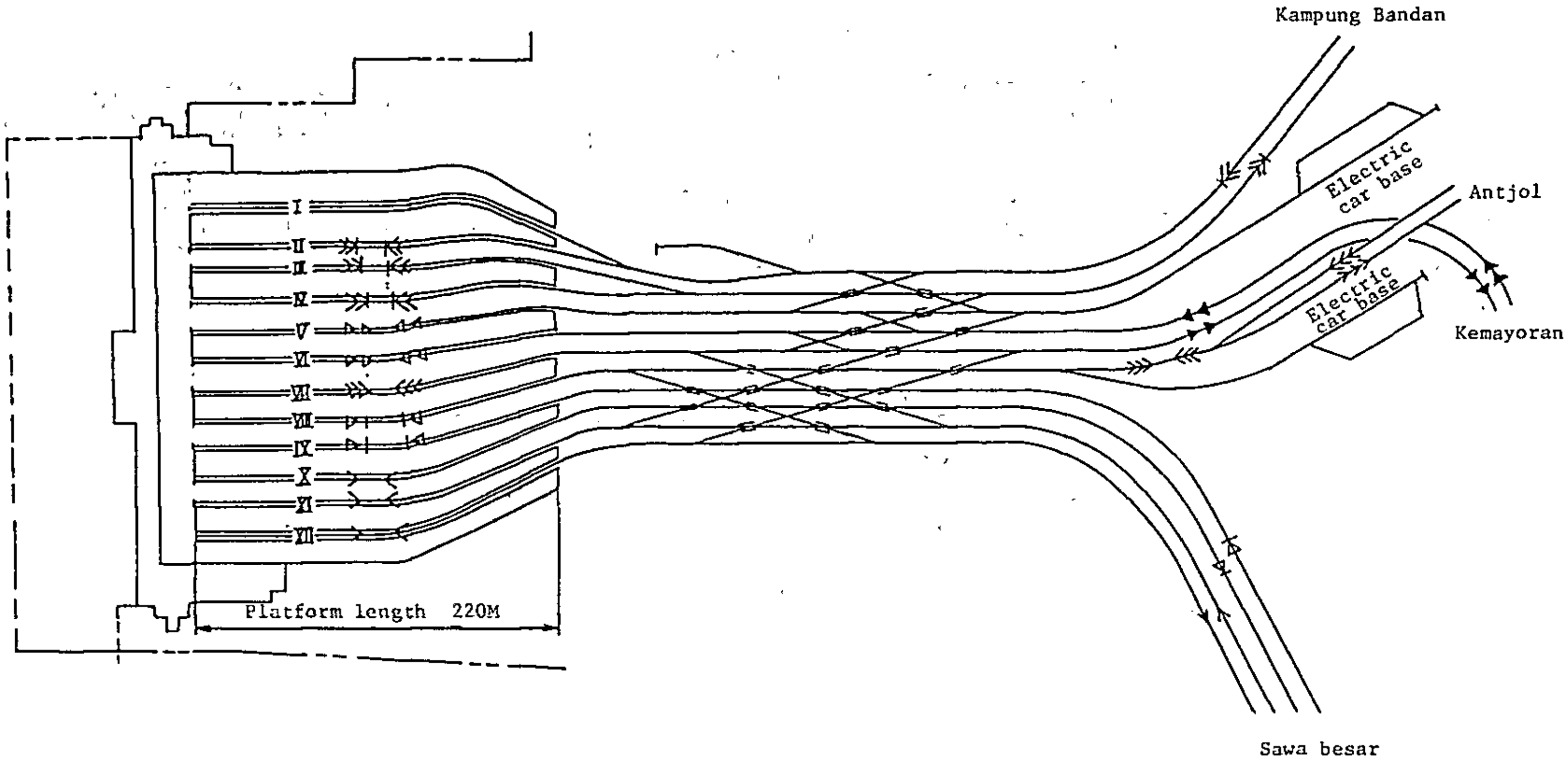
1. Proposed Double Tracking Length: $10^{k}4$

2. Stations : Jakarta, Gambir, Manggarai

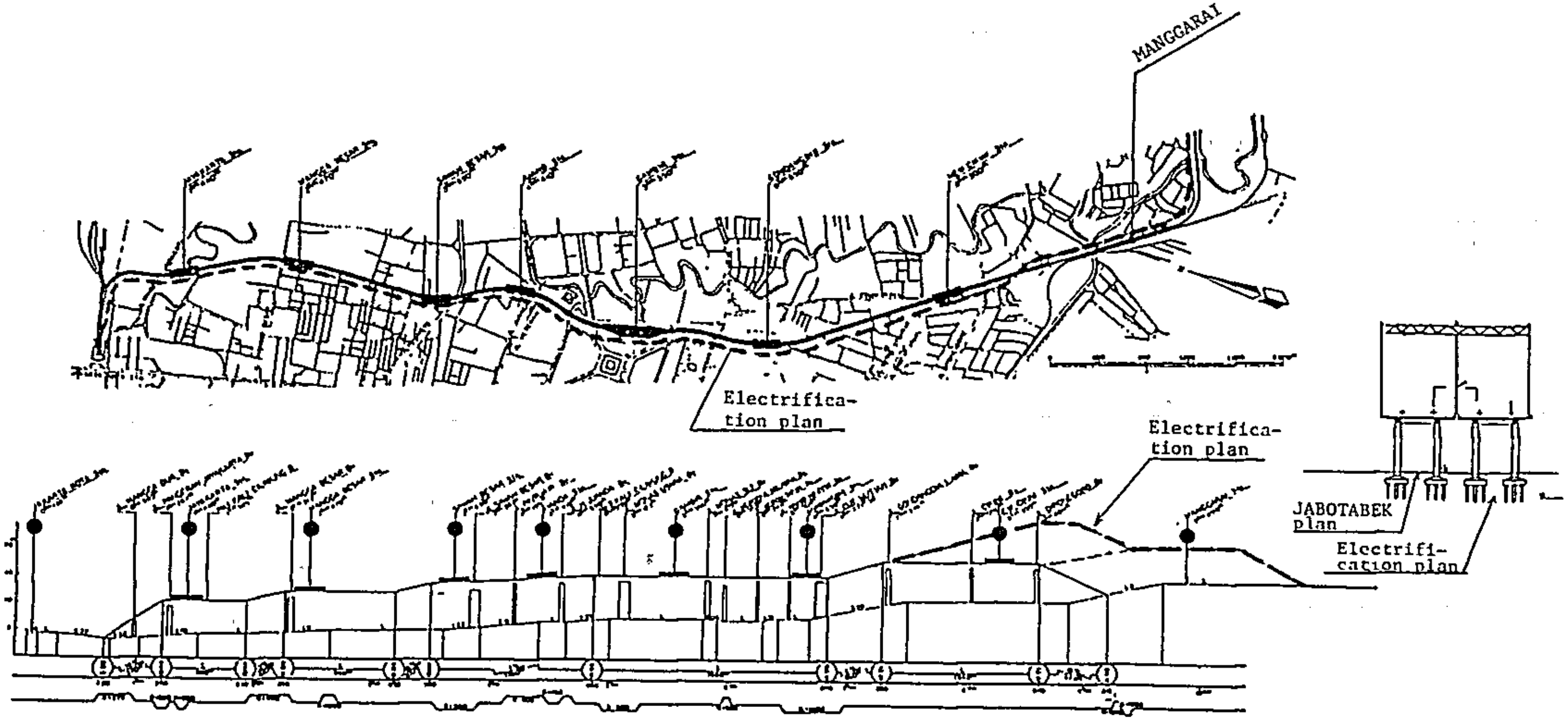
3. Structure : Elevating

4. Construction Cost :

Jakarta	1,527	$\times 10^6$ RP
Gambir	10,558	
Manggarai	6,471	
Intermediate line	72,455	
Total	91,011	

