4-10 Transport Capability and Critical Traffic

4-10-1 Setting Transport Capability

(1) Set of track capacity of passenger and freight trains

Track capacity of each link (both in "With the Project" and "Without the Project") was set assuming the ratio of passenger and freight trains at 9:1.

(2) Setting transport capability

Transport capability of each link was calculated by multiplying the number of trains set above by the average train capacity shown below:

a. Average number of passengers: 569 passengers/train

b. Average tonnage:

(a) Bekasi - Cirebon Section : 500 tons/train
(b) Cikampek - Bandung Section: 300 tons/train
(c) Other Section : 300 or 500 tons/train

4-10-2 Calculation of Critical Traffic

Critical traffic for each link was obtained by comparing link traffic with transport capability mentioned above. The procedure is described as follows (see Fig. 4.10.1).

(1) Electrified section

a. Passenger traffic

Critical traffic was obtained for links where the link traffic exceeded transport capability. If two or more such links were found, the adjustment was made starting with the link with the largest transport capability (see Appendix 4-10-2).

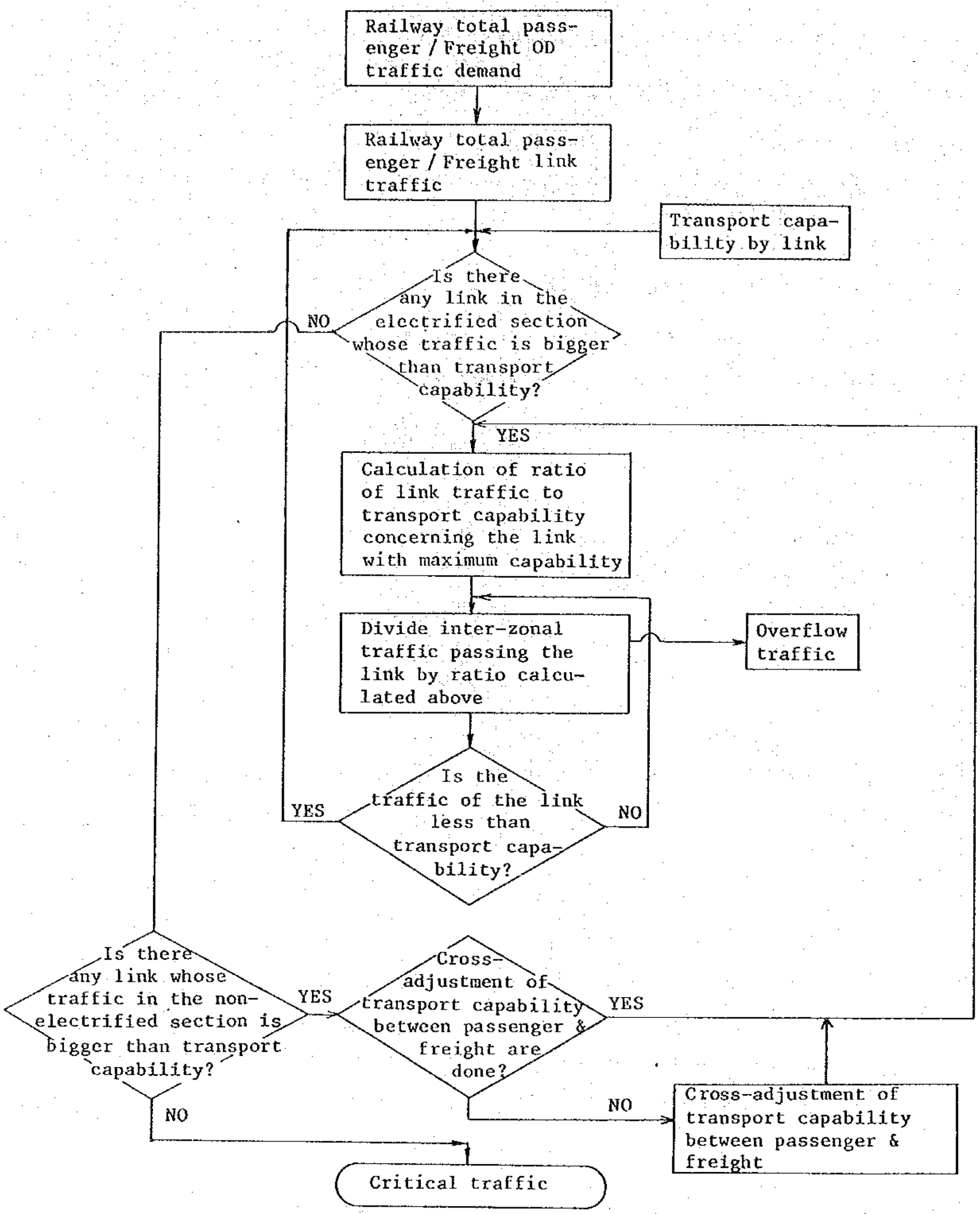


Fig. 4.10.1 Flow Chart of Critical Traffic Calculations

b. Freight traffic

Adjustments of traffic demand were made separately for west-bound and east-bound traffic demand by using the same method.

(2) Non-electrified section

Transport capability was adjusted, for any link where link traffic for either passenger or freight trains exceeded transport capability. For links where total link traffic for both passenger and freight trains exceeded transport capability, adjustments were made by employing the same method as above.

(3) Influence of "Government Regulation" to critical traffic

Even if railway traffic demand would be further increased due to enforcement of "Government Regulation" of the axle load capacity of road, railway critical traffic will not increase because transport capability has already been saturated.

4-10-3 Result of Critical Traffic

(1) Total critical traffic

The total critical traffic of railway is shown in Tables 4.9.1, 4.9.3.

a. Passenger traffic volume

Although total critical traffic will increase each year, railway's share will decrease to a certain extent. In "Without the Project", the share will decrease from 5.9% in 1992 to 4.2% in 2007 for express trains, and from 2.0% to 1.8% for local trains. In "With the Project" case, the share will decrease from 7.7% in 1992 to 5.3% in 2007 for express trains, and from 2.9% to 2.5%

for local trains. The share for express trains will decrease at a faster rate because traffic demand for express trains exceed the transport capability to a greater extent.

Due to the limited transport capability, the rate of increase in rail traffic volume that will be drawn from other modes will decline each year.

b. Freight traffic volume

A similar trend can be observed in freight traffic. Although total traffic is expected to increase each year, railway's share will decrease from 4.4% in 1992 to 2.9% in 2007 in "Without the Project", and from 5.5% to 3.4% in "With the Project". The decrease is thus larger in "With the Project". The rate of increase in railway traffic volume that will be drawn from other modes will decrease after 1997, for the adjustment between passenger and freight traffic was made by giving priority to the former.

(2) Link traffic after adjustment

Link traffic after adjustment for each link is shown in Tables 4.9.2, 4.9.4 and Figs. 4.10.2 - 7.

(3) Inter-zonal traffic

Adjusted inter-zonal traffic is shown in Appendix 4-10-2 and 4-10-3.

4-10-4 Measures to Increase the Critical Traffic Capability

According to the demand forecast, there is a potentially increasing traffic demand for the railway. Nevertheless the railway, even after the completion of the modernization and electrification, will not have enough capability to handle them. Therefore, it is highly recommended that some measures to improve railway capability, such as track addition, will be taken to satisfy the future requirements.

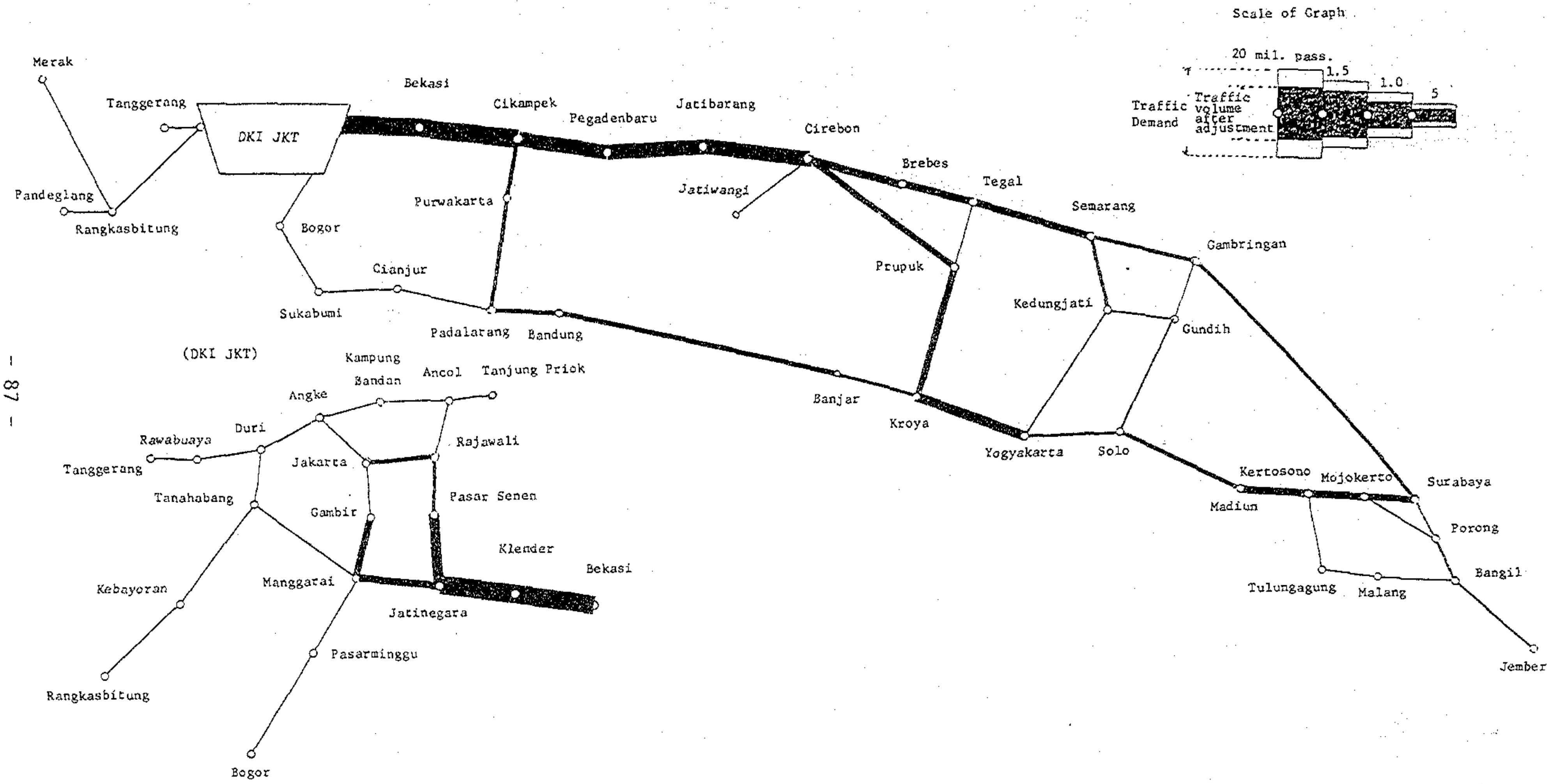


Fig. 4.10.2 Railway Link Traffic of Passengers (1983: One Way)

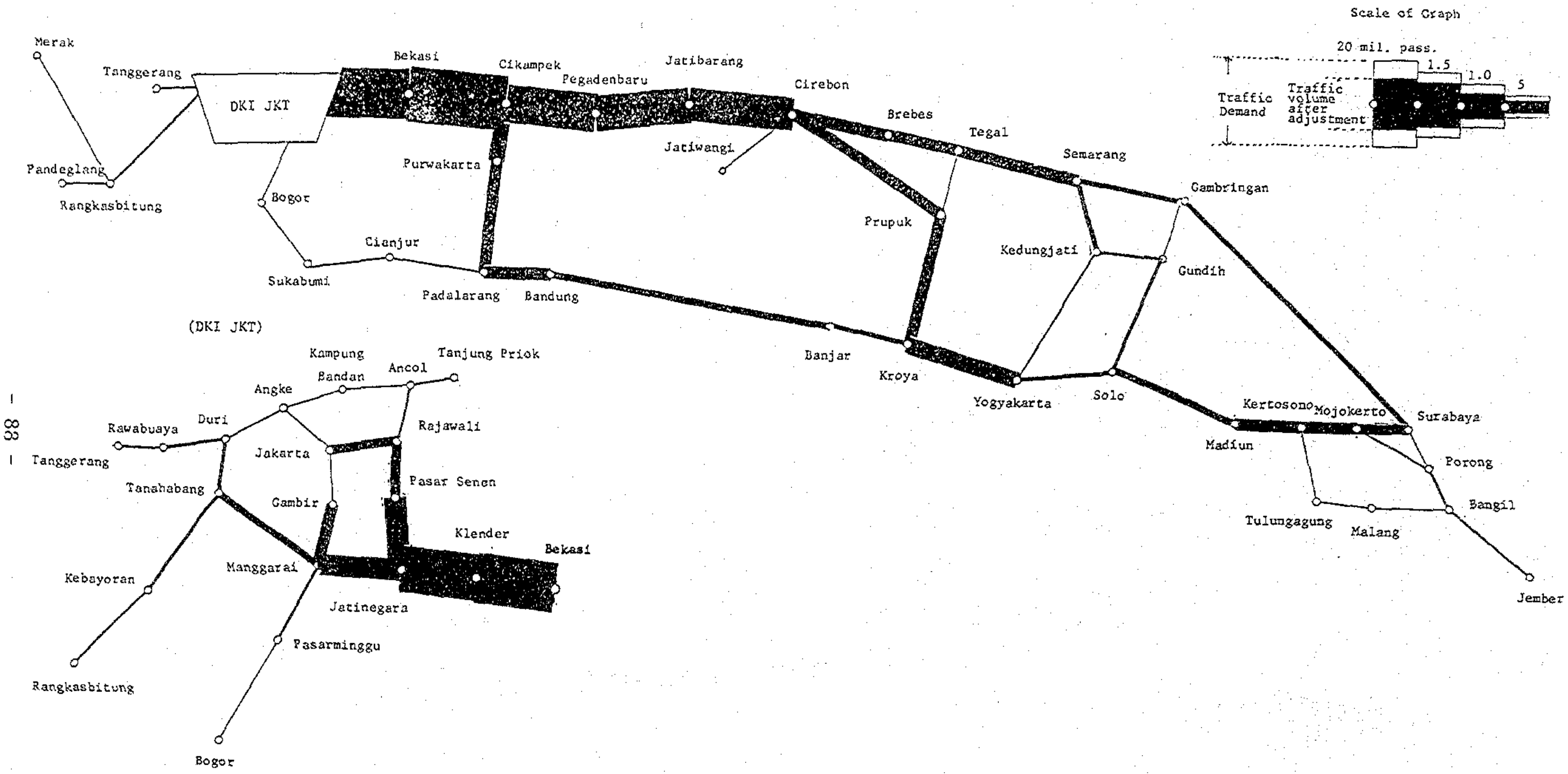


Fig. 4.10.3 Railway Link Traffic of Passengers in "With the Project" Case (1992: One Way)

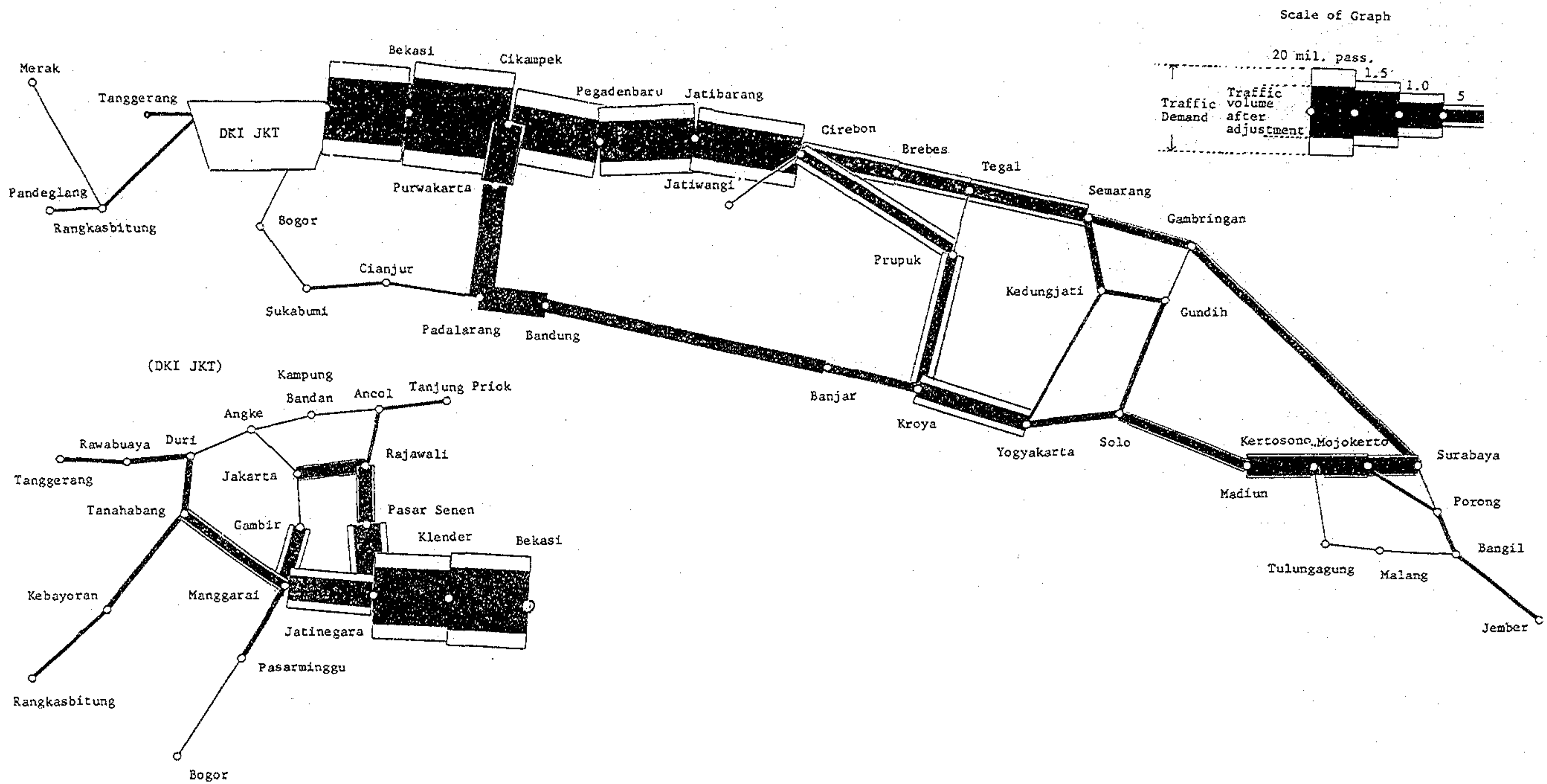


Fig. 4.10.4 Railway Link Traffic of Passengers in "With the Project" Case (2007: One Way)

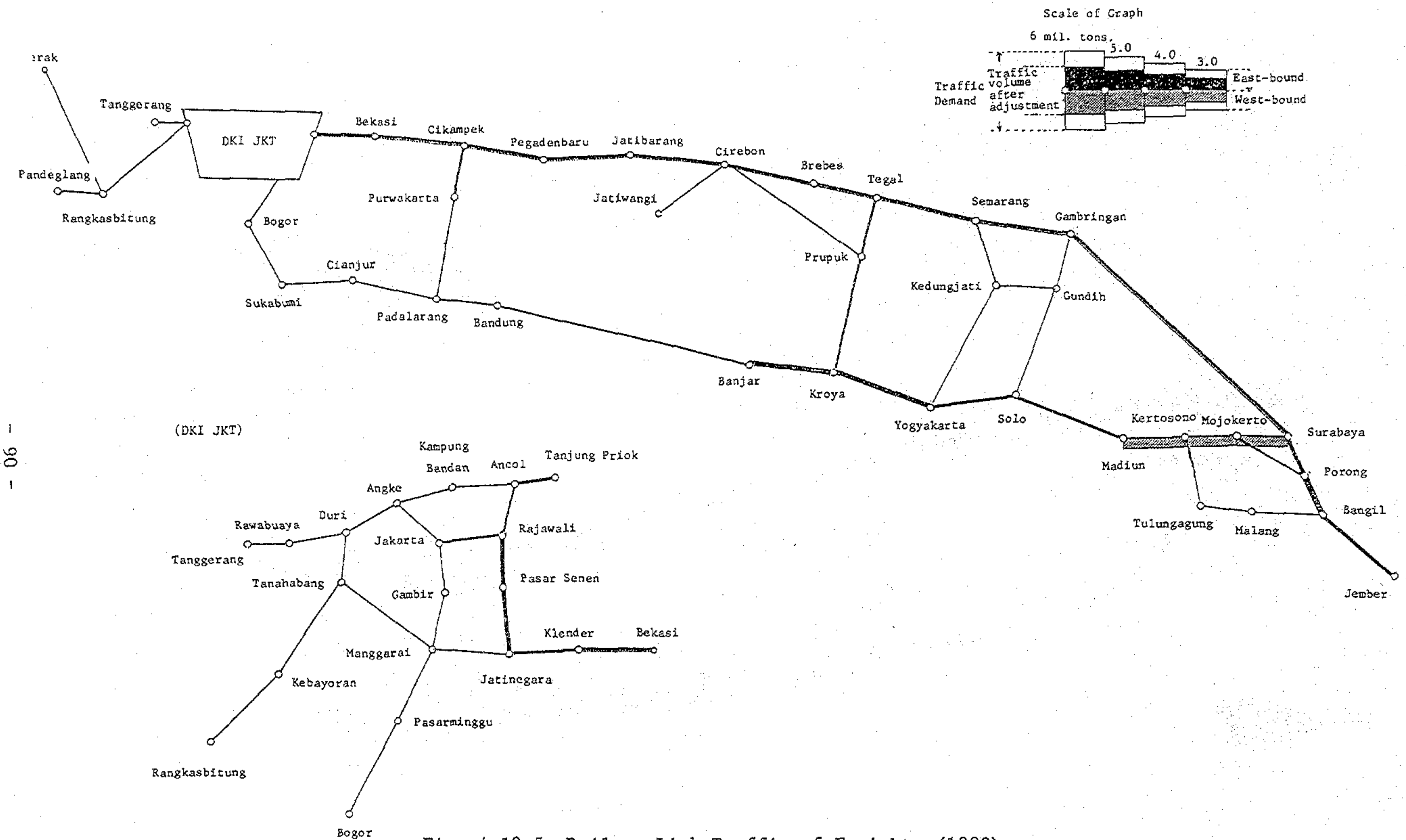


Fig. 4.10.5 Railway Link Traffic of Freights (1983)

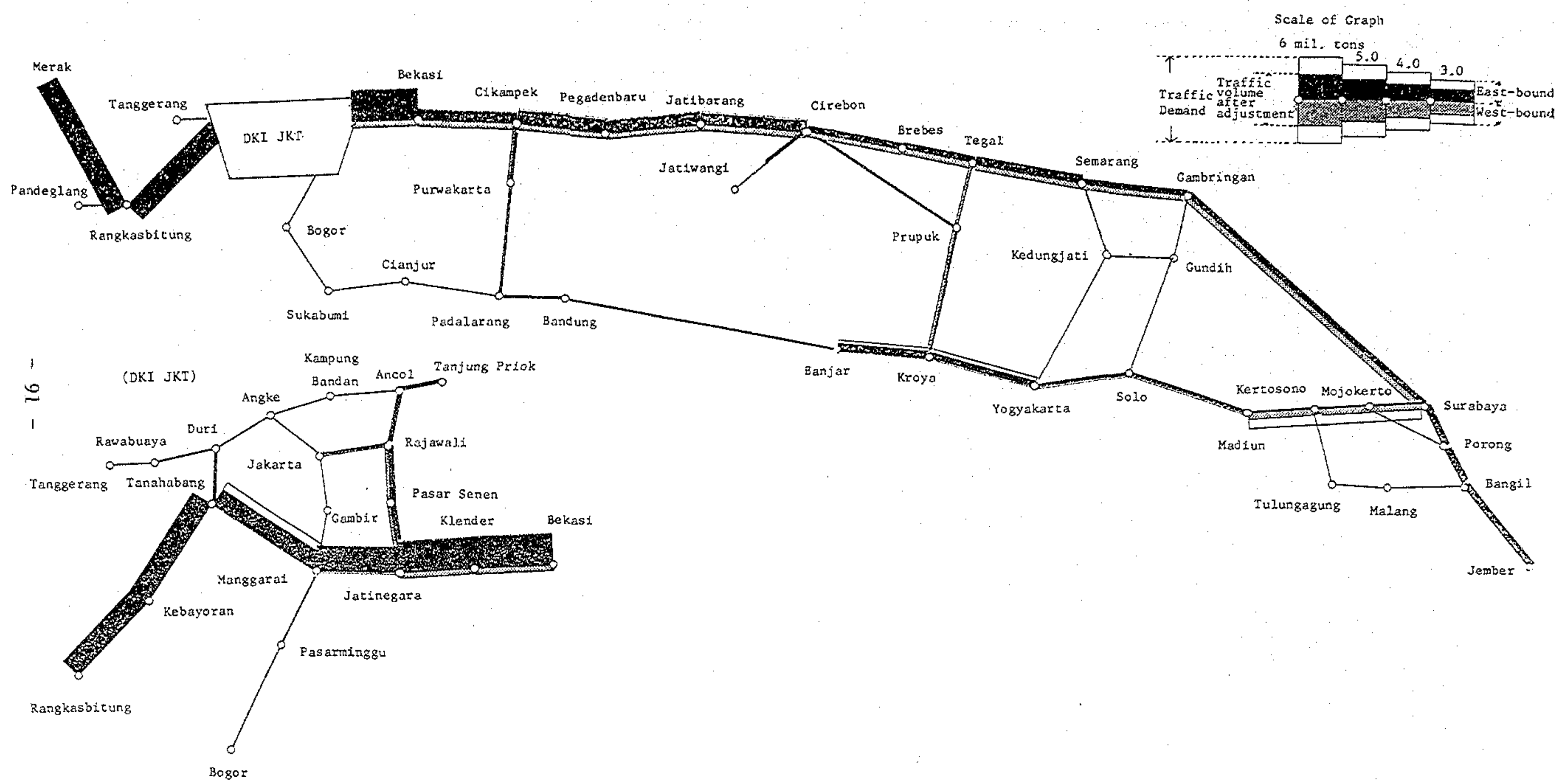


Fig. 4.10.6 Railway Link Traffic of Freights in "With the Project" Case (1992)

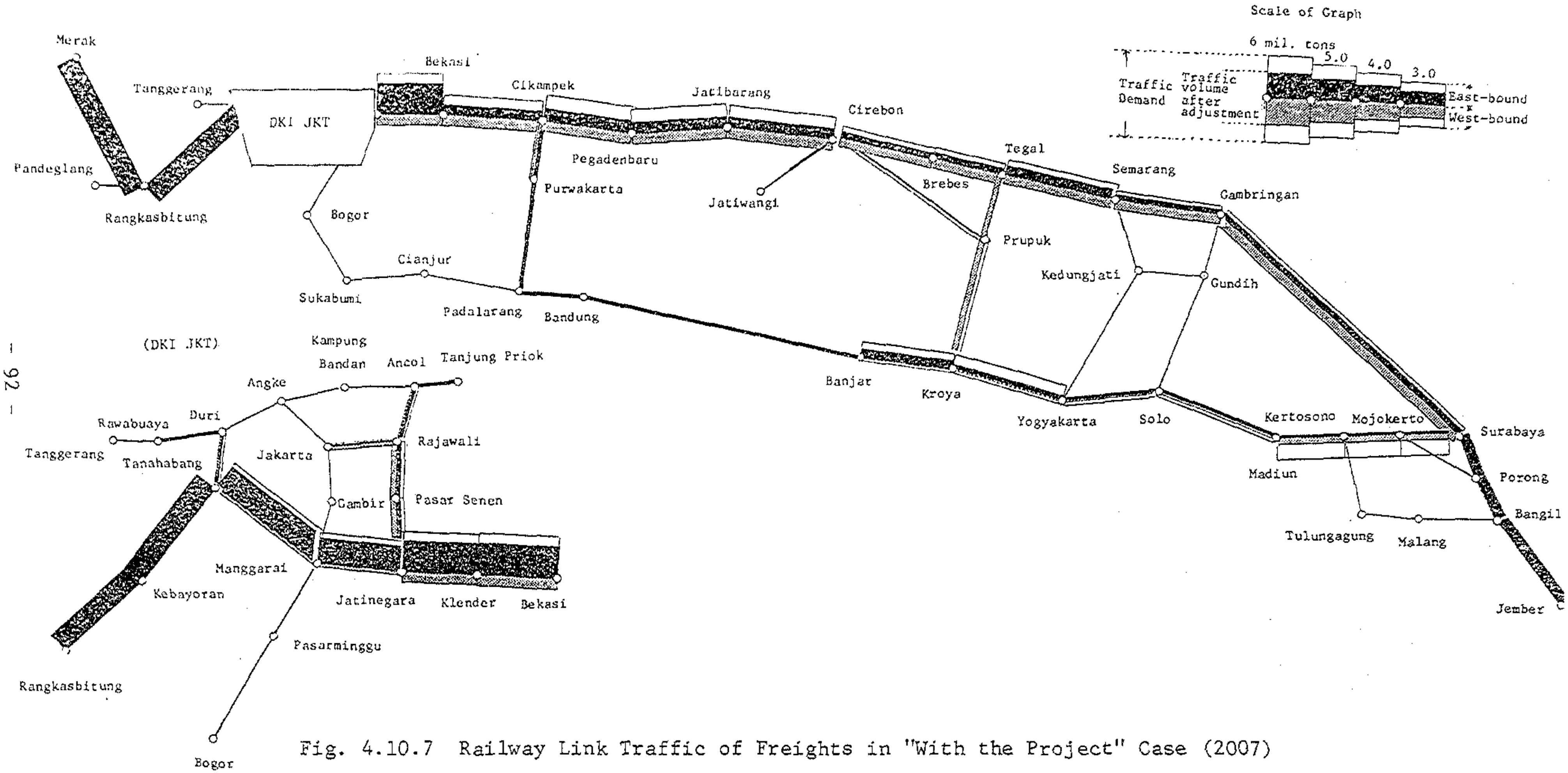


Fig. 4.10.7 Railway Link Traffic of Freights in "With the Project" Case (2007)

CHAPTER 5 RAILWAY TRACTION SYSTEM

CHAPTER 5 RAILWAY TRACTION SYSTEM

5-1 Introduction

The JABOTABEK lines have D.C. electrification and the present JABOTABEK project plans to extend it for commuter service. The starting of the main line electrification by 50 Hz single phase A.C. system requires careful study on possible interfaces of the two systems including complete conversion of the system in the JABOTABEK lines.

5-2 Definition of Alternatives

Two principles were followed in setting up the alternatives. First, the broadest possible range of alternatives was sought; and second, each alternative was intended to seek the best performance under certain limitations.

As a result, eight alternatives were selected for study on train operation in JABOTABEK lines and in the Section and further main lines in the Java island including the Merak line.

They are summarized in Table 5.2.1.

Table 5.2.1 Alternatives of Traction System

Alternative No.	JABOTABEK lines	AC electrified section
1	←— DL —→	←— EL(AC) —→
2	←— EL(DC) —→	←— EL(AC) —→
3	←—— DL ——→	
4	←—— EL(AC/DC) ——→	
5	←—— EC(AC/DC), EL(AC/DC) ——→	
6	←— DL —→	←— EC(AC), EL(AC) —→
7	(Manggarai - Bekasi) ←—— EL(AC) ——→	
8	(All lines) ←—— EL(AC) ——→	

Legend: DL : Diesel Locomotive
EL : Electric Locomotive
EC : Electric MU car
AC : Alternating Current
DC : Direct Current
AC/DC : Dual Current

Each alternative is defined more in detail as follows:

In Alternatives 1 - 7, it is assumed that the JABOTABEK lines will be further DC electrified as planned.

(1) Alternative 1 (DL-EL(AC))

Long and medium distance trains which start from and terminate in the JABOTABEK lines will change locomotives from diesels to AC or vice versa at a station located at the boundary of the two electrification systems. The stations are selected at Tambun for the Section and at Cisauk for the Merak line, so that D.C. commuter trains can serve the JABOTABEK area to a maximum extent.

(2) Alternative 2 (EL(DC)-EL(AC))

D.C. electric locomotives will haul the trains instead of diesel locomotives in the alternative 1 in the JABOTABEK lines. Other conditions are the same as the alternative 1.

(3) Alternative 3 (DL)

Diesel locomotives will haul the trains in the Section without electrification and the JABOTABEK lines under D.C. wire. This is the "Without the Project" alternative treated in this Feasibility Study and, therefore, is excluded from the comparison.

(4) Alternative 4 (EL(AC/DC))

AC/DC dual-current locomotives will haul the trains under D.C. wire in the JABOTABEK lines and under A.C. wire outside the JABOTABEK area. Neutral section which separate A.C. and D.C. systems will be installed. The locations are selected on the track between Bekasi and Tumbun for the Section and between Serpong and Cisauk for the Merak line.

(5) Alternative 5 (EC(AC/DC), EL(AC/DC))

AC/DC dual-current EMU super express trains will be in shuttle service between JABOTABEK and Bandung/Cirebon, and other trains will be hauled by AC/DC dual current locomotives. The fixed installations requirements are the same as the alternative 4.

(6) Alternative 6 (DL-EC(AC), EL(AC))

This alternative is the same as the alternative 1 except AC mono-current EMU trains will replace the super expresses in shuttle service between JABOTABEK and Cirebon/Bandung which are hauled by AC electric locomotives.

(7) Alternative 7 (Addition of double tracks: EL(AC))

AC electrification will be completed over the new double tracks between Bekasi and Manggarai at the same time with the electrification of the Section. The existing double tracks will be D.C. electrified as planned, and the new double tracks will be exclusively used for long and medium distance trains hauled by mono-current locomotives. All of these passenger trains will start and terminate at Manggarai. Freight trains will be hauled by diesel locomotives between Tanjungpriok-gudang and Jatinegara via the Eastern line, changing locomotives at Jatinegara.

(8) Alternative 8 (EL(AC))

D.C. electrification system will be converted to A.C. in the whole JABOTABEK area at the same time with the electrification of the Section to unify the system. AC mono-current electric locomotives and EMUs will be used in the main lines and JABOTABEK lines, respectively.

5-3 Methodology of Comparison

5-3-1 Comparison of Expenditure

Assumptions are set as:

(1) All alternatives have the same revenue, and they are compared in terms of expenditures.

(2) All alternatives will start in 1992 (when electrified railway will be completed), and expenditures compared consist of investment, operation and maintenance expenditures, except common

expenses, in the subsequent 10-year period.
The residual values of the ground facilities and rolling stock after the period are counted as negative investment.

(3) All expenditures are compared in terms of net present values (NPV) at 1992 using annual discount rate of 15%.