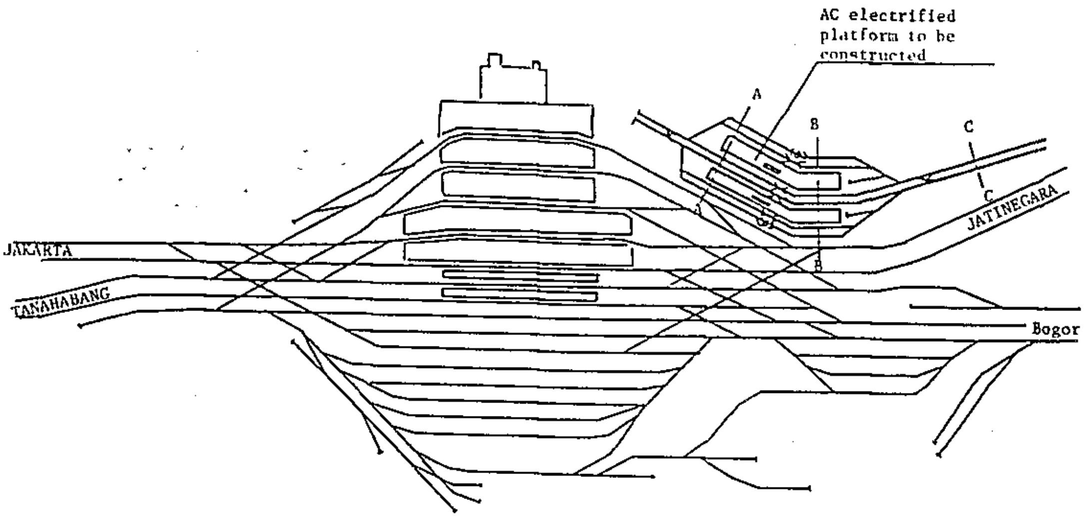


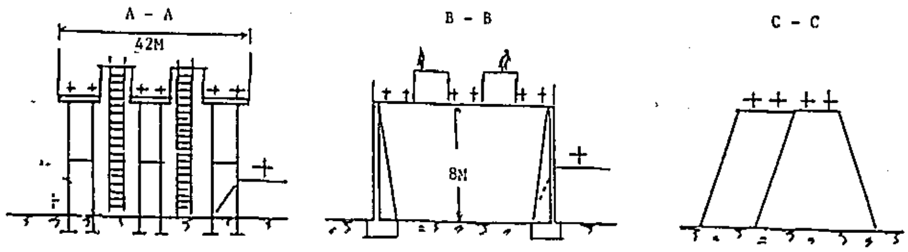
Appendix 7.3.2 Sketch of Track Layout for Jakarta Station



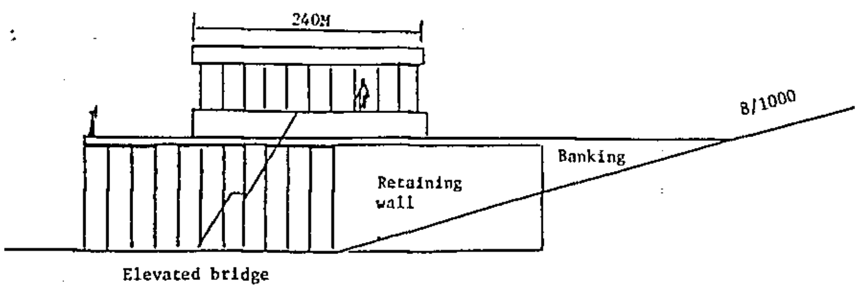
Appendix 7.3.3 Proposed Electrified Line

Appendix 7.4.1 Manggarai Departure Station Plan





Cross section sketch



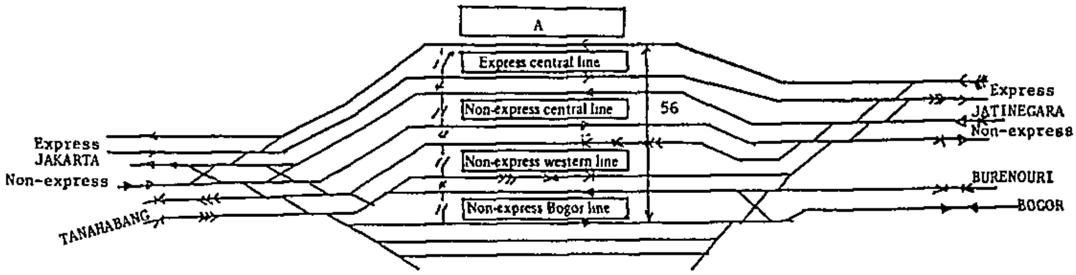
Elevated bridge

Profile sketch

Construction Cost

Earthwork	1227	10^6RP
Station equipment	1500	
Tracks	1043	
Elevated bridges	6753	
Total	10523	

Appendix 7.5.1 Manggarai DC Electrification Plan.



Outline of Construction

1. Jakarta is a departure station and Manggarai is an intermediate station.
2. The new line will be provided for express and freight train operation.
3. In yard improvement, four platforms will be constructed, one for each two tracks.
4. Platforms will be elevated and an overbridge will be constructed.

Construction Cost

	Construction cost
Earthwork	41 $\times 10^6$ RP
Station equipment	2,669
Tracks	1,660
Total	4,370

Appendix 7.6.1 Capacity of Tandjung Priok Gudang Yard

1. Handling Capacity of Arrival and Departure Tracks

$$N = \frac{1440 \times f \times n}{t} = \frac{1440 \times 0.6 \times 1}{30} \fallingdotseq 28 \text{ tracks}$$

N : Number of trains handled by arrival/departure track

f : Track utilization efficiency (0.6)

t : Per-train necessary time (30 min)

n : Number of arrival/departure tracks (1)

1440: 24 hours

2. Sorting Track Capacity

$$N_1 = \frac{L}{F} \times f_1 \times k = \frac{3740}{8.2} \times 0.6 \times 3 = 820 \text{ cars}$$

N_1: Number of cars sorted

L : Effective length of sorting and forming tracks (3,740 m)

F : Freight car length (average) (8.2 m)

f_1: Possible shunting rate

k : Freight car turnover

$$= \frac{\text{24 hours}}{\text{Freight car relaying time (8 hours)}} = 3$$

3. Lead Track Capacity

$$N_2 = \frac{f_2}{t} \times a = \frac{1200}{8.5} \times 5 = 705$$

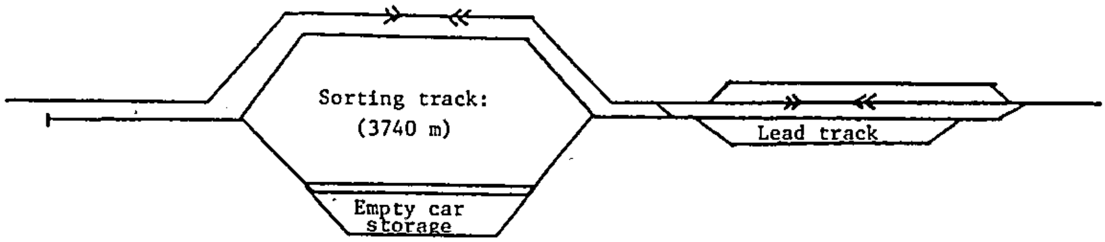
N_2: Number of freight cars by lead track

f_2: Shunting machine operation time (1200 min)

t : Time taken for disassembling (8.5 min)

a : Number of cars per disassembly operation (5 cars) (From past data Cipinang Yard)

4. Yard Capacity: 700 cars a day



Empty car storage track: 5
(590 m)

Appendix 8.1 Electric Railcar

8.1.1 Electric Railcar Plan

The electric railcar train is normally used as a passenger train. When compared with the locomotive operated passenger trains, it has, in general, the following advantages and disadvantages.

(1) Advantages

① For trains with the same number of cars it is possible to take a greater number of drive axles so that it is possible to increase the output per unit train weight. Then, the performance in the higher speed range is particularly improved permitting easy realization of higher speeds.

② Similarly, by increasing the number of drive axles, a greater acceleration can be achieved.

③ As it is possible to reduce the axle load and unsprung weight, it has less effect on the track and is thus readily compatible with the strict axle load restrictions.

④ The trains are comprised of units and are operated under multiple unit control, which enables us to improve control performance and synchronise brake control, ensuring improvement of the deceleration.

⑤ As electric brakes are usable for stopping or balancing the speed along a grade, the maintenance of the brake shoes and wheels are reduced.

⑥ Shuttling at starting or terminal stations is made easily and promptly.

⑦ In the case of multiple unit composition, some unit may have a failure, but by freeing such nit, the train operation can be continued.

⑧ Formation division and recombination is possible at intermediate stations.

⑨ Service power for air conditioning, etc. is easily obtainable.

⑩ By simultaneous operation of the doors or simultaneous display of the destination, the safety of the passengers is ensured, and various passenger services are improved.

⑪ By introducing electric railcar trains, the concept of transport improvement through electrification is clearly displayed.

⑫ In cases of the same effective length, a length equivalent to that of locomotive is usable effectively for passengers.

(2) Disadvantages

① With increasing numbers of motor cars and machines, the probability of failures may increase, but suspension of service occurs on few occasions.

② The maintenance cost increases accordingly.

③ When a partial failure occurs, there is an instance where the whole of the composing units has to be suspended for repairing.

④ For the same reason, it is desirable to have stand-by compositions.

⑤ In the case of longer compositions, energy consumption tends to increase over that of locomotive systems.

⑥ Noise insulation is required for passenger cabins.

⑦ The car cost is expensive.

The foregoing features show that some of the advantages and disadvantages are in a reverse relationship to each other. Therefore, for the introduction of the electric railcar trains, a line or section of advantages can be fully utilized should be chosen.

In the Japanese National Railways, strict restrictions are placed on axle load and speed at, say, curve, turnout, etc., but, for electric railcar trains of less axle load and unsprung weight, the speed limit is more or less relaxed to reduce the schedule time.

Furthermore, for reduction of the schedule time, some lines have body tilting electric rail cars (Electric Multiple Unit) introduced. Such electric railcars in JNR will be described later. (Appendix 8.2.2)

(3) Objective line

Among the objective lines of electrification, those in which the characteristics of the electric railcar train are exhibited are the suburban lines and lines connecting cities where the operation time is relatively short and trains are shuttled frequently. From such a point of view, the objective line will be the Bandung Line for the time being.

In the case of a long distance, there should be chosen a line where available time is effectively utilized while it is possible to raise the speed and, at the same time, reduce the volume of track maintenance, so that the train can have a novel image change as representative high grade trains.

(4) Electric railcar unit

The basic electric railcar formation is comprised of motor cars, and trailers including trailers with driving cab.

Operation is made with a single formation or a plural number of coupled formation. The composition should be chosen in due consideration of operation patterns, track conditions, motor car performance, the operation method in the event of failure of some motor cars. The basic formation is composed primarily of two motor cars (called M and M'), except in some special cases, with trailers (called T) coupled to the front and rear of each motor car. Normally, it is 2M2T or 2M1T.

An even number of motor cars is employed in that with two cars taken as a basic unit, the equipment configuration is facilitated for improving the maintenability and reducing the cost. The T cars include those used at the forehead, and these are called the car with driving cab.

(5) Power classification

The objective line includes the DC 1500 V section of the Jabatobek block and the 25 kV section of the other blocks. The DC 1500 V section is a short length, but to make the best use of the features of electric railcar trains, the running of both DC and AC sections should be allowed, for the time being, that is, AC-DC dual purpose electric motor cars are required.

When the AC section is extended in the future, the AC electric cars will be used, but some trains will start in the DC section so that the AC-DC electric motor cars will by no means be useless.

(6) Running speed and accelerating performance

The electric railcar train has the specific output increased by increasing the proportion of M cars. It is possible to realize a maximum running speed of 120 km/h, acceleration of 2.0 km/h/sec and deceleration of 2.5 km/h/sec, or more respectively. But, they should be applied adequately depending on the character and use of the car.

With electric railcar trains, decreasing the fatigue of the track through reduction of the axle load and increasing speed owing to improvement of the speed limit at the curve are expected to be carried out. But, for these cases, relaxation of the conditions is not made.

8.1.2 Performance Plan

(1) Train composition and weight

From the available length of the station, the train composition is 10 cars maximum (equivalent to 20 m cars), or 8 ∿ 10 cars accordingly.

In the case of 8 cars, the composition is 4M4T or 6M2T, and in the case of 10 units, it is 4M6T or 6M4T. The train weight was taken as 380 t with 8 cars or as 480 t with 10 cars.

(2) Speed, acceleration and deceleration

These were determined with the targets set somewhat above those of the locomotive system.

Maximum speed: 130 km/h
Acceleration : About 2 km/h/sec
Deceleration : About 2.5 km/h/sec

(3) Speed balancing brake

The grade along the Bandung Line is relatively long so that the speed balancing dynamic brakes are effective, and their employment is worth consideration. This system is used particularly when the operation is made with a speed balance taken along a continuous down grade of 20 ‰ or greater. The speed balancing brake force must be compatible with the balancing speed along the steepest grade in the section. The equipment is required to have a capacity satisfying the foregoing requirements.

(4) Rolling stock gauge

The AC-DC dual purpose electric car has many machines mounted. On the roof, it has a pantograph and many other extra-high voltage machines mounted, and it is required to secure a clearance to the tensioned parts.

Beneath the floor, there should be provided a space for the installation of principal machines which are to be shared by two cars, and this is the reason why two cars are taken as a unit.

Thus, the floor is higher than that of the DC car, and a height of at least 1,150 mm is required.

The rolling stock gauge should be taken as 4,300 according to the general rules, as stated in the paragraph for the locomotive, and it is proposed that a reduced gauge should be taken for the time being and be improved later with structures to be modified in the future.

8.1.3 Calculation of Electric Car Performance

In electric car train simulation, the trains were run with the following conditions input, that is, under the same conditions as for the locomotive traction, according to the running simulation in paragraph 8-6-2 of the main text.

(1) Simulation

① Running section: Jakarta - Bandung (Stopping at two stations).

② Power performance of 1-unit: Appendix 8.1.1.

Line Voltage	AC 25 kV
Output	810 kW
Tractive effort	5,700 kg (100% F)
Speed	51 km/h (100% F)
Tractive Motor	357 V 315 A 1,650 RPM
No. of Motors	8

③ Train composition:

(i) 6M4T

(ii) EL - D_3 Type

(2) Simulation results

6M4T Appendix 8.1.2 + attach.

EL - D_3 Appendix 8.1.3 + attach.

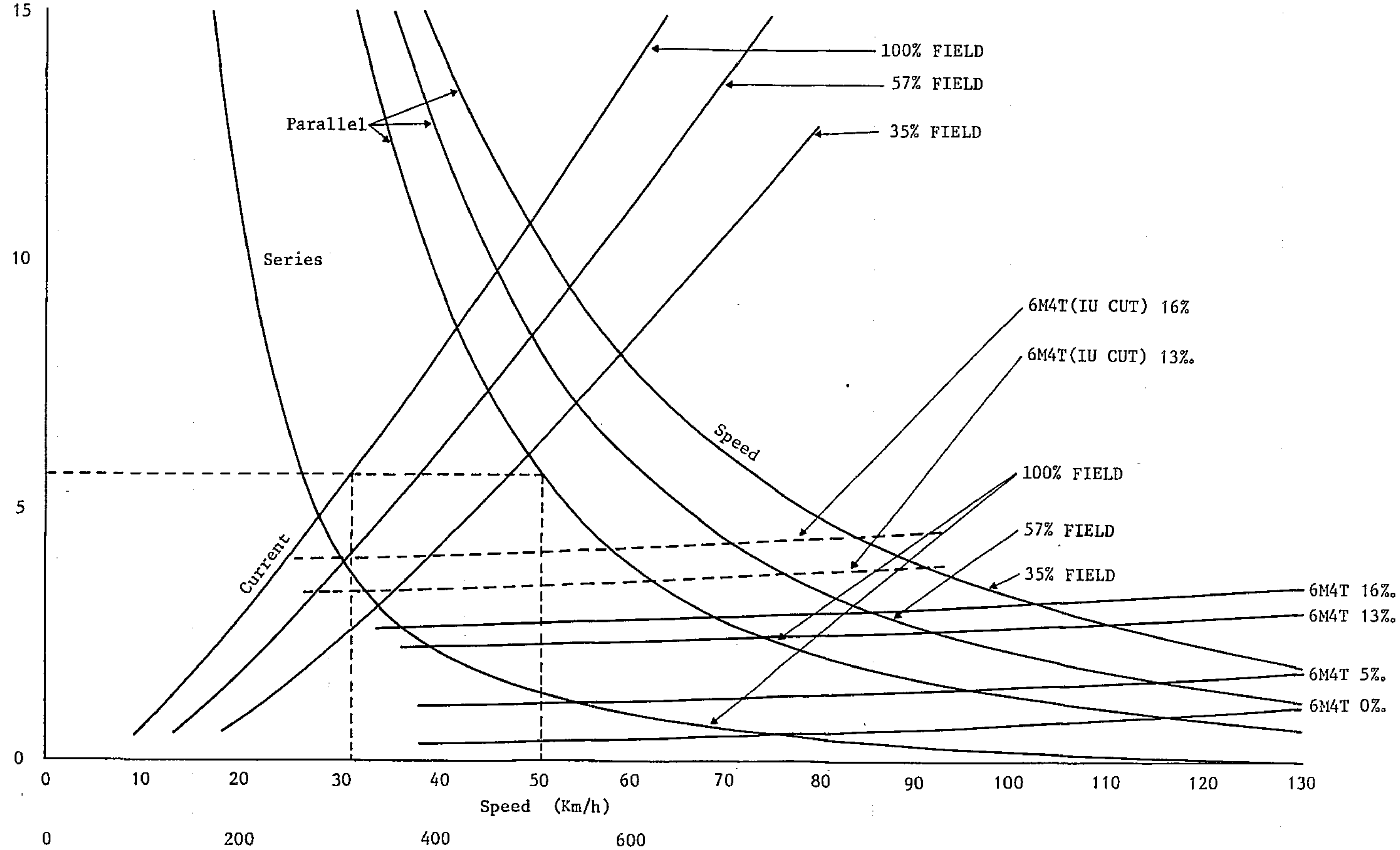
Section	Kind of Train		Required time	RMS (Arr)	Ratio	Power Consumption
	Unit		H.M.S (hour, min, sec)	A	-	k, kwh
Bandung Line (Stopping at two stations)	Electric car	6M4T	$2^H 3^M 47^S$	251.75	0.80	3,036
	EL	D_3	$2^H 9^M 41^S$	376.17	0.70	2,616