(4) The additional ground facilities and rolling stock of the JABOTABEK Lines are based on the "Final Report on Review of F/S".

(5) The electrification of the Merak Line will be completed in 1997.

(Refer to the Appendix 5-3-1 for details).

5-3-2 Other Factors

Other factors which are not included in the comparison, but may influence the decision are discussed.

5-4 Evaluation

5-4-1 Expenditure Comparison

Estimate of investment and operation and maintenance expenditures is as follows:

NPV at 1992 (discount rate: 15%)

Alternative	1	324,818 x 10^6 Rp.
	2	324,455
	4	317,367
	5	336,666
	6	344,779
	7	353,904
	8	364,728

The result shows that the alternative 4 is the most profitable.

Explanation of analysis results:

(1) Although the alternative 1 may save investment for additional locomotives for the JABOTABEK lines, the fixed facilities to

change locomotives at the AC-DC junction will be required. In addition, a diesel locomotive requires higher maintenance and fuel costs than an electric locomotive.

(2) The alternative 2 will become advantageous in terms of maintenance and fuel costs of locomotives in JABOTABEK lines.

(3) The alternative 4 eliminates the need for changing locomotives, so investment for the fixed facilities will be the lowest. However, unit price of locomotive will be the highest.

(4) In alternative 5, the EMU train is less advantageous in terms of investment and maintenance, although its performance is better than electric locomotive.

(5) The alternative 6 has the same disadvantages as those described in the alternative 1.

(6) Investment of the Alternative 7 is the highest, because it requires double tracking between Bekasi and Manggarai.

(7) Alternative 8 requires the highest expenditure, because investment for conversion of JABOTABEK electrification system is enormous.

5-4-2 Other Factors

(1) Increase in travelling time for changing locomotives (Alternative 1, 2, 6)

These alternatives require an extra 5 minutes or more for changing locomotives at Tambun, and Cisauk. Furthermore, these alternatives require additional personnel for this purpose.

(2) Access to the Manggarai station (Alternative 7)

Alternative 7 requires new access road to the Manggarai station to satisfy the passengers' needs.

(3) Difficulties in conversion of the JABOTABEK electrification system from DC to AC (Alternative 8)

a Ground facilities

Existing ground facilities must be converted from DC to AC while keeping up train operation. In particular, replacement of insulators and modification of circuit configuration must be conducted either by making good use of time intervals of train operation or in the night time (when no train operates). As a consequence, the conversion will take a long period, and may cause frequent risk of train operation obstruction.

b. Rolling stock remodeling

Remodeling of EC (260 cars) will take at least 3 years. Therefore, it is necessary to convert them from DC mono-current to AC/DC dual-current type to enable their use in the conversion period.

5-5 Conclusion

Alternative 4 requires the least expenditure and do not accompany problems such as additional time for changing locomotives at DC-AC junction, and conversion of JABOTABEK electrification system.

Therefore, alternative 4 which uses AC/DC dual current locomotive is adopted.

CHAPTER 6 TRANSPORTATION PLAN

CHAPTER 6 TRANSPORTATION PLAN

6-1 Premises

(1) Traction system

In principle, an electric-locomotive-hauled train system will be adopted to utilize the existing stock of passenger cars.

(2) Passenger train type

Four types of passenger train: Super express, express, fast, and local will be operated.

(3) Passenger train composition

Long-distance trains will be operated at a ratio of 1 (super express): 3 (express). Intermediate-distance trains, excluding local trains, will be operated at a ratio of 2 (express): 1 (fast).

(4) Passenger train make-up and class

Locomotive-hauled trains will be of 10-car and 6-car make-up. Half-size dining car and a baggage car will be coupled to the super express train, and a half-size dining car to the express train.

According to the demand forecast, 20% of the passengers on the super express, express and fast trains will travel by 1st or 2nd class cars, with 80% in 3rd class. Train make-up will be made in accordance with this proportion (see Table 6.1.1).

(5) Load factor

The passenger load factor will be 70% for 1st and 2nd class cars, and 80% for 3rd class cars. The freight load factor will be 70%.

(6) Number of passengers per train

The number of passengers per train will be determined based on the above train make-up and load factor (see Table 6.1.2).

(7) Train speed

a. The maximum train speed will be 100 km/h for passenger trains and 85 km/h for freight trains.

b. The passing speed on the main track at station yards will be limited to 70 km/h. The speed limit at points will be limited to 35 km/h. The passing speed at a curve of a 200 m radius will be limited to 55 km/h.

(8) Stopping station and time

Each train type will stop at the stations shown in Table 6.1.3. Stopping time will range from 2 to 5 minutes at large stations and from 1 to 2 minutes at small stations.

(9) Effective time zone for train operation

Passenger trains will depart from or arrive at terminal stations between 5 a.m. and 10 p.m.

(10) Trailing load

Trailing load of an electric locomotive will be 400 tons for a passenger train, and 1,000 tons (on Jakarta - Cirebon section) and 600 tons (on Cikampek - Bandung section) for a freight train.

Table 6.1.1 Number of Passenger Cars by Train Type

Type of passenger car	Super express			Express	Fast	Local
	Jakarta - Bandung	Jakarta - Cirebon	Night train			
1st class sleeping car	-	-	2	-	-	-
1st class passenger car	2	3	1	-	-	-
2nd class passenger car	3.5	5.5	5.5	3	3	-
3rd class passenger car	-	-	-	6.5	7	10
Dining car	0.5	0.5	0.5	0.5	-	-
Luggage car	-	1	1	-	-	-
Total	6	10	10	10	10	10

Table 6.1.2 Number of Passengers by Train Type

Train type		Passenger
Super express	Jakarta - Bandung	219
	Jakarta - Cirebon	340
	Night train	318
Express		590
Fast		807
Local		960

Table 6.1.3 Stopping Stations by Passenger Train Type

Train type	Stopping station
Super express	Jakarta, Gambir, Jatinegara, Cirebon, Bandung
Express	Jakarta, Pasarsenen, Gambir, Jatinegara, Manggarai, Cirebon, Bandung
Fast	Jakarta, Gambir, Pasarsenen, Manggarai, Jatinegara, Pegadenbaru, Haurgeulis, Jatibarang, Purwakarta, Padalarang, Bandung, Kiaracondong
Local	Each station in the Section

6-2 Operation Time

Results of the calculation are shown in Table 6.2.1.

Table 6.2.1 Operation Time

1. Jatinegara - Cirebon

Section	Distance (km)	Passenger train (min. : sec.)			Freight train (min. : sec.)
		Super express Express	Fast	Local	
Jatinegara - Bekasi	14,802	14:00	14:00	15:30	21:30
Bekasi - Cikampek	57,455	41:00	41:00	58:00	68:30
Cikampek - Pegadenbaru	40,257	27:30	28:00	41:00	37:30
Pegadenbaru - Jatibarang	54,856	37:30	41:30	52:00	49:30
Jatibarang - Cirebon	40,048	28:00	29:30	40:00	37:00
Total (Jatinegara - Cirebon)	207,418	148:00	154:00	206:30	214:00

2. Cikampek - Bandung

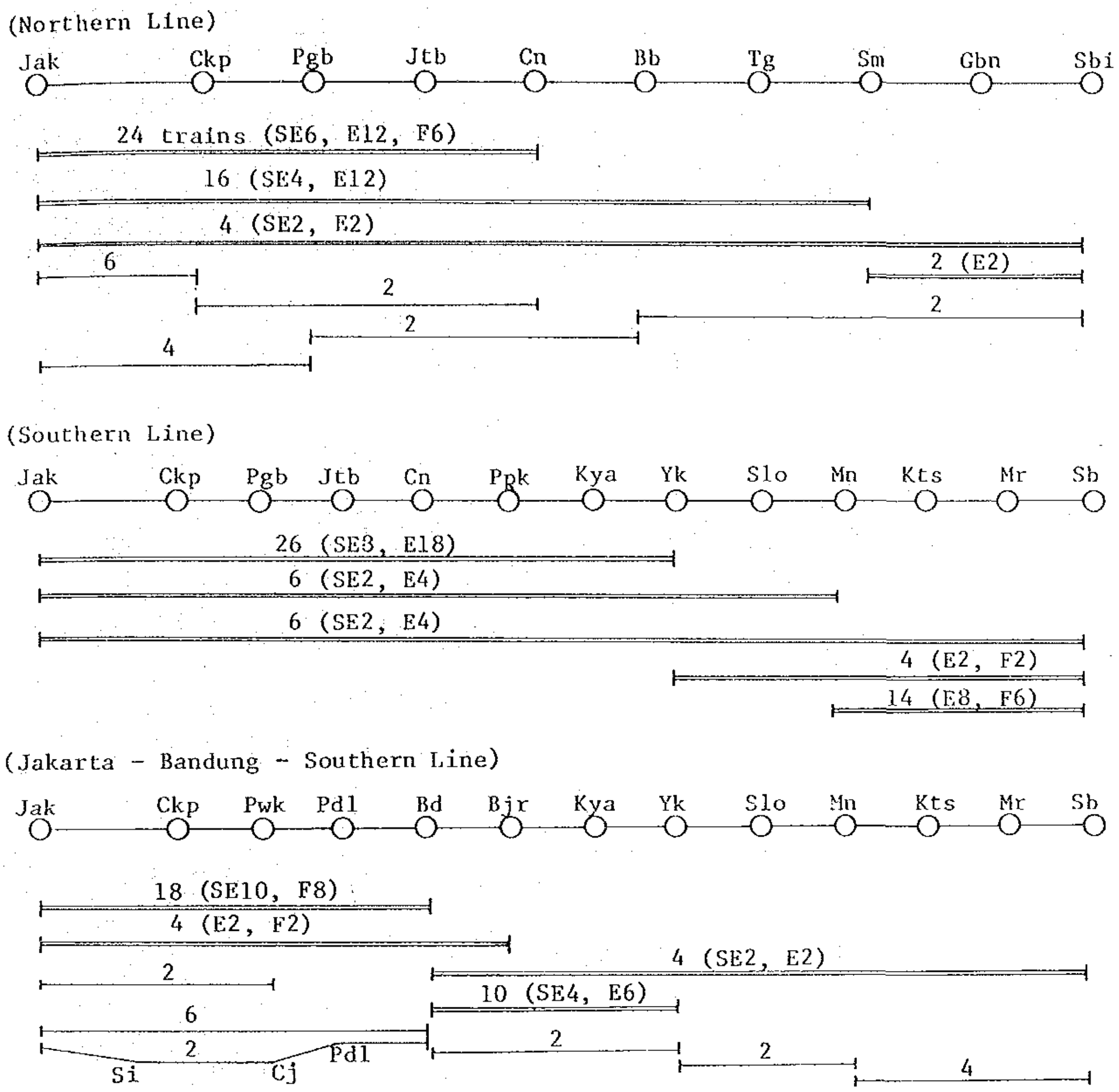
Section	Distance (km)	Passenger train (min. : sec.)			Freight train (min. : sec.)
		Super express Express	Fast	Local	
Cikampek - Purwakarta	19,063	15:30	16:00	24:00	19:30
Purwakarta - Padalarang	56,002	63:00	65:00	85:00	70:00
Padalarang - Bandung	14,662	12:30	14:00	21:00	17:30
Total (Cikampek - Bandung)	89,727	91:00	95:00	130:00	107:00

Note 1. The operation times are for trains bound for Cirebon and Bandung.
2. Super express and express passenger trains will stop at Jatinegara, Cirebon, and Bandung.
3. Local passenger trains will stop at all stations except Jatinegara - Bekasi section.
4. Freight trains will stop at Cipinang, Klender, Bekasi, Tambun, Cikarang, Krawang, Kosambi, Dawuan, Cikampek, Pegadenbaru, Jatibarang, Cirebon, Purwakarta, Sukatani, Plered, Padalarang, Bandunggudang, Bandung and Kiaracondong.
5. The operation time does not include stopping time and train passing time.

6-3 Route and Number of Trains

6-3-1 Train Operation Routes

Train operation routes in 1992 and 2002 are shown in Figs. 6.3.1 - 6.3.4.



Legend: ═══ : Super express train / Express train / Fast train

──── : Local train

SE : Super express train

E : Express train

F : Fast train

Fig. 6.3.1 Passenger Train Operation Routes and No. of Trains (Both directions, in 1992, after electrification)

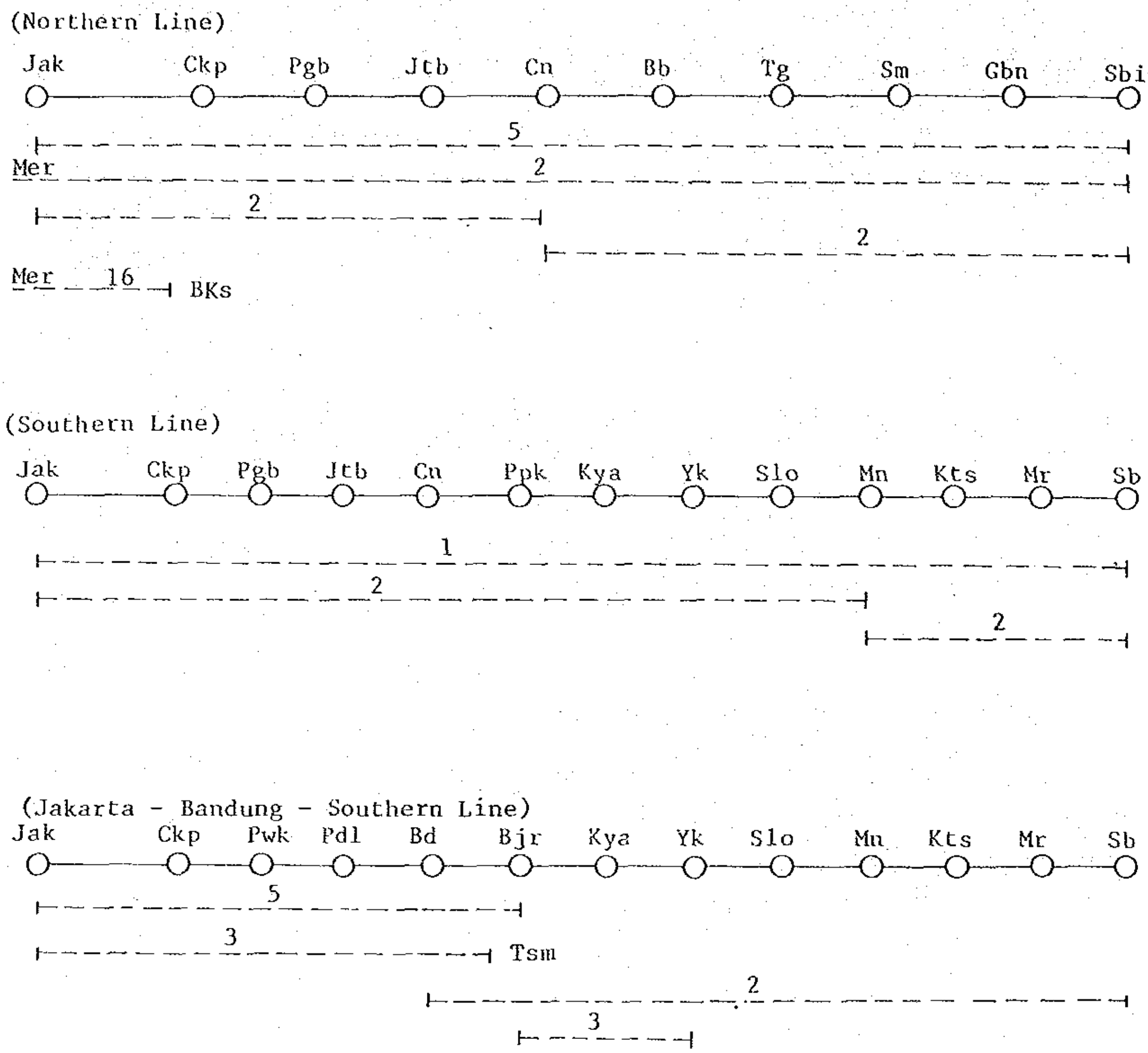
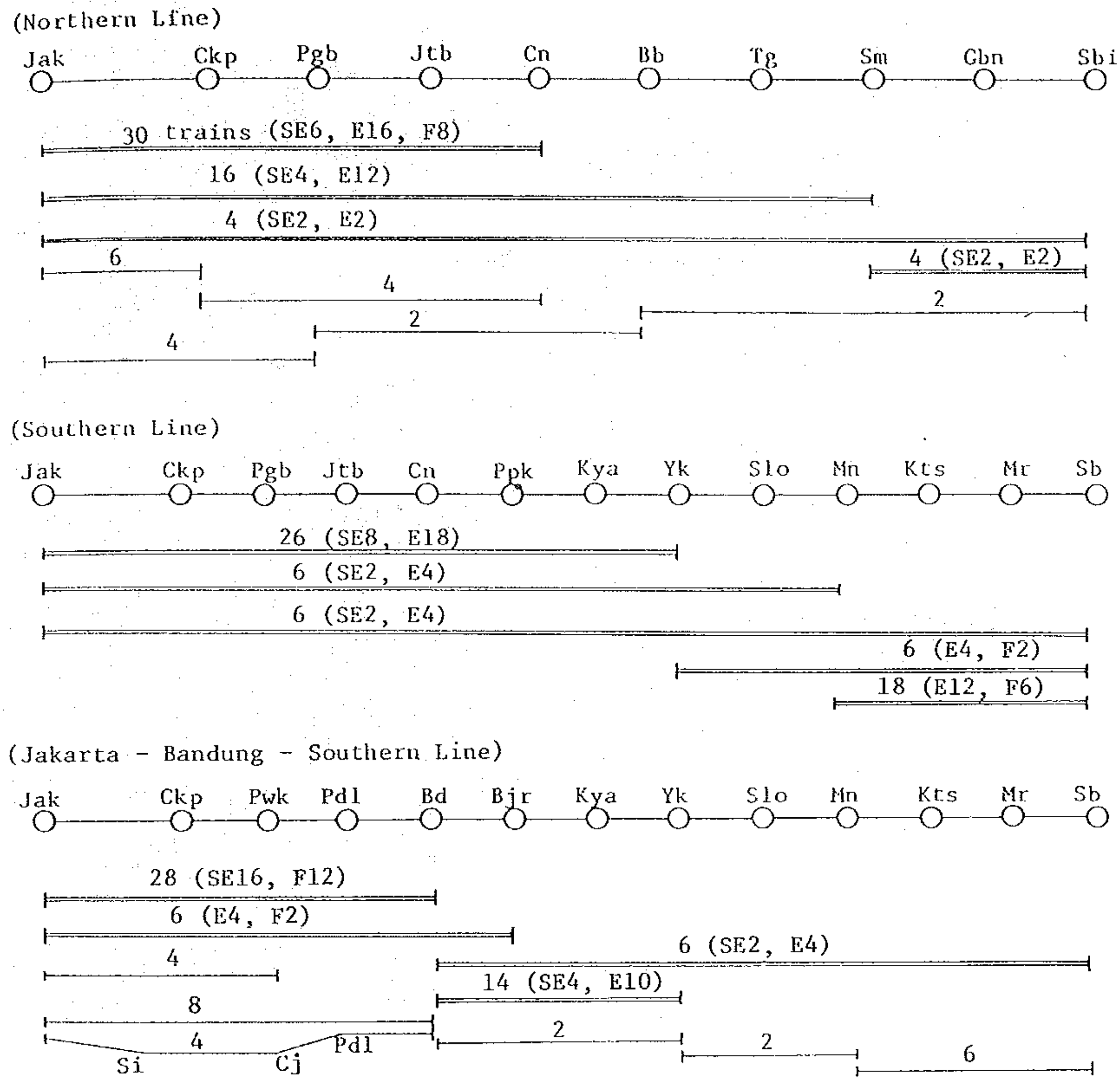