(3) 1-Unit cut operation

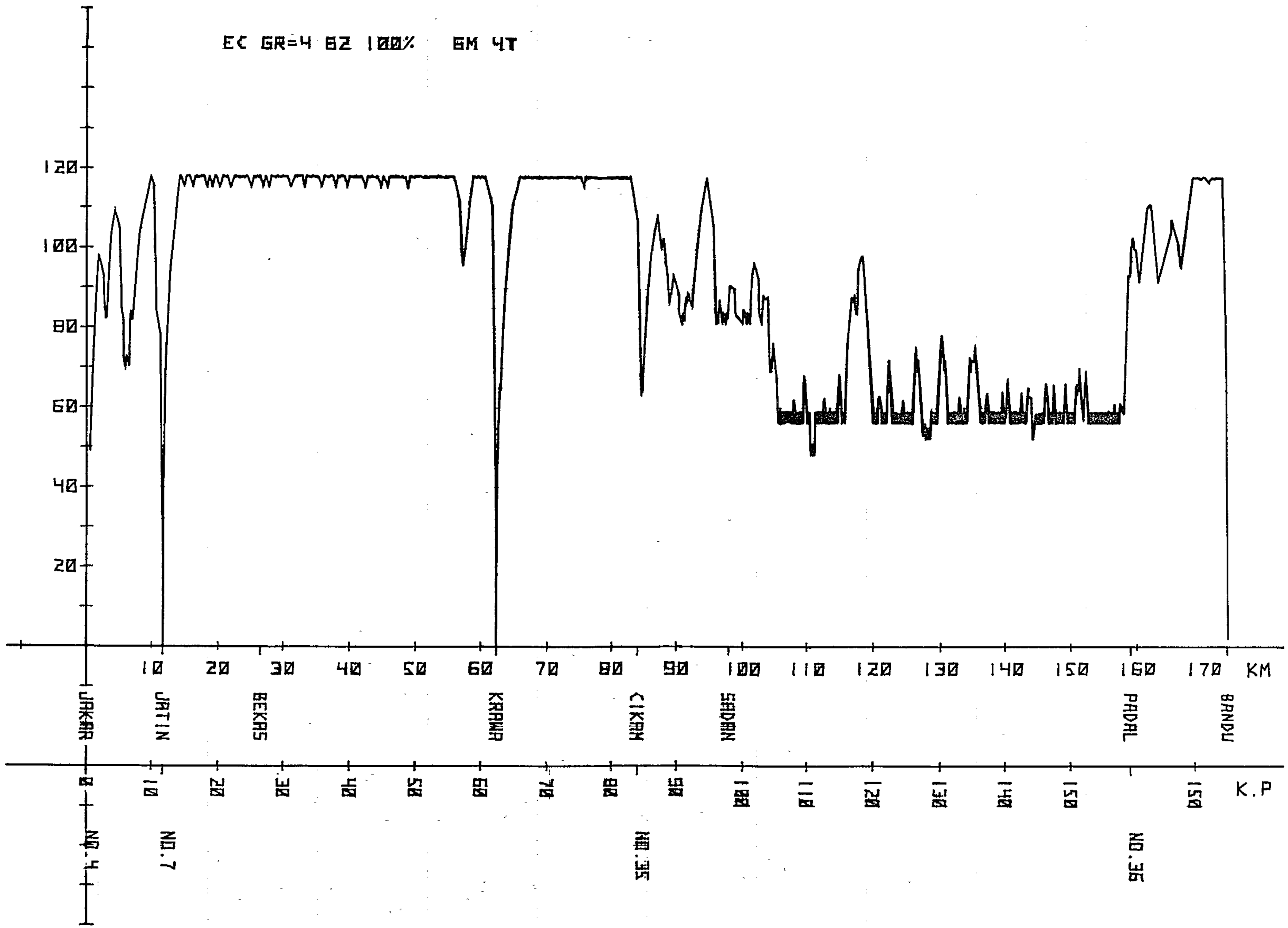
As described previously, the electric car train is composed of a plurality of units. In the case of 4M4T, if a motor car has a failure so that 1 unit has to be cut, the operation is 2M6T.

With 2M6T, the operation in the 16 ‰ + curve resistance section is overloaded by about 30 percent more. Consequently, the 1-unit cut in graded sections is limited to down-grade.

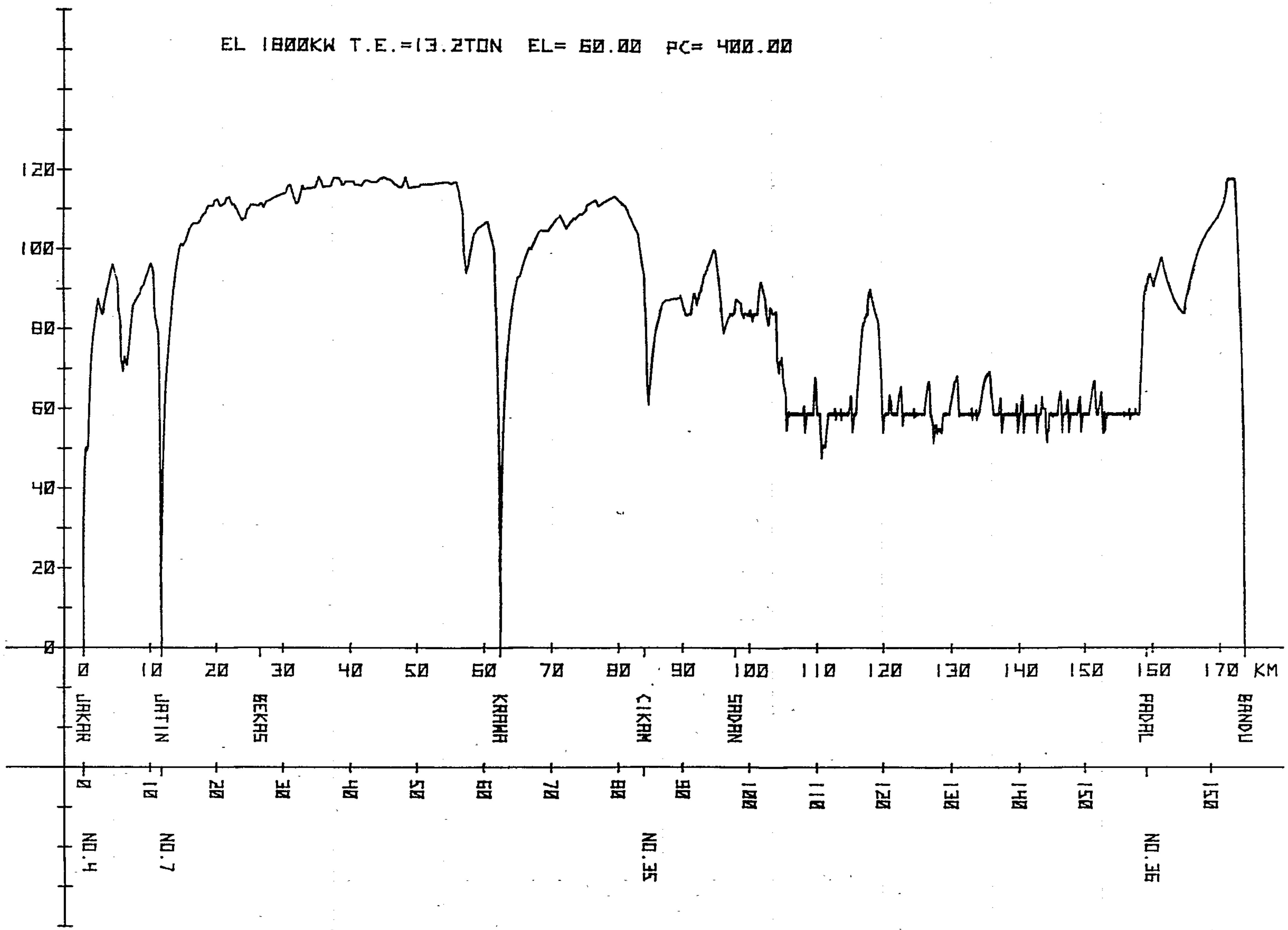
In the case of 6M4T composition, the operation with 1-unit cut is 4M6T. This case means more loading conditionally, but the whole composition train is allowed for continuation of operation by the other remaining 2 units.