Fig. 6.3.2 Freight Train Operation Routes and No. of Trains
(Both directions, in 1992, after electrification)



Legand: ══ : { Super express train / Express train / Fast train }

—— : Local train

SE : Super express train

E : Express train

F : Fast train

Fig. 6.3.3 Passenger Train Operation Routes and No. of Trains (Both directions, in 2002, after electrification)

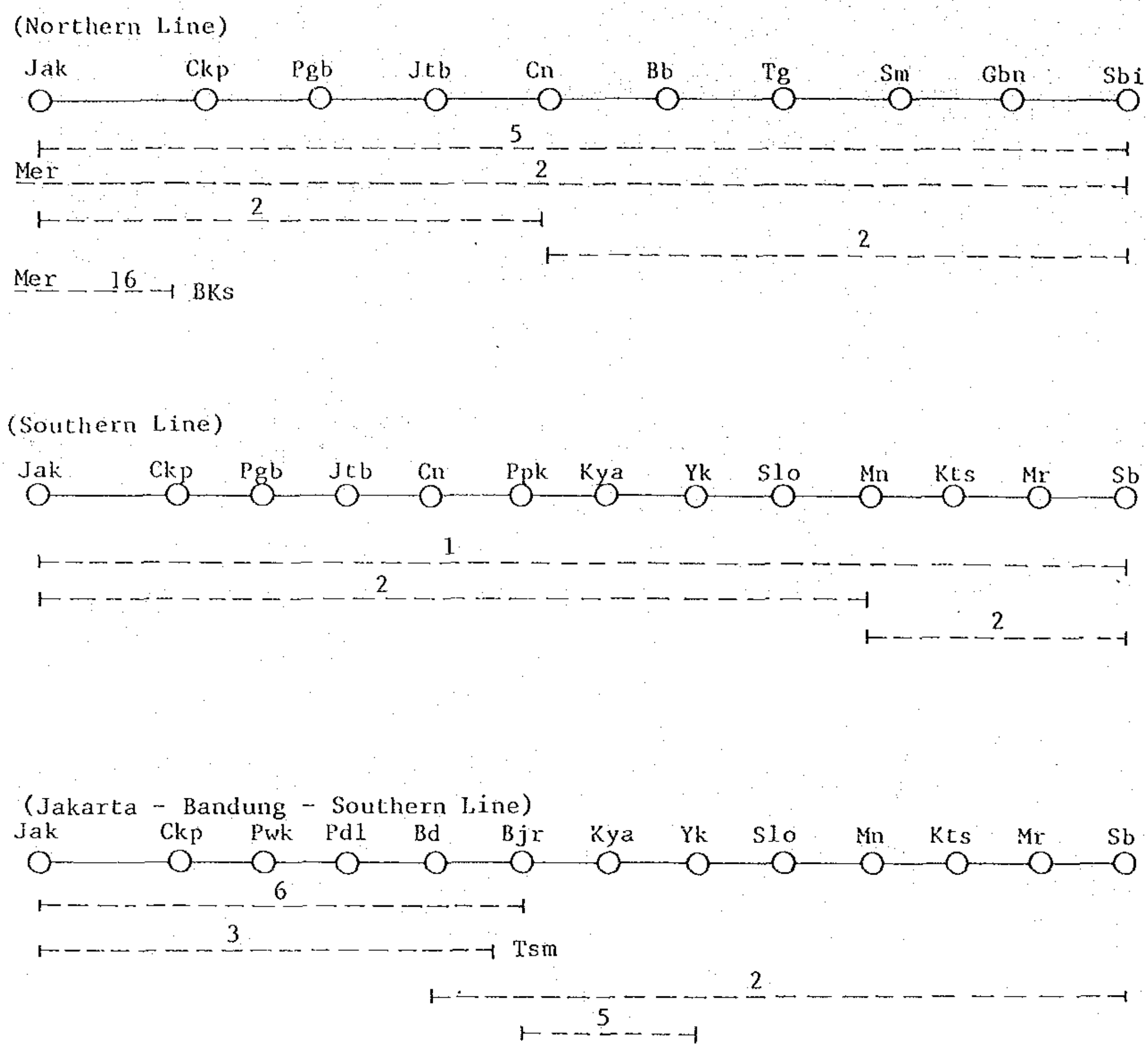


Fig. 6.3.4 Freight Train Operation Routes and No. of Trains
(Both directions, in 2002, after electrification)

6-3-2 Number of Trains

The number of trains in 1992 is shown in Table 6.3.1.

Table 6.3.1 No. of Trains by Section
(1992, both directions)

Train type \ Section		Jakarta - Cikampek	Cikampek - Cirebon	Cikampek - Bandung
Passenger	Super express	34	24	10
	Express	54	52	2
	Fast	16	6	10
	Local	18	6	8
Freight		36	12	8
Total		158	100	38

The number of trains by year is shown in Table 6.3.2.

Table 6.3.2 No. of Trains by Year (Both directions)

Section \ Year	1992	1997	2002	2007
Jakarta - Cikampek	158	172	183	189
Cikampek - Cirebon	100	108	108	110
Cikampek - Bandung	38	46	55	59

6-4 Train Diagram

6-4-1 Planning Concept

Based on the time zone (5 a.m. - 10 p.m.) for passenger trains departing or arriving at terminal stations, train operation time zones in each section are determined as follows:

(1) Between Jakarta and Surabaya, most trains will be operated during the night.

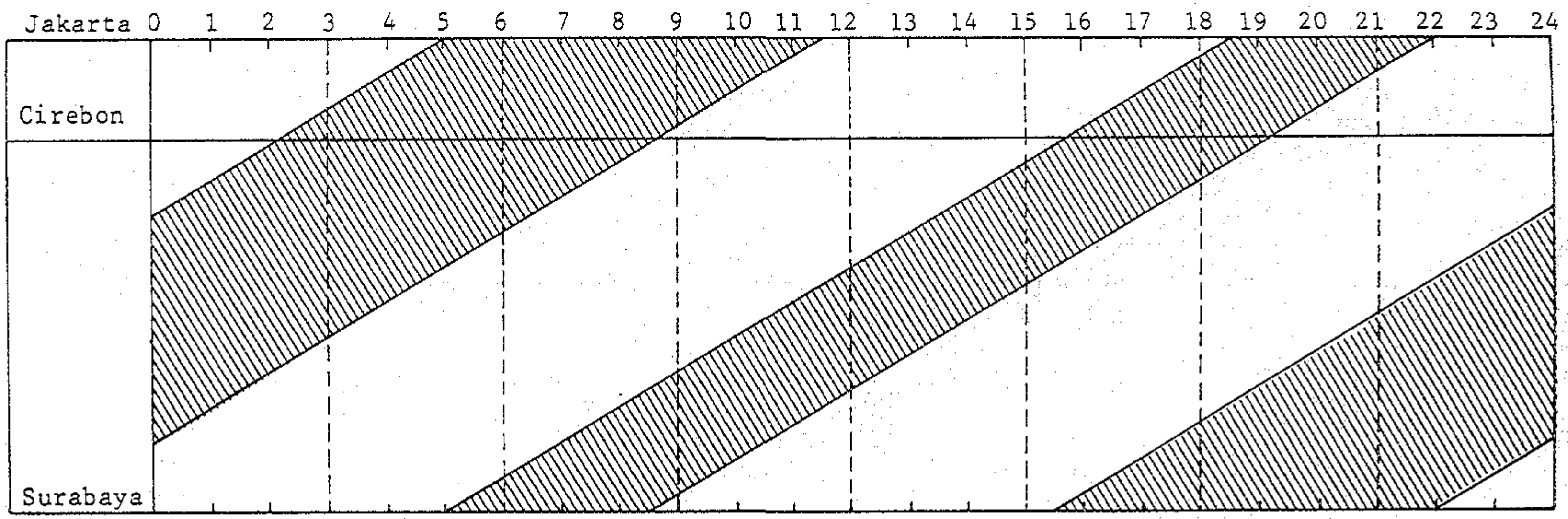
Departure time period of trains during the day time will be limited to 3.5 hours in the early morning (see Fig. 6.4.1).

(2) Between Jakarta and Yogyakarta, and Jakarta and Madiun on the Southern line, night trains will be operated within a 6-hour zone and daytime trains within a 7-hour zone.

(3) Between Jakarta and Semarang, most trains will be operated in the daytime. Night train operation will be limited to a 30-minute zone (see Fig. 6.4.1).

(4) Between Jakarta and Bandung, and Jakarta and Cirebon, all trains will be operated in the daytime.

Based on the above concepts, train operation pattern in the Jakarta - Cirebon section will be as shown in Fig. 6.4.2.



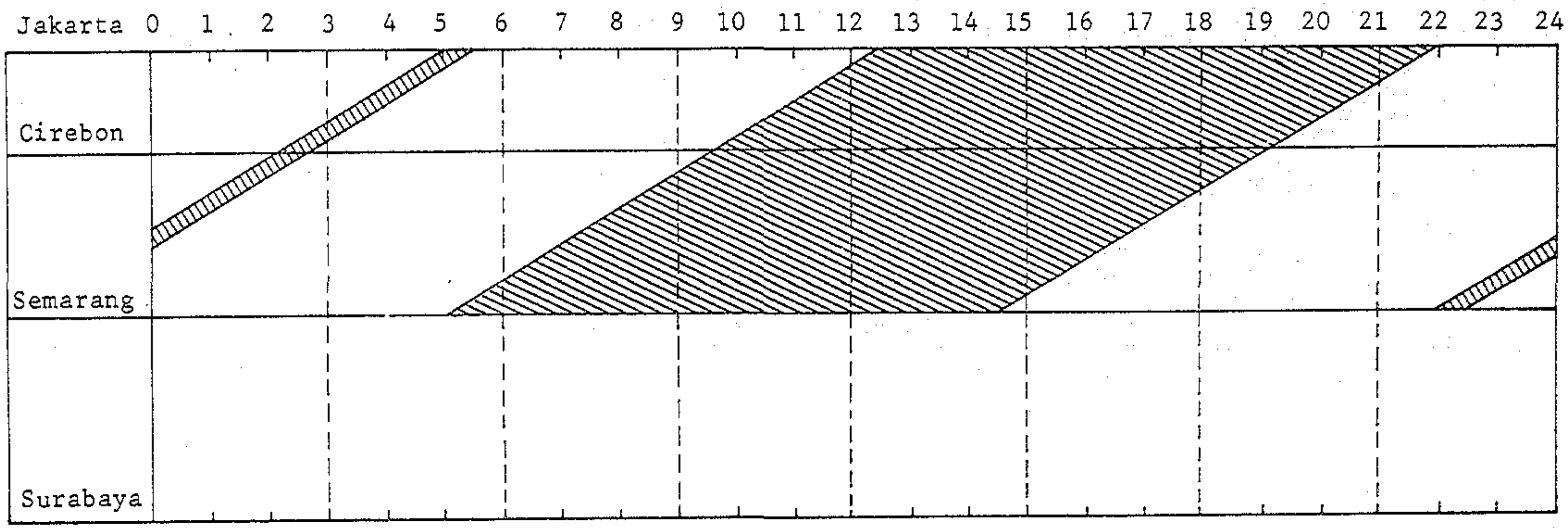
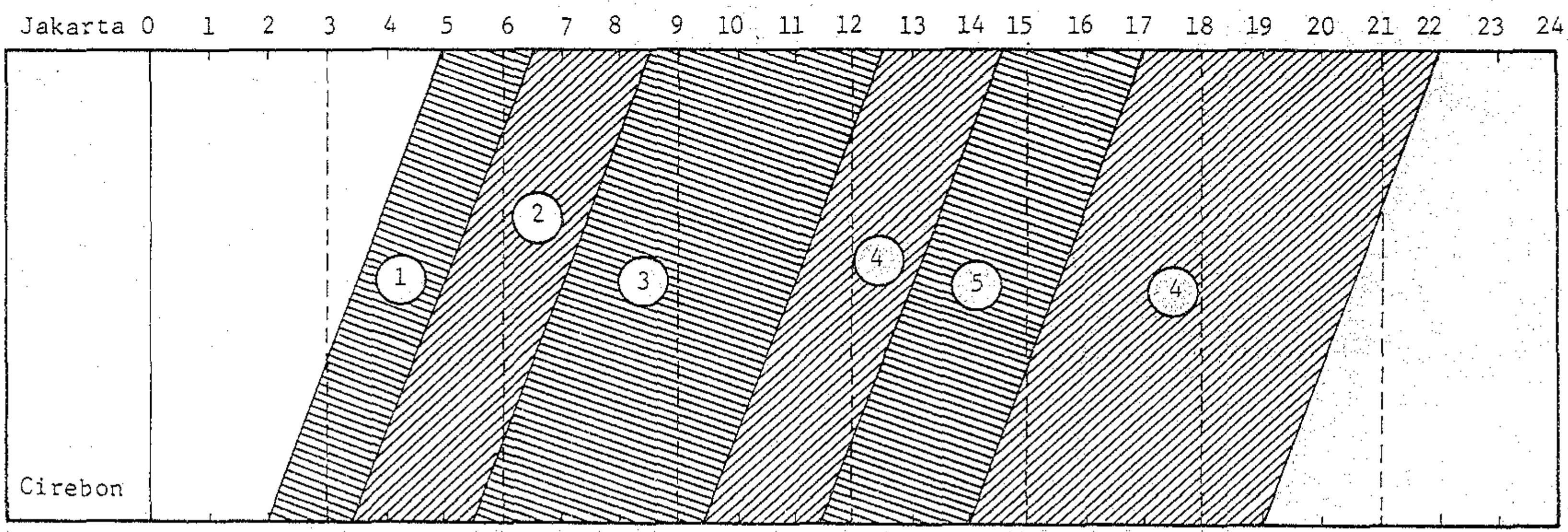


Fig. 6.4.1 Effective Time Zone for Long-Distance Trains Bound for Jakarta

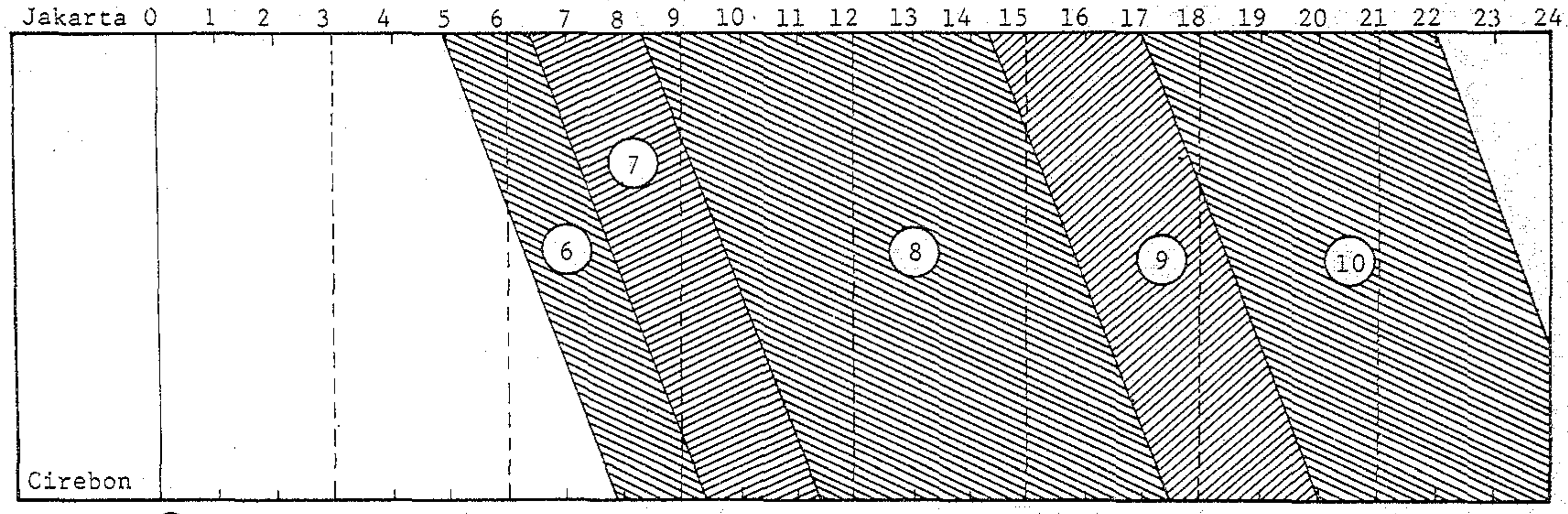
(1) To Jakarta



Note
① Night trains from Surabaya, Yogyakarta, Madiun, and Semarang
② Morning rush hour time in JABOTABEK
③ Night trains from Surabaya and Madiun
④ Daytime trains from Surabaya, Semarang, Yogyakarta, and Madiun
⑤ Evening rush hour time in JABOTABEK

Fig. 6.4.2 (1) Time Zone for Train Operation in the Jakarta - Cirebon Section

(2) From Jakarta



Note ⑥ Daytime trains to Surabaya, Yogyakarta, Madiun, and Semarang
⑦ Morning rush hour time in JABOTABEK
⑧ Daytime trains to Semarang, Yogyakarta, and Madiun
⑨ Evening rush hour time in JABOTABEK
⑩ Night trains to Surabaya, Yogyakarta, and Madiun

Fig. 6.4.2 (2) Time Zone for Train Operation in the Jakarta - Cirebon Section

6-4-2 Train Diagram

(1) Cikampek - Cirebon

Patternised train diagram of the Cikampek - Cirebon section is shown in Fig. 6.4.3. This diagram is based on the number of trains in 1992 shown in Figs. 6.3.1 and 6.3.2.

The train operation headways are 1 hour 30 minutes for super-express, express, and fast passenger trains; and 3 hours for local passenger trains. The stopping stations are shown in Table 6.1.3. The traveling time in the Cikampek - Cirebon section is 1 hour 35 minutes for super-express trains, 1 hour 59 minutes for express trains, 2 hours 14 minutes for fast trains, and 4 hours 17 minutes for local passenger trains.

(2) Cikampek - Bandung

The train diagram of the Cikampek - Bandung section is shown in Fig. 6.4.4. The number of trains is based on that of 1992, in the same way as for the Cikampek - Cirebon section.

The train operation headways are 3 hours 20 minutes for super-express trains and 3 hours for express/fast and local passenger trains. The travelling time in the Cikampek - Bandung section are 1 hour 32 minutes for super-express trains, 1 hour 37 minutes for express trains, 1 hour 42 minutes for fast trains and 2 hours 22 minutes for local passenger trains.

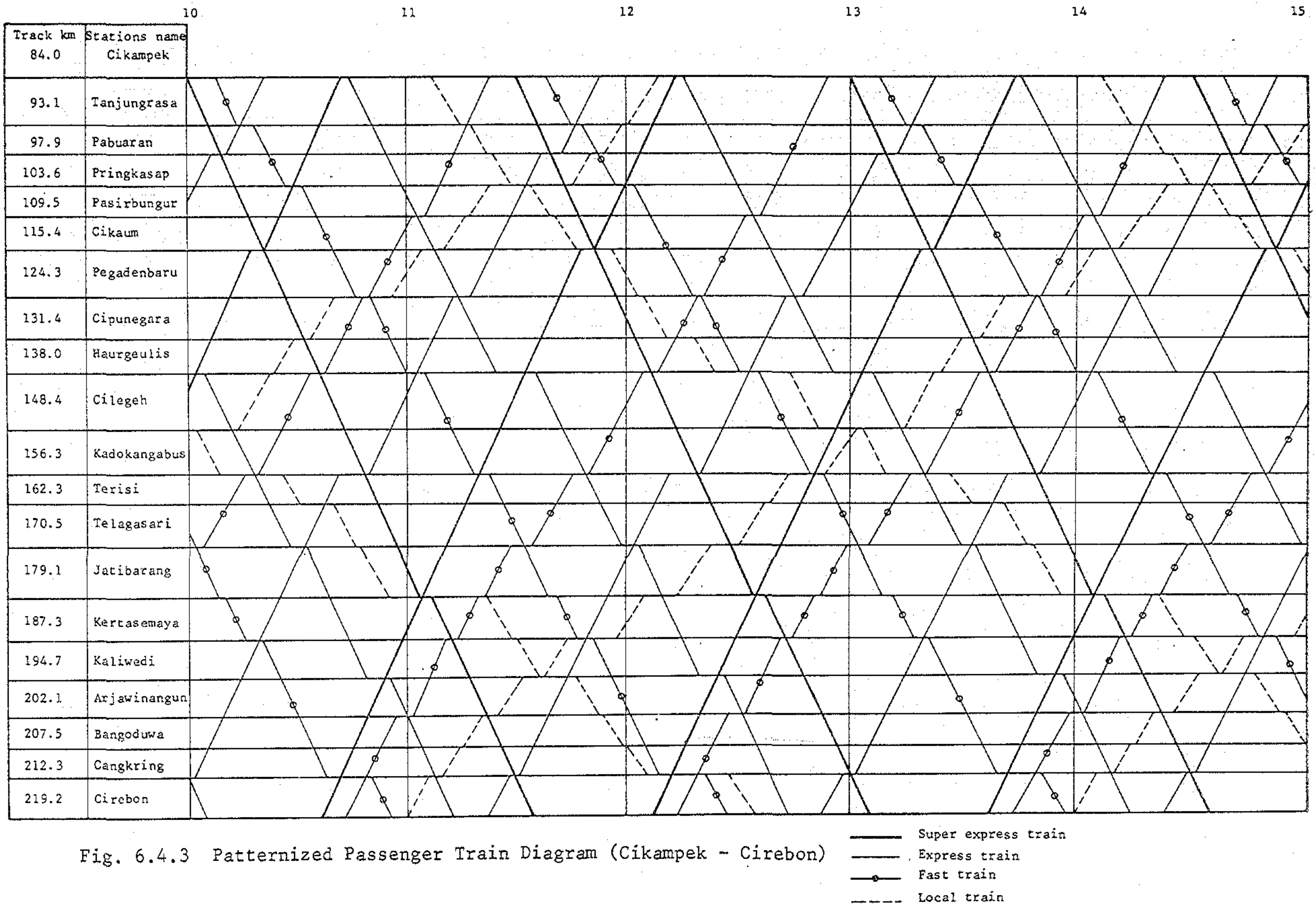


Fig. 6.4.3 Patternized Passenger Train Diagram (Cikampek - Cirebon)

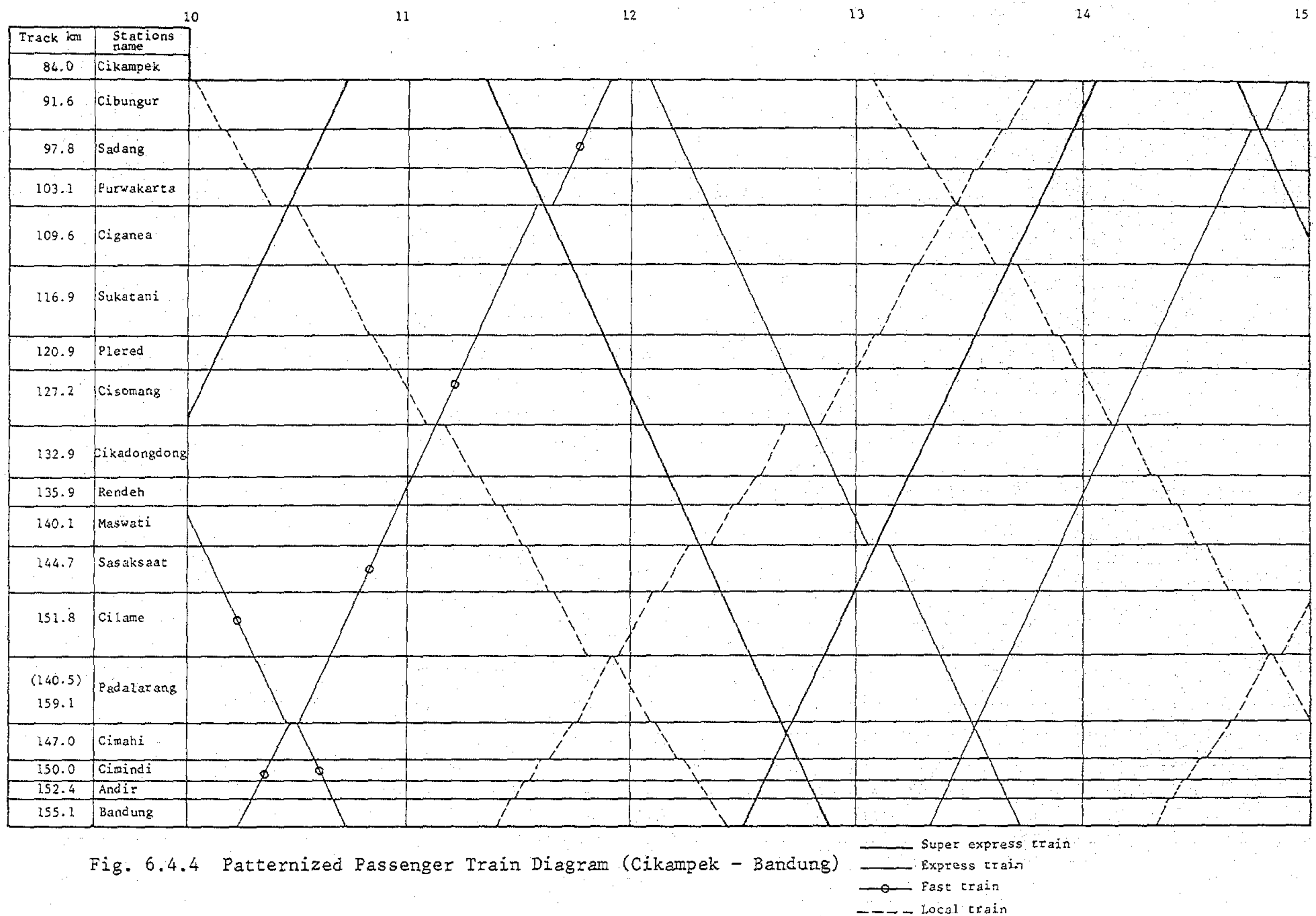


Fig. 6.4.4 Patternized Passenger Train Diagram (Cikampek - Bandung)

6-5 Train Operation on the JABOTABEK Lines

6-5-1 Passenger Terminal Stations for Long- and Intermediate-Distance Trains

Table 6.5.1 shows the number of long- and intermediate-distance train passengers handled at major stations (one direction) on the JABOTABEK lines after electrification in 1992. From this table, four stations (Tanahabang, Jakarta, Pasarsenen and Manggarai) are expected to serve as terminal stations for the long- and intermediate-distance trains.

Tanahabang station serves as a junction to the Merak and Tangerang lines with ample open space available. Manggarai station occupies a key position and acts as a junction to Jakarta and Tanahabang, although it handles a relatively small number of passengers. Pasarsenen station handles large number of passengers, indicating a need for train operation on the Eastern line.

Table 6.5.1 Estimate of Daily Passengers Handled at Major Stations on the JABOTABEK Lines (1992, after electrification, one direction)

Station	Express train	Local train	Total
Tangerang	415	614	1,029
Rawabuaya	196	265	461
Kebayoran	431	201	632
Duri	273	101	374
Tanahabang	454	52	506
Kampungbandan	48	29	77
Jakarta	3,036	109	3,145
Gambir	6,814	1	6,815
Manggarai	1,087	41	1,128
Pasarsenen	6,399	0	6,399
Tanjungpriok	859	4	863
Jatinegara	2,075	0	2,075
Pasarminggu	592	614	1,206
Klender	447	1,087	1,534
Bekasi	2,577	24	2,601
Bogor	46	131	177

6-5-2 Freight Terminal Stations

Table 6.5.2 shows freight tonnage originated from or destined for the JABOTABEK lines in 1992. This table indicates that Jakartagudang and Tanjungpriokgudang are the two major freight stations.

Taking into account the relatively large amount of cargo handled at Rawabuaya, Duri and Tanahabang stations, freight trains will mainly be operated on the Western line.

Table 6.5.2 Estimate of Daily Freight Tonnage Handled at Major Stations on the JABOTABEK Lines (1992, after electrification)

Station name	From JABOTABEK	To JABOTABEK
Tangerang	4	10
Rawabuaya	202	92
Kebayoran	61	29
Duri	110	56
Tanahabang	274	53
Kampungbandon	59	31
Jakartagudang	299	410
Gambir	0	0
Manggarai	87	39
Pasarsenen	3	3
Tanjungpriok-gudang	607	153
Jatinegara	93	104
Pasarminggu	45	43
Klender	110	76
Bekasi	9	49
Bogor	142	11

6-5-3 Passenger Train Operation on the JABOTABEK Lines

Intermediate- and long-distance trains on the JABOTABEK lines will be operated under the following principles:

(1) Operation will be permitted in morning rush hours so long as JABOTABEK train operation is not seriously hindered.

(2) To be operated up to terminal stations specified in 6-5-1: to Jakarta Kota station via the Central line or the Eastern line, and to Tanahabang station via Manggarai. If operation to the terminal stations becomes difficult (due to the increased traffic on the JABOTABEK lines) some rescheduling will be made as follows:

   a. To avoid operation during the rush hours;
   b. to change the train route from the Central line to the Eastern line; and
   c. to originate or destine more trains from/for Manggarai and Jatinegara stations.

(3) In order to maximize JABOTABEK track capacity, intermediate- and long-distance trains will be operated at the same scheduled speed as that of JABOTABEK trains ("in parallel diagram").

6-6 Number of Locomotives Required

6-6-1 Basic Conditions of the Rostering Method

The number of electric locomotives will be calculated based on the following conditions.

(1) The use of AC/DC dual current electric locomotive will enable through train operation over AC/DC junction without changing locomotives.

(2) The AC/DC dual current locomotives will be commonly used for both passenger and freight trains.

6-6-2 Electric Locomotive

(1) Daily average running distance of an electric locomotive will be calculated from the travelling time between each section and turn-around time at terminal stations, with the assumption that each locomotive is available for 16 hours per day.

Then the number of electric locomotives will be calculated based upon the train-kilometer per day and the daily average running distance.

(2) Stand-by ratio of the electric locomotives will be set at 15% (see Table 6.6.1).

Table 6.6.1 Number of AC/DC Dual Current Locomotives by Year

Year	Section	In use	Total
1992	Jak - Cn	36	42
	Jak - Kac	14	16
	Total	50	58
1997	Jak - Cn	39	45
	Jak - Kac	16	18
	Total	55	63
2002	Jak - Cn	39	45
	Jak - Kac	20	23
	Total	59	68
2007	Jak - Cn	40	46
	Jak - Kac	22	25
	Total	62	71

6-7 Track Capacity

6-7-1 Cikampek - Cirebon

The number of trains operated in the Cikampek - Cirebon section will reach its track capacity in 1992 after electrification (see Table 6.3.1). Maximum track capacity, which can be attained by electrification and modernization of related facilities without double tracking, is simulated by computer (see Table 6.7.1). Details of the simulation are described in Appendix 6-7-1.

The result indicates that the track capacity can be increased to 100 trains per day through higher operating speeds achieved by electrification, and shortened block-setting and train-handling times by modernizing signalling facilities. Furthermore, it can be increased to 113 trains by providing passing tracks at 2 signal posts which will be implemented in 1997.

Table 6.7.1 Increase in the Track Capacity of the Cikampek - Cirebon Section by Grading Up of the Railway

Case	Railway system				Track capacity (Train)
	Electrification	Block system	Interlocking device	Additional passing track	
1	None	Electro-mechanical (S & H)	Mechanical	None	58
2	Yes	Ditto	Ditto	None	66
3	Yes	Automatic (without block signal)	Relay/ electronic	None	78
4	Yes	Automatic (with block signal)	Ditto	None	100
5	Yes	Ditto	Ditto	Yes (for 2 signal posts)	113

6-7-2 Jatinegara - Bekasi

The number of trains operated in the Jatinegara - Bekasi section, including long-distance trains and JABOTABEK commuter trains is calculated by taking the track capacity of the section into consideration.

(1) Basic conditions for calculation

a. Number of long-distance trains

The number of long-distance trains operated in the Jatinegara - Bekasi section is given from Table 6.3.2 as follows:

Table 6.7.2 Number of Long-Distance Trains (Jatinegara - Bekasi, both directions)

Year	1992	1997	2002	2007
Number of trains	158	172	183	189

b. Headway of JABOTABEK commuter trains

According to the "Final Report on Review of Feasibility Study" on JABOTABEK railway project, the number of JABOTABEK trains and their headway during morning rush hours are as follows:

Table 6.7.3 Headway of JABOTABEK Trains
(in morning rush hours)

(Unit: min.)