Appendix 8.1.1 Performance



Appendix 8.1.2 Running Curve (Bandung Line-EC)



Appendix 8.1.3 Running Curve (Bandung Line-PC)

BANDUNG LINE

```
EC GR=4.82 100%
M= 6   Wm= 277.44
T= 4   Wt= 168.96
MT61      WF=  35
WD= 820  GR=4.82
Vm= 120  Vd=    2
Vrp=  3  Vcv=   0
Tco= 30   N=    3
α= 2.18   480.0A
β= 2.00  -279.6A

 * JAKAR
D(km)        11.75
T(s)        516.14
E(kWh)      234.16
RMS(A)      284.74
 * JATIN
D(km)        14.80
T(s)        492.80
E(kWh)      247.35
RMS(A)      247.47
 ↓ BEKAS
D(km)        35.78
T(s)       1133.93
E(kWh)      356.90
RMS(A)      164.79
 * KRAWA
D(km)        21.68
T(s)        711.24
E(kWh)      349.47
RMS(A)      221.06
 ↓ CIKAM
D(km)        13.77
T(s)        539.33
E(kWh)      228.02
RMS(A)      255.87
 ↓ SADAN
D(km)        61.29
T(s)       3512.89
E(kWh)     1429.08
RMS(A)      276.35
 ↓ PADAL
D(km)        14.66
T(s)        520.45
E(kWh)      190.90
RMS(A)      230.49
 * BANDU

---TOTAL---
D(km)       173.73
T(s)       7426.76
E(kWh)     3035.88
RMS(A)      251.25
```

Appendix 8.1.2
attach

③ EL 1800
D3 Type
Stop Two Stations
BANDUNG LINE

```
EL 1800KW T.E.=1
3.2ton
L= 60.0   PC= 400
Pr=1800   Fr=13.2
Ir= 540   Vr=49.1
WF=  50
Vm= 120   Vd= 2.0
Iac= 630A  16210
α= 1.08   β= 1.50

 * JAKAR
D(km)        11.75
T(s)        574.52
E(kWh)      154.97
RMS(A)      360.97
             66.85
 * JATIN
D(km)        14.80
T(s)        553.70
E(kWh)      195.95
RMS(A)      370.23
             68.56
 ↓ BEKAS
D(km)        35.78
T(s)       1170.34
E(kWh)      302.67
RMS(A)      253.95
             47.03
 * KRAWA
D(km)        21.68
T(s)        796.64
E(kWh)      268.25
RMS(A)      349.45
             64.71
 ↓ CIKAM
D(km)        13.77
T(s)        581.25
E(kWh)      182.70
RMS(A)      344.22
             63.74
 ↓ SADAN
D(km)        61.29
T(s)       3533.29
E(kWh)     1341.86
RMS(A)      430.12
             79.65
 ↓ PADAL
D(km)        14.66
T(s)        571.91
E(kWh)      170.55
RMS(A)      310.41
             57.48
 * BANDU

---TOTAL---
D(km)       173.73
T(s)       7781.65
E(kWh)     2616.96
RMS(A)      376.17
             69.66
```

Appendix 8.1.3
attach

(4) Electric car composition and consideration

The Bandung Line will have an increasing number of trains operated so that it is important to secure the train diagram. The step of 1-unit cut is to reduce adverse effects at the time of a failure and is one of the outstanding advantages of the electric car train. Accordingly, the formation is preferably in units equivalent to 6M4T. But, the 1-unit cut is an emergency measure, and such units should be changed with stand-by units at the nearest base.

Accordingly, the number at 6M4T formations will probably be much larger than is presently thought.

(5) Supplements

Profile of EC Train: Profile of the electric car trains of 6M4T formation is reproduced below.

Electric system	AC 25 kV 50 Hz; DC 1,500 V
Basic unit	2M1T
Composition number of cars	10 (6M4T)
Formation	Trailers (including those with driving cab) 2 Trailers 2 Motor car 6
Tare weight	48 t or less (axle load, 12 t or less)
Continuous rating	Output 2,430 kW Speed 51 km/h (100%) Traction motor 375 V 315 A 105 kW 1,650 rpm
Maximum speed	130 km/h
Control system	Resistance control, Serial/parallel control Field control (weakest field coefficient 35%) Electromagnetic straight brake Stop and speed balancing dynamic brake
Wheel diameter	860 mm (for calculation 820 mm)
Gear ratio	4.82 (82:17)
Transmission	Cardan drive, parallel

The MT composition should be determined depending on the running condition. For the body tilting multiple unit (series 381, described later), the basic unit is 2M1T, and the formation is 6M3T.

Longer distance electric car trains must satisfy the conditions as a passenger train.

> Higher class car, seat layout, dining car, window, door and deck construction, air conditioning equipment, toilet, water (hot water), etc.

Appendix 8.2 Answer to Questionnaire

8.2.1 Question: Electric Magnetic Brake System

Rail Brake

The rail brake is independent of the adhesion between the wheel and the rail and has the brake device mounted on the truck or body so as to act directly on the rail and is, therefore, one of the so-called non-adhension brakes. As a principal system, it includes the electromagnetic shoe brake and eddy current brake.

(1) Electromagnetic brake

The electromagnetic brake has a brake shoe including an electromagnetic coil adsorbed to the rail by an electromagnetic force and thus utilizes the friction between them. In Europe, it is mounted on passenger cars for use as an emergency brake. But, in Japan, it is used only for staying along steep grades or as a security brake in the mountain railways having steep grades or on mining cars.

(2) Eddy current brake

The eddy current brake has an electromagnet which is maintained at a certain spacing to the rail and uses the drag generated by an eddy current induced on the rail surface by the relative movement of both as a braking force. This brake produces a suction force with the rail and is , therefore, effective when the axle load is increased. It also has the effect of increasing the apparent adhesion coefficient. Control of the brake force is effected by current excited electromagnetic force, that is controlling the excited current by the dynamic brake current. The eddy current brake has greatly varying braking force depending on the gap to the rail. Thus, it must be constructed so that a constant gap is maintained. Then, the brake has to be mounted beneath the spring of the truck, and there occurs problems which need to be resolved such as, the decrease of the running performance due to increase of the unsprung weight, complexity of the truck structure, etc. But, to comply with the needs for higher car speed, this brake is being examined as being the most expecting among the non-adhesion brakes.

In our country, the brake was tested on the Shinkansen cars, and it was found that in addition to the foregoing problems, there was another problem of an effective brake force not being obtainable in the low speed region, and so this brake is not yet in practical use.

8.2.2 Tilting Electric Railcar Train (Series 381)

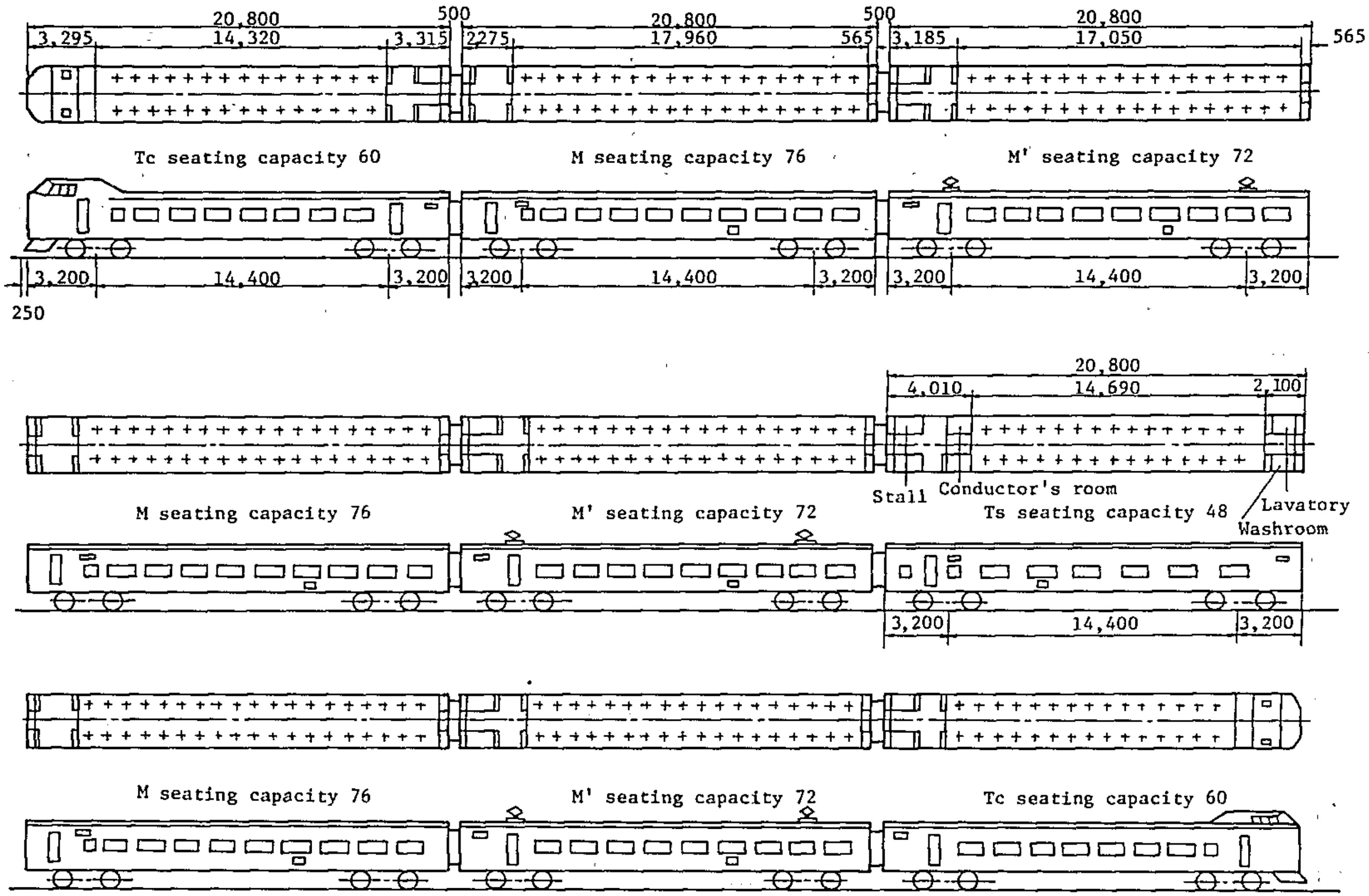
The series 381 limited express d.c. electric railcar train (App. 8.2.1) is the first practical version of the series 591 prototype a.c./d.c. electric railcar with a tilting device which has been put to various tests on different lines of JNR since 1969. Up to June, 1973, 47 cars had been built and since July, 1973, they have been operated over 252 km in the mountainous ragions of the central part of Japan, taking three hours and 20 minutes as against three hours and 57 minutes taken so far by the KIHA 181 series limited express diesel railcar train. With the electrification of the line, the new electric railcar train with a tilting device was introduced which could cut the running time by about 40 minutes with a speedup on curves.