Line	1992	1997	2002	Remarks
Jatinegara - Bekasi	10	8	6	
Eastern line	10	8	6	Jakarta - Pasarsenen - Jatinegara
Central line	6	5	3	Jakarta - Gambir - Manggarai
Western line	10	8	6	Tanahabang - Jatinegara

Source: Final Report on Review of Feasibility Study (June 1985)

Table 6.7.4 Number of JABOTABEK Trains per Day
(both directions)

Line	1992	1997	2002	2007	Remarks
Jatinegara - Bekasi	82	102	134	(166)	
Eastern line	82	102	134	(166)	Jakarta - Pasarsenen - Jatinegara
Central line	134	164	268	(330)	Jakarta - Gambir - Manggarai
Western line	82	102	134	(166)	Tanahabang - Jatinegara

Note: ( ) - Study estimate

Source: Final Report on Review of Feasibility Study (June 1985)

c. Commuter train from/to outside the JABOTABEK area

According to the OD table in 1983 offered from PJKA, the number of commuter trains between Purwakarta/Cikampek and JABOTABEK lines are estimated as follows:

Table 6.7.5 Number of Commuter Trains from/to Outside the JABOTABEK Area (both directions)

Year	1992	1997	2002	2007
Number of trains	8	10	12	14

(2) Result of calculation

Based on the above conditions, total number of trains in the Jatinegara - Bekasi section is summed up as follows:

Table 6.7.6 Number of Trains in the Jatinegara - Bekasi Section per Day (both directions)

Year	Long-distance train	JABOTABEK train	Commuter train from/to outside the JABOTABEK area	Total
1992	158	82	8	248
1997	172	102	10	284
2002	183	134	12	329
2007	189	(166)	14	369

In the above table, if the three types of trains are operated in parallel with 6 minute headway, theoretically 340 trains (both directions) can be operated per day in an operating time zone of 17 hours per day. Accordingly, the estimated number of trains in Table 6.7.6 can be operated on the existing double track until 2002.

6-7-3 Jakarta - Manggarai

As shown in Table 6.7.3, the shortest headway for JABOTABEK trains during morning rush hours is found on the Central line, 6 minutes in 1992 and 3 minutes in 2002. Consequently, long-distance trains will not be able to be operated during morning rush hours after 1992 and during the daytime after 2002 when daytime headway will become 6 minutes.

To cope with this situation, terminal station for some trains must be shifted to Manggarai.

6-8 Train Dispatching

The number of trains between Cikampek and Cirebon in 1992 will reach 100. This is nearly the maximum track capacity of the section attained by electrification and upgrading of the signalling system. As a result, recovery or rescheduling of the train diagram will become very difficult if traffic disorder were to occur due to an accident or delay.

In the Jatinegara - Bekasi section, commuter trains will be operated during morning rush hours with 10 minute headway in 1992. Long-distance and commuter trains will be jointly operated bringing the total number of trains to as many as 248 in 1992 (see Table 6.7.6).

To ensure smooth traffic flow and punctual train operation of both long-distance and JABOTABEK trains under the above conditions, the grading-up of the train dispatching system becomes indispensable.

According to the train operation record of October and November in 1984, 50 trains were operated per day and average delay of long-distance trains exceeded 60 minutes with 55% of it occurring in the Cirebon - Jakarta section. To cope with this situation, the CTC (centralized traffic control) system should be introduced firstly to the Cikampek - Cirebon section of the most severe traffic conditions. The CTC system should monitor and control not only train traffic in the section but also traffic that merges and diverts to/from Cirebon and Cikampek. Taking into consideration the location of the present dispatcher center as well as the possibility of future expansion of the CTC system to sections west of Cirebon, the dispatching center will be located at Cirebon.

CHAPTER 7 ELECTRIFICATION SYSTEM

CHAPTER 7 ELECTRIFICATION SYSTEM

7-1 Power Supply System

7-1-1 Selection of Power Supply System

(1) Load characteristics of electric railway

Electric railway load is characterized by: a. fluctuating load, b. moving load, c. single-phase load, and d. higher harmonics in load current. Thus, the PLN power source for proposed electric railway must have the capacity to keep the influence of these characteristics within the allowable ranges specified in Table 7.1.1.

Table 7.1.1 Permissible Characteristics of PLN

Character-istics	Description	Value
Voltage fluctuation	Less than once in an hour	Less than 8%
	Maximum four times in an hour	4% or less
	More than four times in an hour	1.5% or less
Higher harmonics	Total distortion factor for 70 kV networks	Less than 5%
	Total distortion factor for 150 kV networks	Less than 1.6%
Voltage unbalance	Continuous	1.5% or less
	Less than an hour	2.0% or less

Source: Data/Informations for PJKA by PLN

(2) Measures against voltage fluctuation and higher harmonics

Since electric railway load fluctuates and moves, it will cause voltage fluctuation in the power source. In addition, electric motive power unit generates higher harmonics. The voltage fluctuation and higher harmonics exert an adverse effect on the electric equipment/appliances of general consumers served by the same power supply system. Also, higher harmonics increase inductive interference in communication lines nearby. Voltage distortion caused by higher harmonics is inversely proportional to the short circuit capacity of the power source.

Therefore, to minimize these adverse effects, the electric railway must be fed from a PLN system of sufficient short-circuit capacity.

After the amount of higher harmonics generated by motive power unit has been estimated, if necessary, suitable countermeasures on the unit and/or ground facilities will be selected.

(3) Measures to control voltage unbalance

Since the railway load is served by a single-phase power source, voltage unbalance is produced in the three-phase PLN power supply system. Hence, in general, the following countermeasures are taken at the railway substation:

a. To receive in rotation each one phase of electric power from the same transmission line.

b. To receive electric power from a power source with short-circuit capacity large enough to keep the voltage unbalance ratio within the permissible value. In this case, less costly single-phase transformer can be employed.

c. To employ transformer of Scott-connection type or revised Woodbridge-connection type.

(4) Selection of power supply system

The PLN power supply network in West Java is shown in Fig. 7.1.1, the substation short-circuit capacity related to the project in Table 7.1.2, and outage rate in the PLN system in Table 7.1.3. PLN power supply systems to serve each railway substation must be selected in consideration of their short-circuit capacity, reliability and economy.

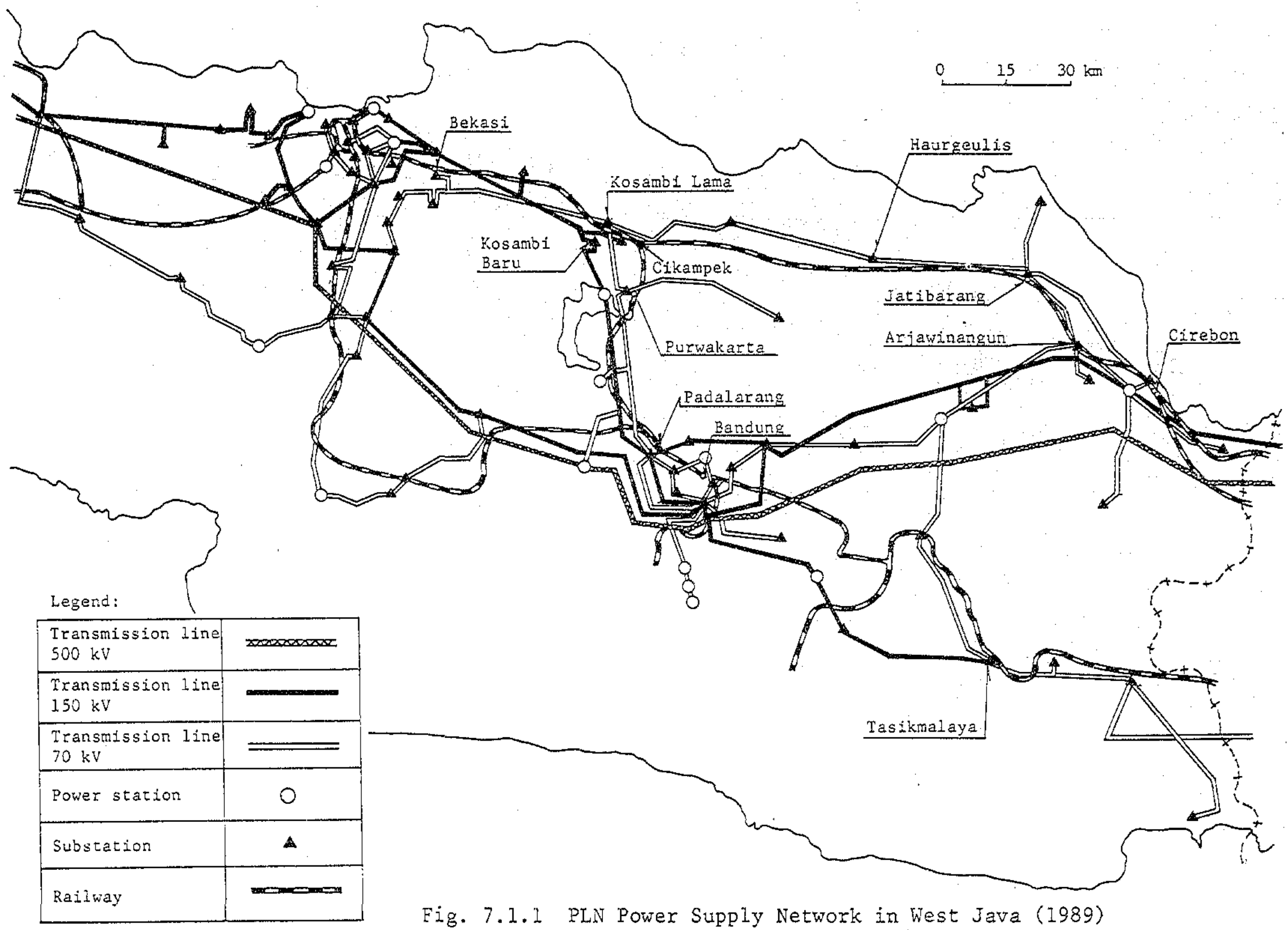


Fig. 7.1.1 PLN Power Supply Network in West Java (1989)

Table 7.1.2 Short-circuit Capacity of PLN Substations (1992)

Location	Voltage (kV)	Short-circuit capacity (MVA)
Bekasi	150	6,540
Poncol	70	962
Kosambi Baru	150	2,798
Kosambi Baru	70	1,148
Kosambi Lama	70	901
Purwakarta	70	826
Padalarang	150	3,561
Padalarang	70	1,315
Jatibarang	70	666
Haurgeulis	70	342
Arjawinangun	70	814
Tasikmalaya	70	705
Tasikmalaya	150	1,500

Source: DKT-SUBDITEKS PLN (Jakarta, 25 - 09 - 1985)

Table 7.1.3 Outage Rate of PLN System (1976 - 81)

System voltage (kV)	Transmission line system (times/100 km/year)	Transformer system (times/100 units/year)
70	20.42	174
150	3.66	39.4

Source: Annual Report 80/81 PLN

7-1-2 Selection of Feeding System

Railway electrification can be roughly classified into DC and AC systems. In this project, the commercial frequency, single-phase, 25 kV AC system is selected on the basis of study result of the Master Plan.

(1) Types and characteristics of AC electrification systems

Possible feeding systems for the project are as follows;

a. Simple feeding (SF) system

The system is made up of a simple feeding circuit, an overhead contact line and rails, thus featuring the lowest construction cost.

Also, relatively wider spacing of substations, 50 - 60 km, is possible in this system.

Meanwhile, no measure for reducing inductive interference is provided in this system, giving rise to inductive interference 3 to 8 times greater than the AT and BT feeding systems. For this reason, this system is not suitable for sections along which many communication lines are installed alongside. On the other hand, this system can be most economically applied for the sections with sparse communication lines installed alongside the rail and where access to the power source is relatively easy.

b. Autotransformer (AT) feeding system

The system is made up of relatively complicated feeding circuit - contact wire, feeder line, AT and rails - making its construction cost relatively high.

This system features high feeding voltage from railway substations (twice the voltage fed to the motive power unit), making it suitable for heavy power feeding over a long section. It allows substations to be spaced 100 - 130 km apart, permitting more flexibility in selecting their location. In addition, the AT system considerably reduce inductive interference by absorbing the return current by AT to the feeder line.

c. Booster transformer (BT) feeding system

The system is a modification of the simple feeding system, that is, BT and negative feeder (NF) are added to it to reduce inductive interference in communication lines.

Although it is effective in immunizing inductive interference as in the AT system, this system has a complicated circuit configuration (booster section is inserted in overhead contact line). This causes high impedance in feeding circuits, requiring substation location at relatively short spacing of 30 to 40 km.

(2) Factors to be considered in selecting the feeding system

The following factors must be taken into consideration before selecting the feeding system for a particular railway section.

a. Power supply network to be accessed
b. Communication lines alongside the railway
c. Reliability and maintainability of the system
d. Construction cost

Factor a. is related to the location and spacing of substations as well as short-circuit capacity and economy of power supply system, while factor b. is related to inductive interference.

Factor c. and d. are closely related: in general, the higher the reliability and maintainability the greater becomes investment.

(3) Selection of the feeding system

The AT feeding system is selected for the following four sections.

The following selection is conducted based on the estimation of the unbalance and fluctuation rate in case power is supplied from PLN substations listed in Table 7.1.2.

a. Bekasi - Cikampek (57 km)

A simple feeding system is not suitable for this section which, being densely populated, may suffer serious communication interference hazard. As shown in Fig. 7.1.1, 70 kV and 150 kV PLN power transmission lines are installed along the railway, so any of the feeding systems can be employed. Considering construction costs for the AT and BT feeding systems as shown in Table 7.1.4, the AT feeding system is selected for this section.

Table 7.1.4 Construction Cost Ratio between AT and BT Feeding Systems

Feeding system	Number of railway substation	Construction cost ratio			
		Substa-tion & related equipment	Overhead line equip-ment	*Countermea-* sures for communication interference	Total
AT	1	100	139	23	262
BT	2	130	141	23	294

b. Cikampek - Cirebon (135 km)

As shown in Fig. 7.1.1, PLN power transmission line of 70 kV will exist in the year 1989 along the railway. Since this line near Haurgeulis, Jatibarang and Arjawinangun does not have sufficient short-circuit capacity, the power for this section will be supplied from the 150 kV Transmission line passing by Arjawinangun (See Appendix 7-1-1).

Under this condition, substations must be installed 130 km apart, necessitating adoption of the AT feeding system.

c. Cikampek - Padalarang (75 km)

Since this section is located in a sparsely populated area, communication interference hazard is considered to be relatively small. So simple and AT feeding systems are compared based on the existing conditions of the PLN power supply network. In view of the existing PLN routes, adoption of the BT feeding system which necessitates construction of two railway substations and longer access lines to the PLN system will require a large investment.

As shown in Tables 7.1.5 and 7.1.6, the simple feeding system costs more than the AT feeding system in terms of countermeasures for inductive interference, while total cost for other facilities are comparable. In conclusion, the AT feeding system is selected for this section.

Table 7.1.5 Construction of Simple and AT Feeding Systems in Cikampek - Padalarang

Feeding system	Substation facility	Overhead line system	Communication line
SF	One substation: 70 kV (Purwakarta)	Overhead line equipment	Underground heavily screened cable
AT	AT posts at approximately 15 km spacing	Overhead line equipment, AT feeder lines (75 km)	Underground screened cable

Table 7.1.6 Construction Cost Ratio between Simple and AT Feeding Systems

Feeding system	Number of railway substation	Construction cost ratio			
		Substa-tion & related equipment	Overhead line equip-ment	Countermea-sures for inductive interference	Total
SF	1	145	340	125	610
AT	0	100	380	100	580

d. Padalarang - Kiaracondong (20 km)

Since a part of this section is included in the Bandung Metropolitan area, adoption of the simple feeding system is not appropriate in view of communication interference, while the AT feeding system is preferable to the BT feeding system in view of future expansion of AC electrification beyond Kiaracondong.

The feeding system and railway substations selected are shown in Fig. 7.1.2 (See Appendix 7-1-2 and 7-1-3). Maximum power, voltage fluctuation and unbalance estimated in this system are shown in Table 7.1.7.

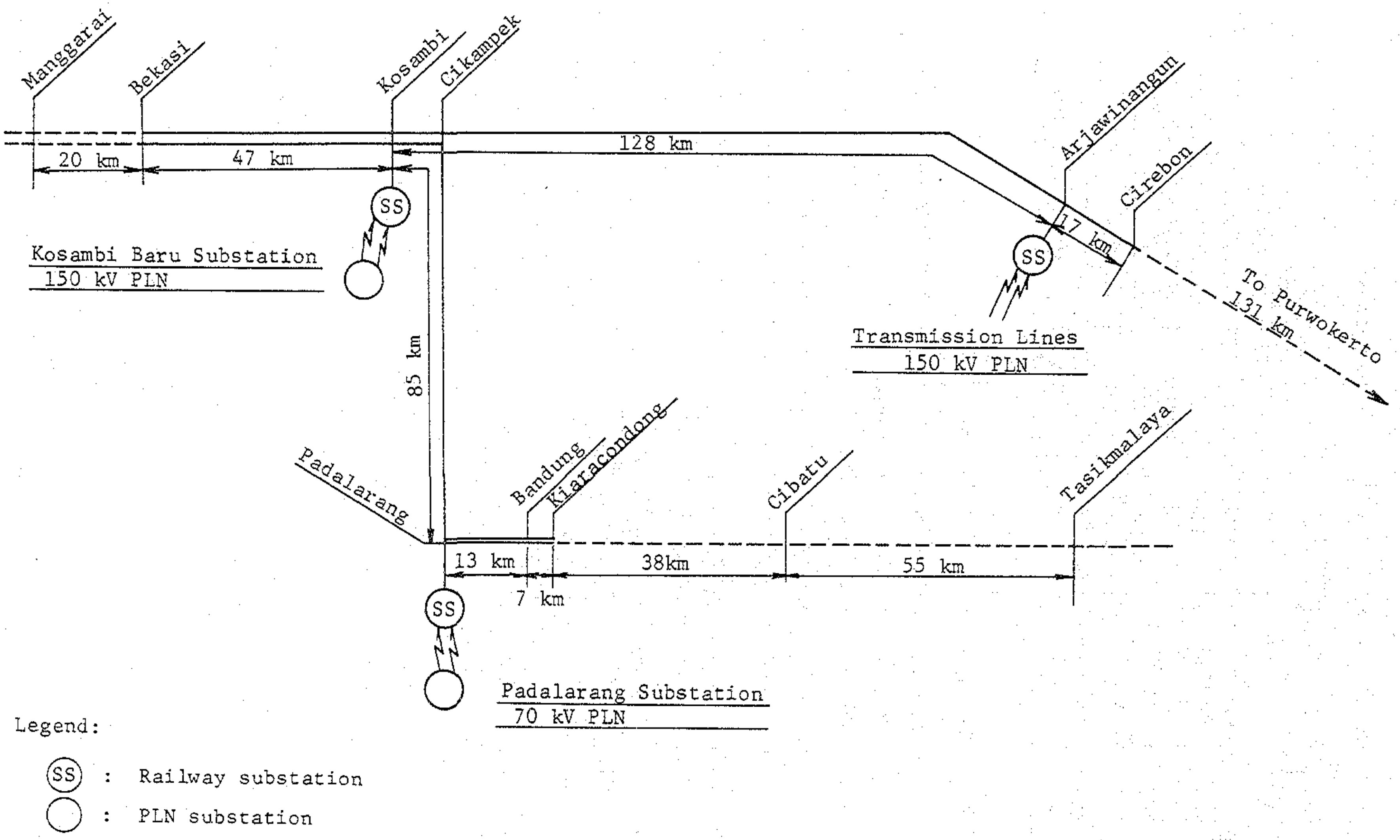


Fig. 7.1.2 Feeding System Plan

Table 7.1.7 Estimation of Unbalance and Fluctuation Rate (1992)

Name of substation	Vol-tage (kV)	Short-circuit capacity (MVA)	Maximum average value in an hour					Instantaneous maximum value					Voltage fluctua-tion (%)
			Load (kVA)			Trans-former type	Voltage un-balance (%)	Load (kVA)			Trans-former type	Voltage un-balance (%)	
			Total	Up	Down			Total	Up	Down			
Kosambi Baru	150	2,798	16,300	6,800	9,500	1P	0.58	27,100	13,800	17,800	1P	0.96	0.16
						V	0.49				V	0.64	0.16
						T	0.09				T	0.64	0.21
Arjawinangun	150	1,000*	6,300	4,800	1,500	1P	0.62	13,700	11,400	5,100	1P	1.37	0.45
						V	0.56				V	1.13	0.45
						T	0.33				T	1.13	0.60
Padalarang	70	1,315	2,800	2,000	800	1P	0.20	7,800	6,300	3,300	1P	0.58	0.34
						V	0.18				V	0.47	0.34
						T	0.09				T	0.47	0.45

Notes:
1. Permissible characteristics of PLN applied to this plan.
   Voltage unbalance rate 1.5% (continuous)
   2.0% (less than an hour)
   Voltage fluctuation rate 1.5% (more than four times in an hour)
2. The voltage fluctuation caused by train start and stop is supposed to occur more than four times in an hour.
3. About calculation method, see Appendix 7-1-4, 7-1-5, and 7-1-6.

Legend:
1P: Single-phase, V: V-connected, T: Scott-connected
*: Supposed value
UP: To Jakarta Down: To Cirebon/Bandung

7-2 Catenary System

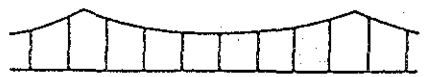
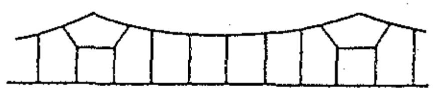
7-2-1 Types of Catenary Systems

The catenary system is generally selected considering train speed, current collection capacity, maintainability and economy. It is classified into the following four types (each type can be subdivided into many types in terms of the number of contact wires and tensile stress) as follows;

(1) Direct suspension system,
(2) Simple catenary system,
(3) Stitched catenary system, and
(4) Compound catenary system.

Table 7.2.1 shows the configuration of each catenary system and their characteristics in case of one pantograph passing. Their speed perfomance will lower in case of multipantograph passing, since the frequency of contact loss and amount of uplift will increase due to multiple vibration caused by successively passing pantographs.

Table 7.2.1 Comparison of Catenary Systems

	Type	Typical construction	Standard wire type (mm^2)			Wire tension (ton)	Speed performance (km/h)
			Catenary	Auxiliary catenary	Contact wire		
1	Direct suspension system				GT 110	1.3	100 or less
2	Simple catenary system		St 90		GT 110	2	120 or less
3	Stitched catenary system		St 90		GT 110	2	200 or less
4	Compound catenary system		St 135	Cu 100	GT 110	3	200 or more

Note: Speed performance is based on one-pantograph passing

Legend: St: Galvanized steel wire
Cu: Hard-drawn copper wire
GT: Hard-drawn grooved contact wire

7-2-2 Comparison of Catenary Systems

(1) Direct suspension system

The direct suspension system is classified into two types, one which directly supports the contact wire at each support and the other which suspends the contact wire, by means of short rods or wires, improving the system performance.

These systems can be adopted most economically for sections where train speed is less than 85 km/h (100 km/h for one pantograph passing).

A simple sketch of a direct suspension system is shown in Fig. 7.2.1.

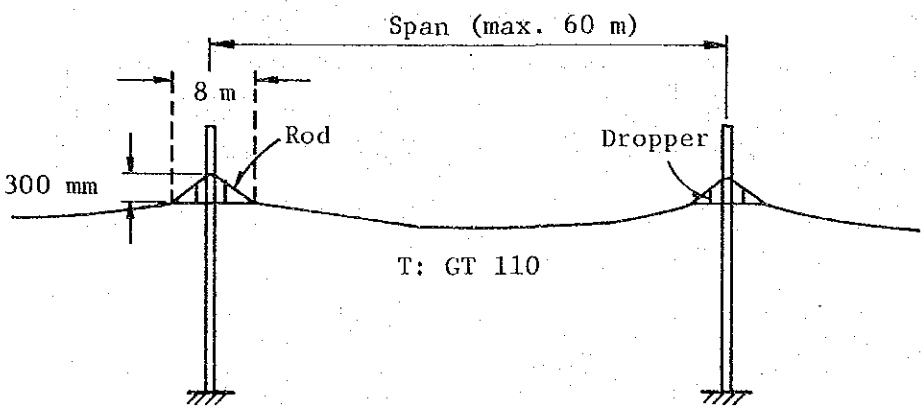


Fig. 7.2.1 Construction of Direct Suspension System

(2) Simple catenary system

This system is generally used for sections where train speed is less than 120 km/h (e.g., part of the JABOTABEK lines).

(3) Stitched catenary system

Stitched wire is added to the simple catenary system to improve system performance.

(4) Compound catenary system

This is another modification of the simple catenary system, in which auxiliary wire is added to improve overall performance.

Although both stitched catenary system and compound catenary system have excellent speed performance, they require relatively high construction costs.

7-2-3 Selection of Catenary System

The simple catenary system will be employed for most sections since train speed is planned at 100 km/h. The direct suspension system will be adopted for a mountainous section of about 50 km between Purwakarta and Padalarang where train speed is limited to 80 km/h due to steep grades and sharp curves to save construction costs.

Construction costs for the two catenary systems in this section are compared in Table 7.2.2.

Table 7.2.2 Comparison of Construction Costs of the Two Catenary Systems in Purwakarta - Padalarang Section

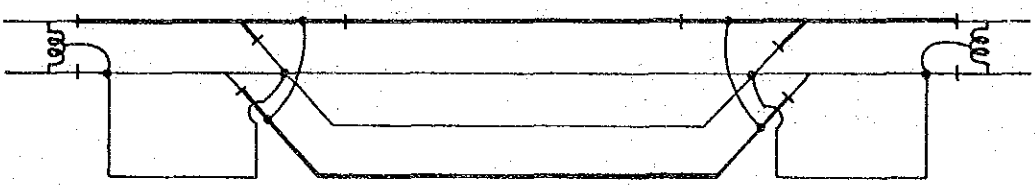
Catenary system	Construction cost ratio (%)	Cost difference (10^6 Rp.)
Simple catenary system	100	220
Direct suspension system	91	

7-3 Track Circuit

In the AC electrification system, traction current supplied from an overhead contact line to a motive power unit flows through the rails and returns to a substation. At the same time track circuit current is fed to the same rails. Hence, both return and track circuit currents flow in the same rails.

Although the DC track circuit has a relatively simple configuration, and thus, is relatively cheap to construct, it is not possible to use an impedance bond for separating track circuit and return currents. As a result, the return current must flow in one rail and the track circuit current in the both rails.

In this system, the so-called "single rail track circuit", rail breakage on the return current side sometimes leads to an abnormal rail potential which might cause an electric shock to personnel or damage track circuit equipment. Therefore, this system cannot be adopted except for a station yard, where countermeasures can be taken as shown in Fig. 7.3.1.



Legend:

(thick line) Rail where track circuit current flows

(thin line) Rail where return current flows

Fig. 7.3.1 DC Track Circuit with Measures against Rail Breakage

In the commercial frequency track circuit, a part of the return current will enter a track circuit receiver due to an imbalance factor of the track circuit impedance, causing a possible malfunction of the receiver. To avoid this, the track circuit current must employ a frequency different from that of the return current as well as its higher harmonics; i.e. either a low frequency (LF) band of 20 to 300 Hz or an audio frequency (AF) band of 1 to 3 kHz. To control wayside signal or cab signal, the track circuit current is modulated with a code frequency of several Hz. The main features of the LF and AF track circuit systems are shown in Table 7.3.1.

Table 7.3.1 Main Features of LF and AF Track Circuit Systems

Track circuit system / Item	LF	AF
Frequency	20 - 300 Hz	1,000 - 3,000 Hz
Max. Control length ($G < 0.5$ s/km)	2 - 4 km	1 - 1.2 km
Number of information (wayside/cab signal control)	4 or more	10
Jointless configuration (non-insulated track circuit)	Difficult	Possible

In view of the minimum headway (5 min.) and train speed (max. 100 km/h) requirements in the Section, the block length in the automatic block signalling system is assumed to be 2 to 3 km. In this case, the LF system, which can control the whole block length with one track circuit, can have a simpler configuration than the AF system, bringing about lower construction and maintenance costs.

For the above reasons, the DC track circuit will be installed in the station yards, while the LF code track circuit will be adopted for the main tracks between stations (see Figs. 7.3.2 - 7.3.3).

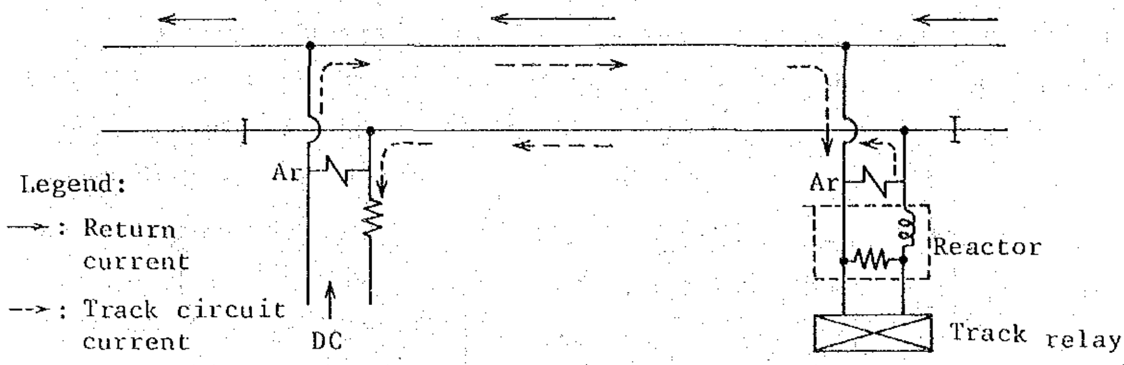


Fig. 7.3.2 Schematic Drawing of DC Track Circuit

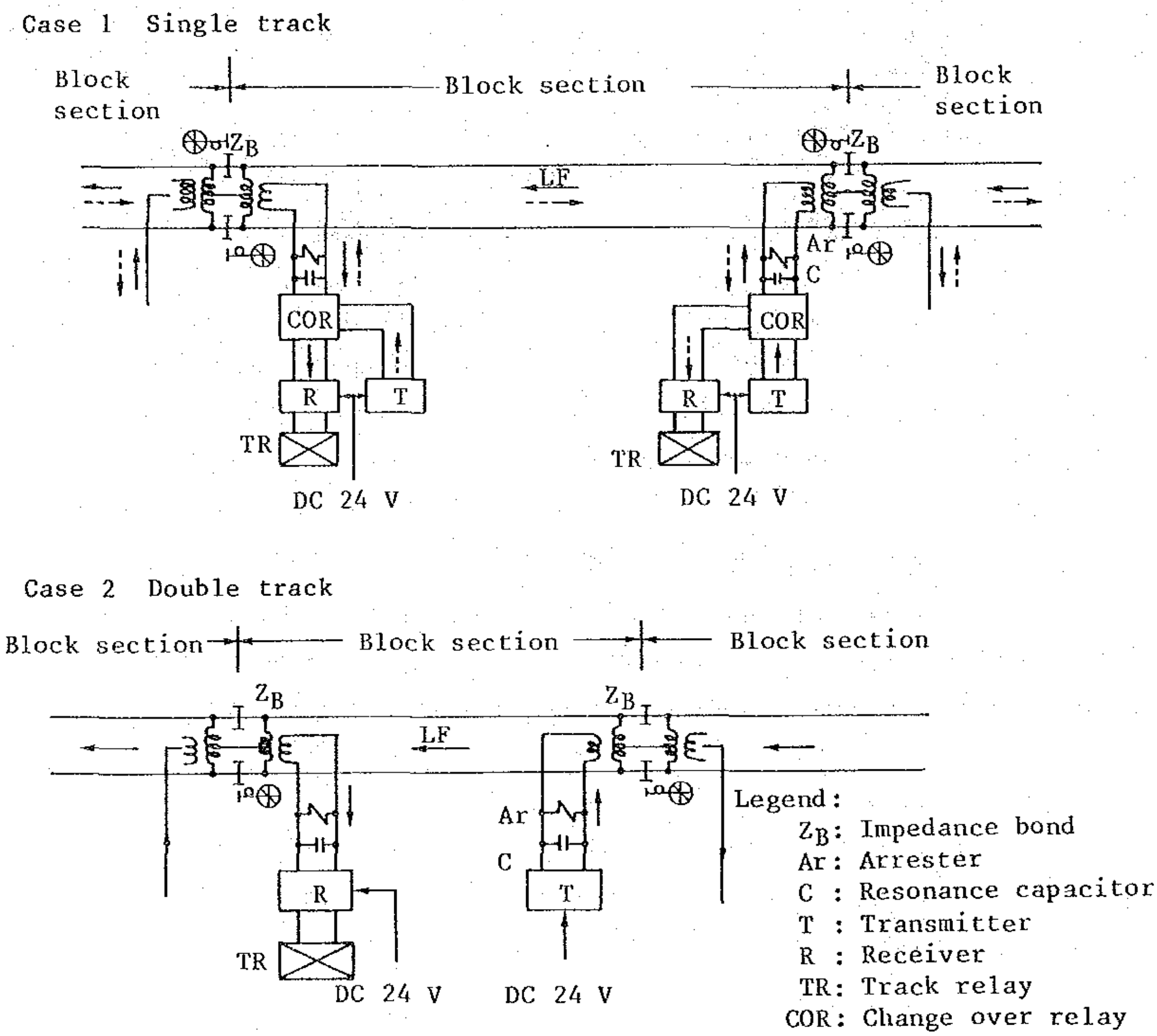


Fig. 7.3.3 Schematic Drawing of LF Track Circuit

In the final design stage, the relationship among maximum short circuit resistance/rail breakage detecting function and track circuit length should be examined on the basis of the actual track length, the maximum leakage conductance, the maximum harmonic current in the traction current, etc. For reference, their relationship in the 80 Hz track circuit is shown in Appendix 7-3-1.

Finally, appropriate measures should be taken against interference caused by the following phenomena;

a. DC track circuit

- Rush current generated when pantograph of AC electric motive power unit is raised or its air blast circuit breaker is switched on

- Polarization of rails in sections provided with PC ties

b. LF code track circuit

- Higher harmonics generated by VVVF motive power unit (See Appendix 7-3-2)

7-4 Inductive Interference

When an electrified railway is located in close proximity with communication lines, the electromagnetic energy of the electrification system is transmitted to the communication line, generating hazardous voltage/current or noise interference. These inductive interferences are caused by either electrostatic or electromagnetic induction.

(1) Electrostatic induction

The magnitude of electrostatic induction is determined by the voltage of the overhead contact wire system, the distance between the catenary and communication lines, the exposed length of the communication lines, etc. The allowable value for electrostatic induction is specified by International Telegraph and Telephone Consultative Committee (C.C.I.T.T.) at 150 V or 15 mA. To keep the electrostatic induction effect below these values, the distance between the track center and a communication line should be at least 36 m for the simple feeding system and 9 m for the AT feeding system (see Appendix 7-4-1).