The most outstanding feature of this railcar is its tilting device. This device gives good riding quality even when the curve-passing speed in increased by 20 km/h over, the speed of the conventional electric railcar. Moreover, since the gravity center of the car body is set low to enhance the effect of tilting, an increased curve-passing speed does not cause an overturning of the car. It has been confirmed with the series 591 prototype electric railcar with the tilting device that good riding quality under centrifugal force, and running safety can be assured up to an increase of 30 km/h over conventional curve-passing speed.

(1) Measures for Raising the Scheduled Speed

Lines other than Shinkansen of JNR are narrow gauge, i.e., 1,067 mm in track gauge; and the maximum running speed of trains for service is set at 120km/h. A speed-up over this limit would be hard to realize, because the emergency bracking distance is set at less than 600 m. For the purpose of increasing the scheduled speed of trains with the maximum speed remaining at 120 km/h, it would be effective to raise the points-passing speed, but there is a solution that can be obtained with the vehicle alone, that is, a reduction of axle load, which would enable speedup over curves and speedup on gradients. Lines of JNR, even trunk lines, are full of 300 m curves and 25 ‰ gradients.

Speedup on gradients can be effectively realized through electrification of the line, and speedup on curves can be realized by providing the car with a tilting device and lowering the gravity center of the



Appendix 8.2.1 Series 381 Electric Railcar Train

car-body without any sacrifice of riding quality or increasing the chances of the car overturning.

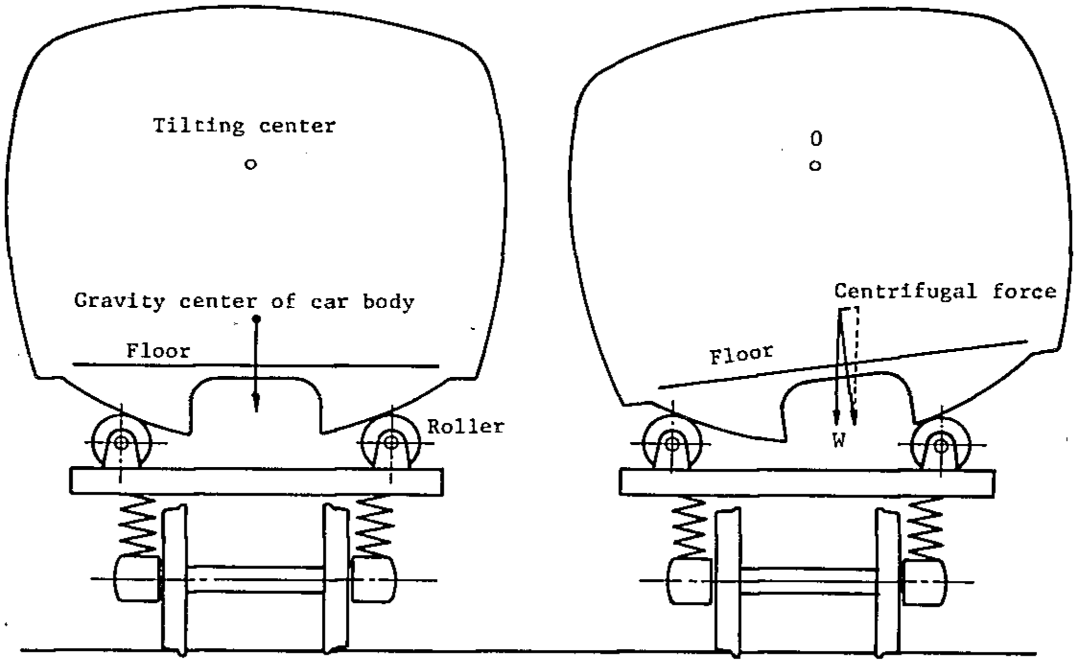
(2) Tilting Device Adopted by JNR

The device adopted by JNR is a natural tilting system with rollers, which utilizes the centrifugal force working on the car body as it passes a curve. For the purpose of natural tilting, the gravity center of the car body has to be located below the tilting center. Thus, all the electrical equipment, excepting the pantograph, the braking system and the air conditioning equipment, are mounted under the floor of the body, thereby making the gravity center far lower than the tilting center. Namely, the tilting center is about 2,300 mm above the rail level, while the gravity center is about 1,300 mm. The maximum tilting angle is set at 5°. At low speeds the tilting effect is suppressed so that the swing of the car body is prevented when passengers get on or off the car. (See Appendix 8.2.2)

To abate the swivelling lateral force acting in the passage of curves, a pivot-shifting device and a link device to transfer the pivot position were tested with series 591 prototype electric railcars. But they were discarded because they were complicated in structure and were not so effective as expected in passing curves at speeds faster by about 20 km/h than the conventional electric railcar. The fact that the lateral force could be reduced by the tilting effect alone was another reason for discarding them.

(3) Section of Car Body

The maximum tilting angle of the car body is set at 5° and under the tilting effect, a car with standard cross-sectional dimensions begins to violate the car construction gauge. Therefore, the bottom width of the car body has been reduced and the equipment mounted under the floor has been made small. Under the tilting effect the pantograph is heavily inclined, but it has been confirmed with the series 591 prototype electric railcar that a pantograph of the stationary type can suffice if only the current-collecting area is enlarged; thus a pantograph of the stationary type with a simple structure has been adopted.



Appendix 8.2.2 Explanation of Tilting Device

(4) Car Performance

The maximum speed of the series 381 electric railcar train, which is intended for operation on lines full of curves and gradients, is set at 120 km/h and its basic train set is three-cars, including two motive cars, mounted with a set of 8 traction motors in total, with a one hour rated output of 120 kW each, and one trailer car, thereby increasing the acceleration and the balanced speed on gradients. A dynamic brake for speed control is available on the down gradient and emergency braking is also done by the dynamic brake.

Appendix 8.2.3 is the running notching curve. These are essentially the same as those of practically all electric railcars of JNR.

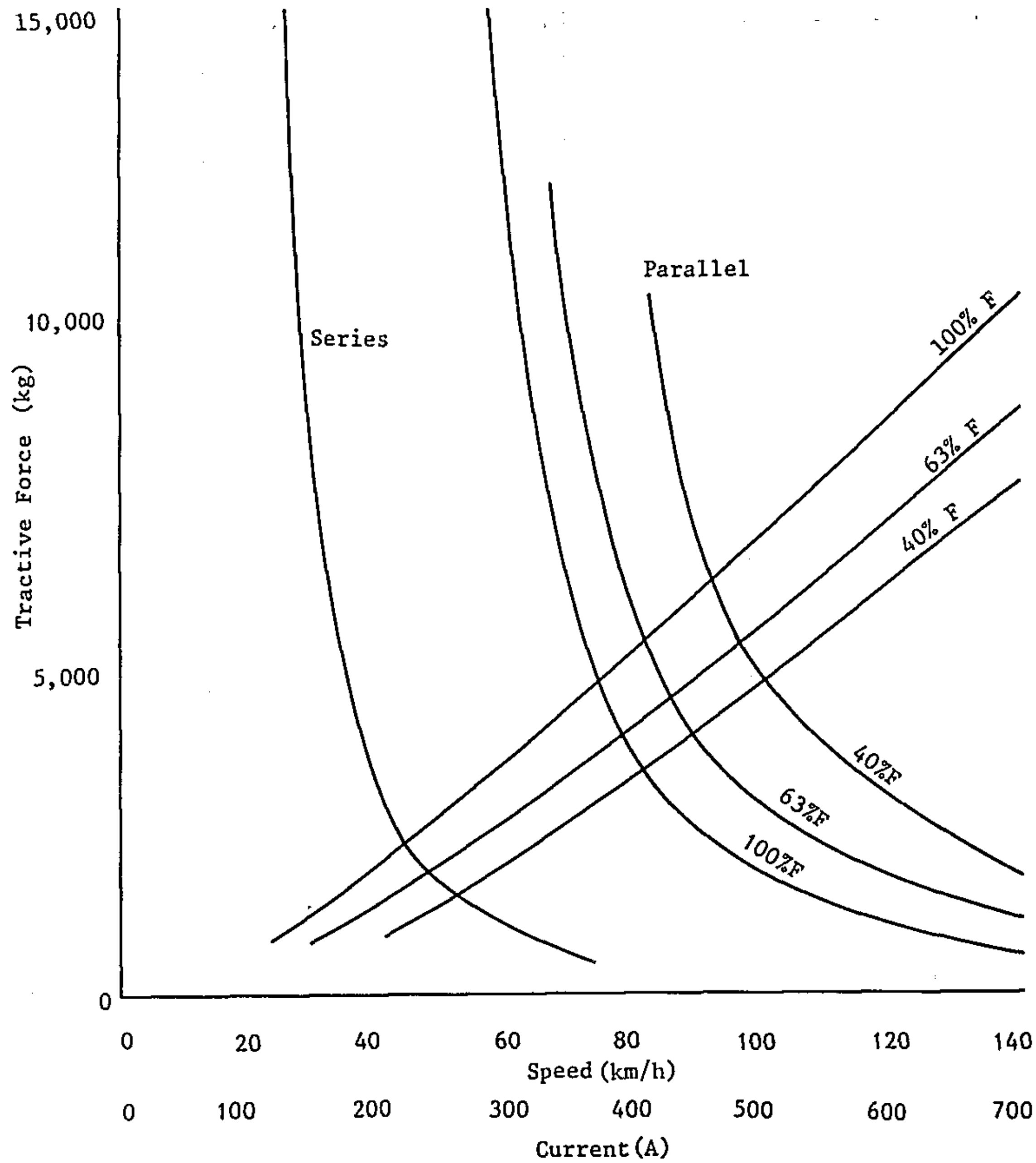
The major part in the braking is played by the dynamic brake, and as a backup to the dynamic brake, air brakers are installed. These are automatic air brakes and electromagnetic direct air brakes, which are controlled by a separate line from the dynamic brake. There is an additional direct air brake installed, which takes over when the regular air brakes get out of order. The brake rigging includes synthetic resin shoe brakes and disk brakes; to improve the rail-tread adhesion, a tread-cleaning device is provided.

Main features of the series 381 electric railcar are listed in Appendix 8.2.4.

(5) Car Body and Equipment

As indicated in Appendix 8.2.1, the train consist is 9-cars with a seating capacity of 612 passengers. For the sake of weight reduction the car body is built of an aluminum alloy. On each side of the car one entrance-exit opens, the doors being automatic. The air conditioning equipment is mounted under the floor and air is introduced into the car through air ducts. The seats are one-step reclining types that can be swivelled in the travel direction of the train. The windows are double-glazed with a blind in between, being manually movable up or down. Ceiling lamps are disposed in two rows and they can be dimmed at night. Washrooms and lavatories are distributed two for three cars, and a drinking-water cooler is provided in each washroom.

The front cab is raised for better forward visibility and for the protection of drivers in case of accidents at railway crossings; accordingly, the ceiling of the cab is about 560 mm higher than that in the passenger room.



Appendix 8.2.3 Traction Motor Characteristic Curves

Appendix 8.2.4 Main Feature of the Series 381 Electric Railcar Train

		Tc	M	M'	Ts
Car body	Body length (mm)	20,800			
	Length over couplers (mm)	21,300			
	Distance between bogue center (mm)	14,400			
	Maximum width (mm)	2,900			
	Body	aluminum			
Seat capacity (Psngs)		60	76	72	48
Tare weight (t)		(approx)36	(approx)39	(approx)39	(approx)35
Bogie	Rigid wheel base (mm)	2,300			
	Wheel diameter (mm)	860			
	Power transmission system		Parallel cardan drive with hollow shaft		
	Tilting device	Natural tilting by roller			
Maximum speed (km/h)		120			
One-hour rating	Voltage (V)	DC 1,500			
	Out put power (kw)	960			
	Speed	77			
	Traction motor	120 kw, 375 V, 360 A			
Traction motor	Number of traction motor per unit		8		
Control system			Series-parallel connection and weak field control. Dynamic brake for stop and for speed control on the gradient		
Brake system		Dynamic brake, electro-magnetic air brake and additional straight air brake			

8.2.3 Regenerative Brake

The regenerative brake is a device using the kinetic and potential energy of the train for braking and is used mainly for trains running in mountainous area.

(1) Features of the regenerative brake

The regenerative brake is advantageous in (i) economy of the electric power, (ii) less requirement for transformation substations and (iii) reduction of brake resistors. However, it has shortcomings such as (i) increasing the control system, (ii) fluctuations of the braking force due to catenary voltage, (iii) requirement of protective devices against commutation failure, (iv) increasing the initial investment and maintenance cost, (v) influence extending over wider range when the source capacity is small and (vi) generation of high frequencies and reduction of power factor.

JNR has been using power regenerative electric locomotives operated exclusively in continuous slope sections of 33 ‰. The power regenerative rate is about 35 percent with the passing of trains.

(2) Restricting conditions of power regenerative brake

In the power regenerative brake which uses the traction motor as a generator and takes its energy out and feeds the energy back to the contact wire, the generated direct current must be converted to suit to the alternate current of the contact wire, and the control of such conversion is important. The voltage of the catenary to which the power is to be fed back is subject to fluctuations depending on the load condition. If the reactance is great, the influence is great accordingly, and the incidental control is indispensable.

(3) Principle of power regeneration

For conversion from DC to AC, a DC-AC inverter incorporating thyristor bridges is used. With the field of power regeneration excited separately, the armature current is allowed to flow in the same direction to that at the time of powering, and when the phase control angle is 90° or greater, the contact wire is positive, that is, the current is negative, the power is fed back to the source. This is the principle of the power regeneration. As the contorl angle increases from 90° to 180°, both efficiency and the power factor are improved. But, if it comes up close to 180°, the commutation is hardly completed before the voltage is inversed, resulting not only in failure of power regeneration but in excessive direct current flow. This is a failure of commutation.

Commutation failure also occurs at the time of separation from the wire or power interruption. It is a phenomenon unavoidable with the regenerative brake. Also, commutation results in failure when the direct current increases sharply with a drop in the contact wire voltage. Thus, a more refined controller is required. Furthermore, it is required to provide a protective circuit against commutation failure, and the technology of maintaining the function is important.

(4) Influences of the regenerated power

Once the regenerated power is produced, it comes back to the powersupply unless there is an adequate source of consumption, and when the source capacity is small, it apts to produce influences which are by no means negligible. Furthermore, during the phase control, the voltage and current phase difference changes with the control angle. When braked regeneratively, the maximum control angle determined from the commutation failure is relatively small to that at the time of powering so that the power factor is considerably decreased.

Phase controlled cars have the high frequency current increased or decreased by the control angle. But, the power regenerated car has the thyristor bridge operated for inverter so that it has the high frequency current increased, resulting in increasing influence on the power system and induction interferance to telecommunications.

(5) Consideration

Regenerative braking has been described briefly in the foregoing. When the object lines in Indonesia are considered, only the Bandung Line is graded, and the grade is only 12∿13 ‰ when the curve resistance is counted so that the power of regeneration is not much and also the load fluctuation is considerable because of the single track. Furthermore, the adverse effect on the power supply system has to be taken into consideration if the regenerated power thus obtained is not used effectively. Also the initial investment will increase, and a commensurate economic effect is hardly obtainable.

In conclusion, power regeneration may be considered if the transport increases in the future and when locomotives designed exclusively for slopes are required. But, so long as the present universal type locomotive is used, power regeneration is not advantageous.

Appendix 9.1 New Workshop Construction Plan and Semarang Workshop Improvement Plan

When a new workshop is constructed on a new land according to the equipment scale of the electric locomotive workshop set forth in paragraph 9.1.2 of the text, and when a new workshop is constructed with the land of the Semarange Shop used, their approximate plans are as follows.

(1) New workshop construction plan diagram — Appendix 9.1.1

(2) Semarang Shop improvement plan diagram — Appendix 9.1.2

(3) Table of Comparison of Approximate Construction Costs — Appendix 9.1.3

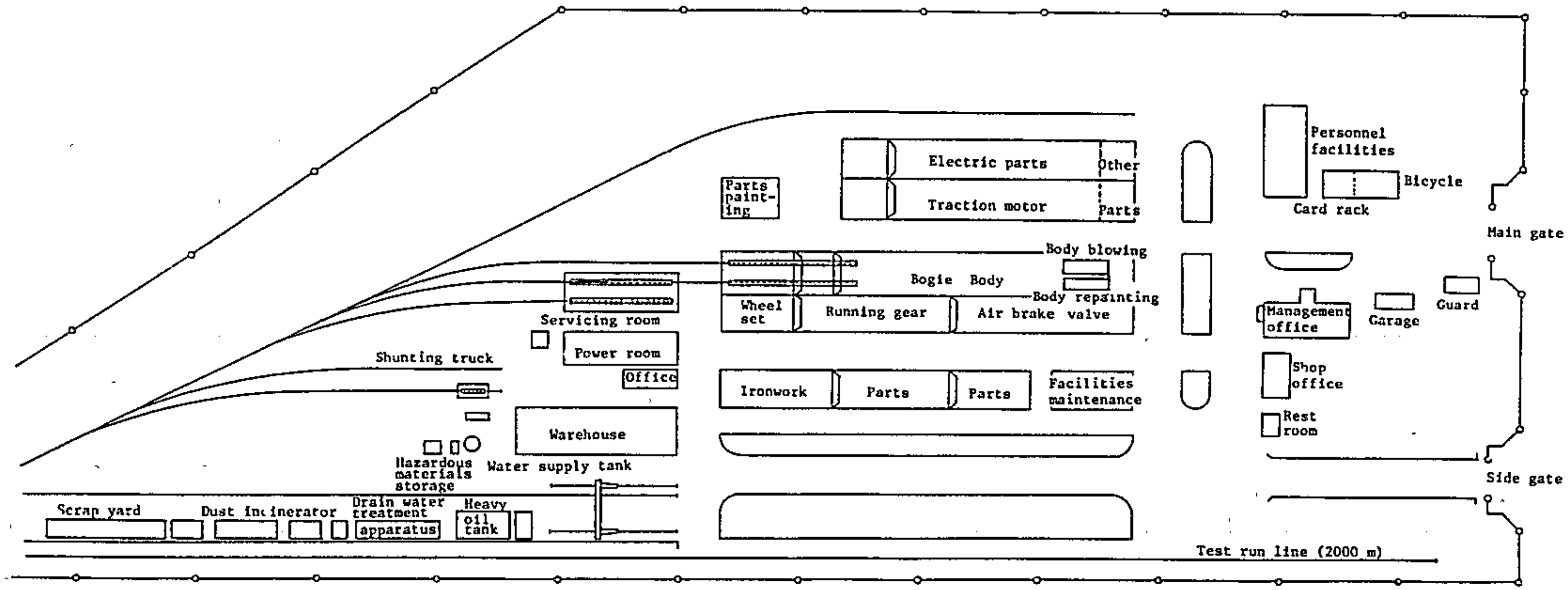
Appendix 9.1.3 Table of Comparison of Approximate Construction Cost

(Unit: 10^6 RP)

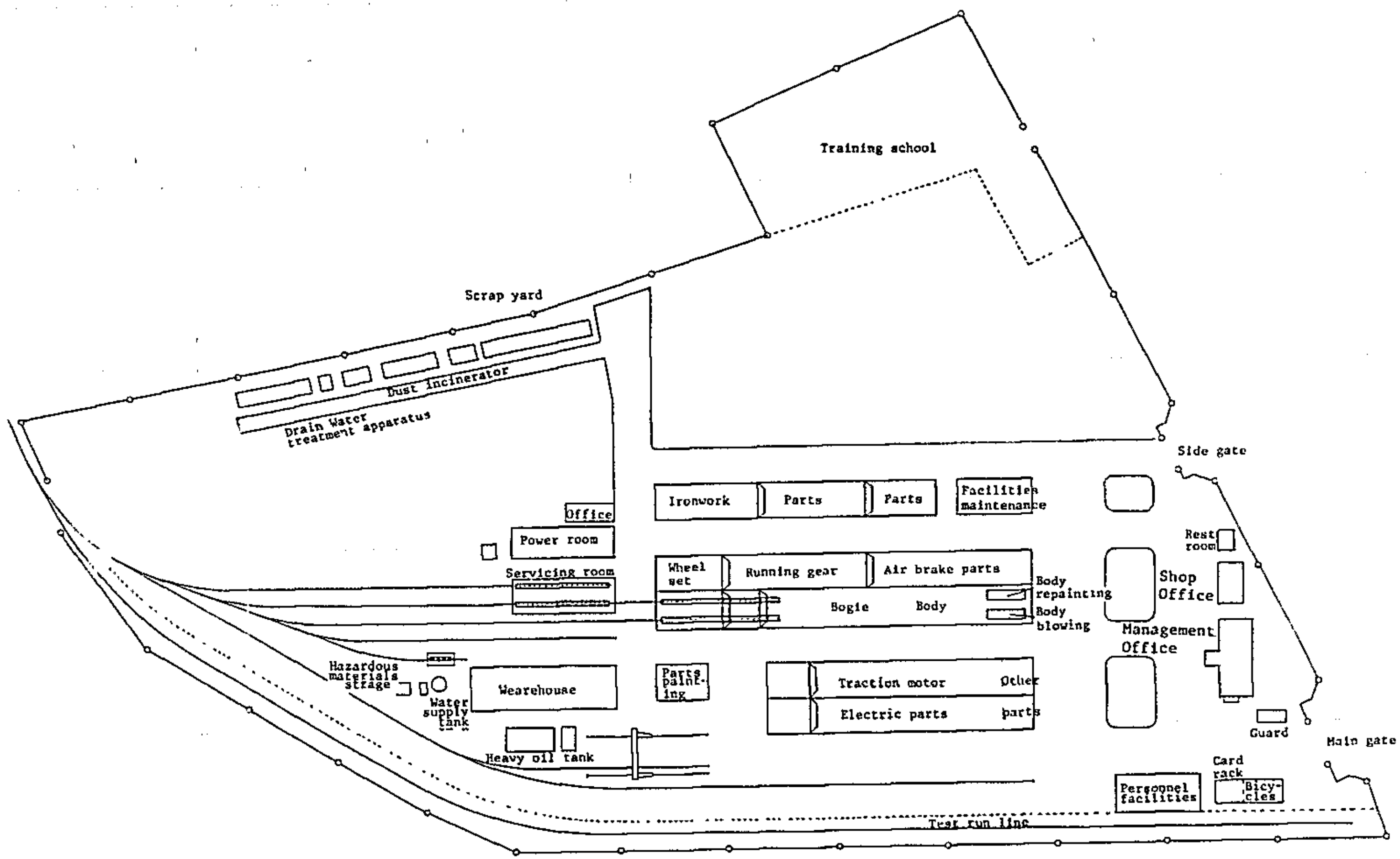
Items	Yogyakarta Shop Improvement		New Workshop Construction		Semarang Workshop Improvement	
	Quantity	Construction Cost	Quantity	Construction Cost	Quantity	Construction Cost
1. Land purchase	-	-	m^2 33,300	306	-	-
2. Land levelling	-	-	m^3 embankment 35,000	470	m^3 embankment 77,000	1,046
3. Track	m 2,430	583	m 3,000	738	m 2,400	704
4. Building	m^2 12,861	4,049	m^2 15,484	5,382	m^3 15,484	6,004
5. Mechanical equipment	Sets 167	18,927	Sets 266	21,670	Sets 266	21,670
6. Electrical equipment	-	1,196	-	806	-	806
7. Other equipment	-	405	-	1,451	-	1,202
Total	-	25.160	-	30,823	-	31,432

Note: 1. The land for the new workshop was estimated with 2/3 acquired without cost and 1/3 with cost.

2. The land leveling cost of the Semarang Workshop was estimated with 1m embanking for 74,000 m^2 of the present shop land of 120,000 m^2 and 1 m embanking for 420 m of the shop-in & -out line.



Appenix 9.1.1 New Workshop Construction Plan Diagram



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Appendix 9.1.2 Semarang Workshop Improvement Plan Diagram