(2) Electromagnetic induction

Electromagnetic induction voltage is determined by such factors as the magnitude and frequency of the traction current in catenary lines, the distance between catenary and communication lines, the exposed length of the communication line, earth conductivity, etc. Its allowable value at commercial frequency is specified by C.C.I.T.T. as 60 V or less under normal conditions. Also, noise voltage (at 800 Hz) is specified by C.C.I.T.T. at 1 mV or less. In Japan, however, noise voltage in overhead open wires is allowed up to 2.5 mV.

To keep electromagnetic induction voltage below the above mentioned allowable values, on the assumptions that communication line is 10 km in length and non-screened, contact wire load current (Ip) is 100 A and equivalent noise current (Jp) is 3 A, then the track center and the communication line must be separated as shown in Table 7.4.1 (see Appendix 7-4-2).

Table 7.4.1 Separation between Non-screened Communication Line and Track to Reduce Electromagnetic Inductive Interference to the Allowable Values

Induced voltage / Allowable value / Separation between communication line & rail	Induced voltage (V)	Noise voltage (mV)	
		Open wire	Underground cable
	60 V	2.5 mV	1.0 mV
Simple feeding	32 m	480 m	400 m
AT feeding	-	250 m	200 m

(3) Countermeasures for inductive interference

In consideration of the study result shown in Table 7.4.1, electrification requires that existing overhead open wires be replaced with an induction-free communication system. Although fiber optics or radio systems are possible alternatives for this purpose, installation of screened underground cable is selected as the most economical solution against electromagnetic induction interference, since the number of communication channels ranges between 50 and 60 and many branches at relatively shorter interval are required along the railway (see Appendix 7-4-3). On the other hand, electrostatic inductive interference in underground cable can be eliminated by screening and grounding its sheath.

CHAPTER 8 ELECTRIC MOTIVE POWER UNIT

CHAPTER 8 ELECTRIC MOTIVE POWER UNIT

8-1 Basic Performance of Electric Motive Power Unit

Rated speed and tractive force of electric motive power unit can be estimated by its operating performances on grades and curves. The output of a particular unit is determined by the operating speed and hauling capacity on such sections.

(1) Running conditions

a. Track conditions

The Cikampek - Cirebon section is generally flat with a 5 % or less grade, while approximately 50 km of the Cikampek - Bandung section has sharp curves of 200 - 300 m radius and many grades of 15 - 16 ‰.

b. Operating conditions

(a) Trailing load

A passenger train is assumed to weigh 400 tons.

A freight train is assumed to weigh 1,000 tons on the Bekasi - Cirebon section and 600 tons on the Cikampek - Bandung section, in consideration of freight traffic demand and station track capacities.

(b) Maximum speed

Maximum train speed is assumed to be 100 km/h for passenger trains and 85 km/h for freight trains.

The above conditions can also be applied to other trunk lines of Java. Consequently motive power units designed for the Section can be used on entire main lines in Java.

(2) Temperature

A critical factor in determining the rated capacity of an electric motive power unit (particularly in case of electric locomotive) is temperature rise in the winding of traction motor. It rises in proportion to the square of the electric current flowing through the equipment, making it necessary to keep the root mean square current (RMS current) below the rated current.

(3) Control system

a. Power control

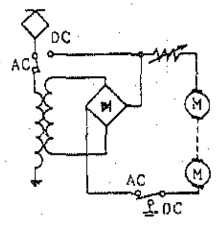
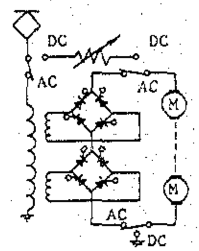
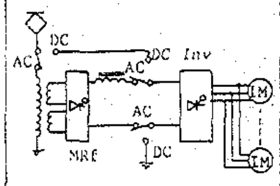
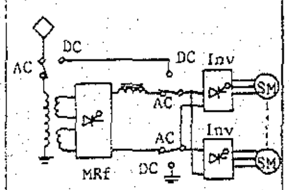
The conventional method of speed control for AC/DC dual current electric motive power unit is to control the voltage applied to the DC motor.

Voltage control systems are divided into the rheostatic control system, which controls the voltage by tap-changing of the main resistor, and the thyristor phase control system.

Furthermore, recently, a VVVF (Variable Voltage and Variable Frequency) system has been developed which uses AC motors and an inverter. As shown in Table 8.1.1, the VVVF system shows excellent adhesion performance and high maintainability due to employment of brushless and commutatorless induction motor.

On the other hand, the phase control type has advantages of smaller axle load and lower manufacturing cost. Power performance of VVVF system and phase control system are summarized in Table 8.2.2.

Table 8.1.1 Comparison of Control System for AC/DC Dual Current Electric Motive Power Unit

Items/Control system		Rheostatic control	Phase control (thyristor)	VVVF Control	
Traction motor circuit					
Principle of speed control		Voltage control	Voltage control	Voltage and frequency control	
Type of traction motor		Direct current motor	Direct current motor	Induction motor	Synchronous motor
Dynamic brake system		Rheostatic brake	Rheostatic brake (DC) Regenerative brake (AC)	Regenerative brake	Regenerative brake
Reliability		C	B	A *1	
Adhesion performance		C	B *2	A *3	
Maintenance of traction motor		C	C	A *4	B
Inductive interference		A		B *5	
Axle load	Electric locomotive	A	A	B *6	
	Electric railcar	A	A	A *7	C *8
Manufacturing cost ratio		100	110-115	117-120 *9	
Experience		A	A	C	
Adopt-ability	Electric locomotive	C	A	A *10	
	Electric railcar	A	C	A	C

Note; *1 System reliability is increased, by use of solid state equipments.
*2 In DC electrification sections, stepless power control cannot be expected.
*3 By adoption of stepless power/brake control, adhesion performance is improved.
*4 Maintenance and inspection is easy as brushless and commutatorless traction motor is employed.
*5 To prevent flux interference caused by the leaked magnetic flux from the motive power unit, related devices and wires are shielded. To prevent of interference caused by current of high frequency, filters are installed to the inverter.
*6 Lighter traction motor can be adopted, but total weight including inverter may be heavier.
*7 1 inverter is equipped for 1 motor car.
*8 4 inverters must be equipped for 1 motor car.
*9 Reduction of manufacturing cost can be expected by innovation of technology and mass production in the future.
*10 In case of VVVF rolling stock of approximately 5,000 kw or less, the induction motor type is more economical because only one inverter is used, while in the synchronous motor type two or three inverters must be installed.

Legend; A: Better B: Good C: Not good
Mrf: Main rectifier
Inv: Inverter

b. Brake control

To improve operating performance on grades and minimize wear on brake shoes and wheels, a dynamic brake system is generally employed in addition to an air brake system.

Two types of dynamic brake systems are possible: rheostatic and regenerative.

Although the phase control system can employ either system, the VVVF system cannot use the rheostatic brake system due to the absence of resistor.

8-2 Electric Locomotive

8-2-1 Axle Arrangement

The number of axles required for an electric locomotive is determined on the basis of the adhesion coefficient, axle load and the weight of the locomotive. Axle load is assumed to be 15 tons.

The adhesion coefficeint of AC electric locomotives having the Bo - Bo arrangement, is 35 - 40% at the start and 27 - 30% in the acceleration range, according to actual measurements in Japanese National Railways (JNR).

When a Bo - Bo type electric locomotive hauls freight cars of 600 tons, the minimum adhesion coefficient required at starting on various grades are determined as shown in the table below.

Table 8.2.1 Adhesion Coefficient of Bo - Bo Type EL Required at Starting on a Gradient

Gradient (‰)	Train speed (km/h)	Acceleration (km/h/s)	Adhesion coefficient (%)
15	0 - 20	0.1	27
16			28
17			30

This indicates that locomotive with 4 axles can be employed for the project in terms of adhesion performance.

8-2-2 Power Performance

(1) Comparison of power performance of VVVF and phase control type locomotives.

The performance characteristics of the two types of locomotives, are compared in Table 8.2.2.

Table 8.2.2 Comparison of Power Control Systems

Items \ Control system		VVVF	Phase
Axle arrangement		B-2-B	B-2-B
Axle load (ton)		15	15
Rated output (kW)		2,600	1,900
Rated speed (km/h)		46	48
Rated tractive effort (kg)		21,800	14,000
Traction motor	Number	4	4
	Rated output (kW)	650	475
	Rated voltage (V)	800	900
	Rated current (A)	550	570

a. Speed vs. tractive effort

The speed vs. tractive effort of VVVF and Phase control electric locomotive is shown in Figs. 8.2.1 and 8.2.2.

The basic criteria indicating locomotive performance are the steepest grade at which the locomotive can start, and its balancing speed. Graphic analysis in Figs. 8.2.1 and 8.2.2 are summarized in Table 8.2.3.

Table 8.2.3 Speed vs. Tractive Effort

Control type	Train	Gradient (‰)	Load (ton)	Balancing speed (km/h)
VVVF	Freight	0	1,000	87
		5		67
		16	600	59
	Passenger	0	400	120
		16		72
Phase	Freight	0	1,000	85
		5		55
		16	600	49
	Passenger	0	400	120
		16		71

As shown in Table 8.2.3, the balancing speed of the phase control electric locomotive (at gradient 0 ‰ and load of 1,000 tons) is just 85 km/h, barely, clearing the required speed vs. tractive effort, while, VVVF shows higher performance in this respect in view of the balancing speed (87 km/h).

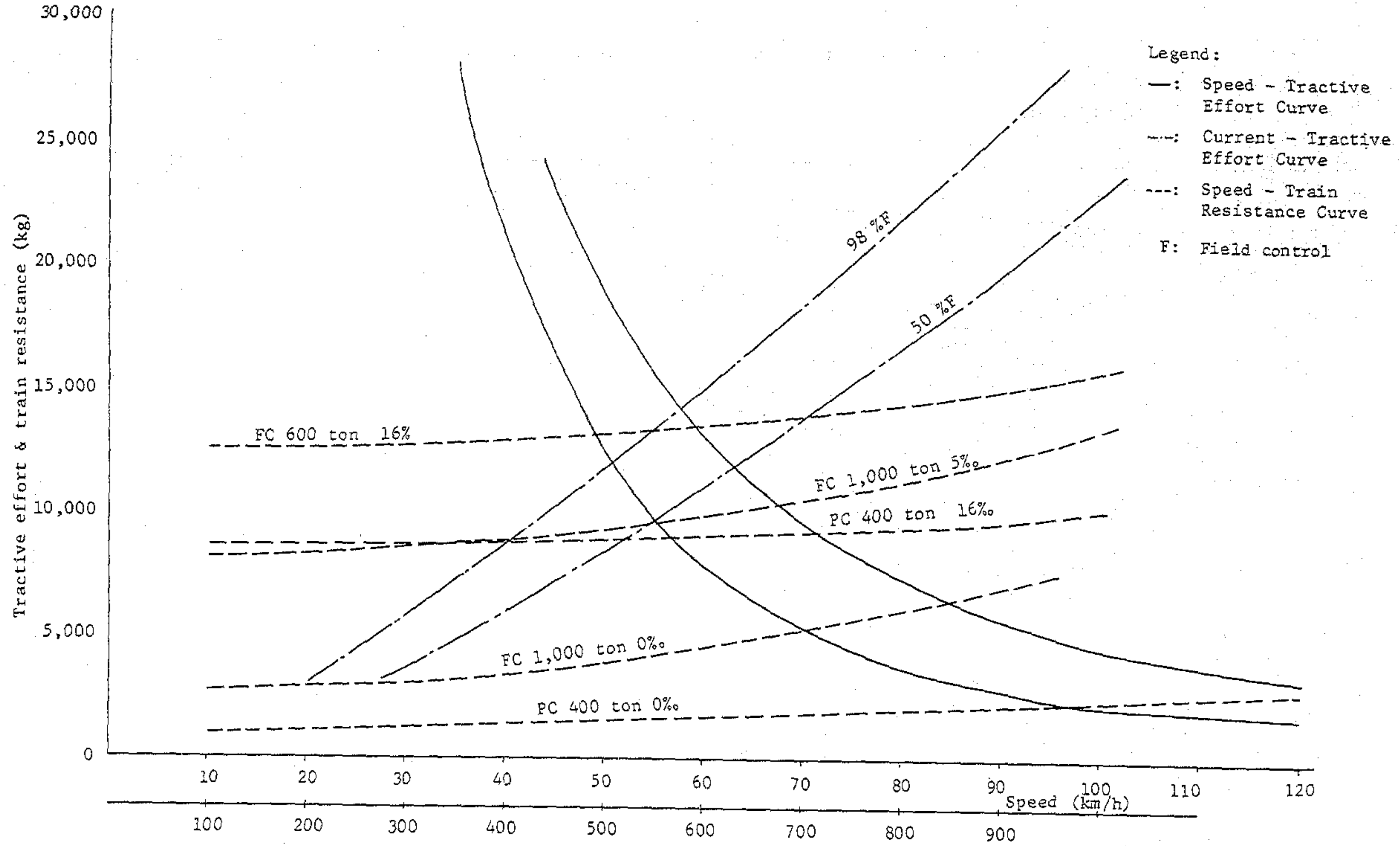


Fig. 8.2.1 Speed vs. Tractive Effort of Phase Control Locomotive

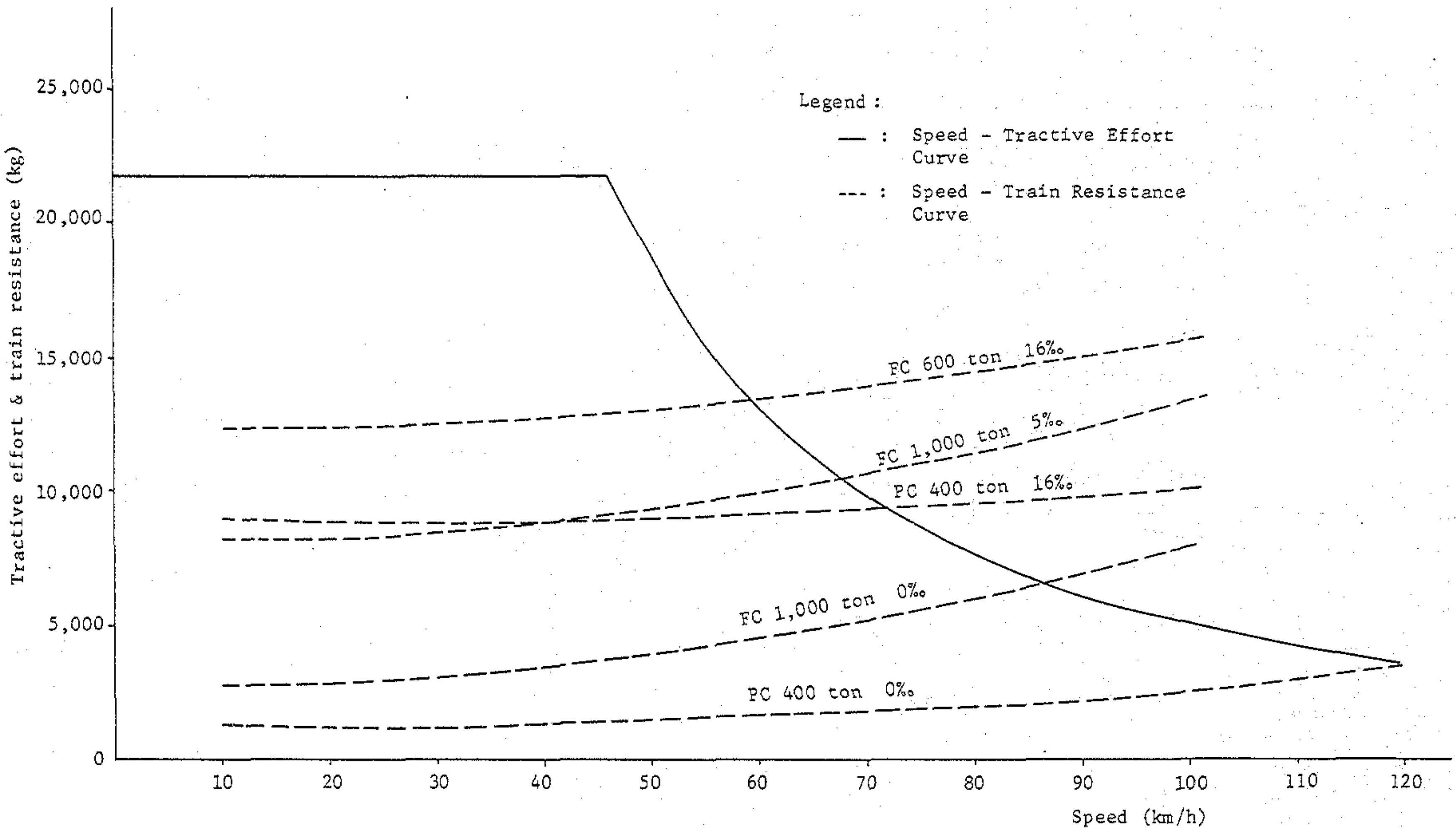


Fig. 8.2.2 Speed vs. Tractive Effort of VVVF Control Locomotive

b. Travelling time and RMS-current

Travelling time and RMS-current on the Cikampek - Padalarang section with numerous curves and grades were studied by computer simulation as follows:

Table 8.2.4 Result of Simulation

Item \ Type	VVVF	Phase
RMS-current (A)	355	530
RMS-current/Rated current (%)	64.5	92.9
Travelling time (min.)	82	83

Note: Simulation conditions:

- Trailing load 600 t
- Maximum speed 85 km/h
- Passing speed at station 70 km/h
- Passing speed at curve

Radius (m)	200	250	300	400	500
Speed (km/h)	55	60	65	75	85

- JNR's running resistance formulas were used.

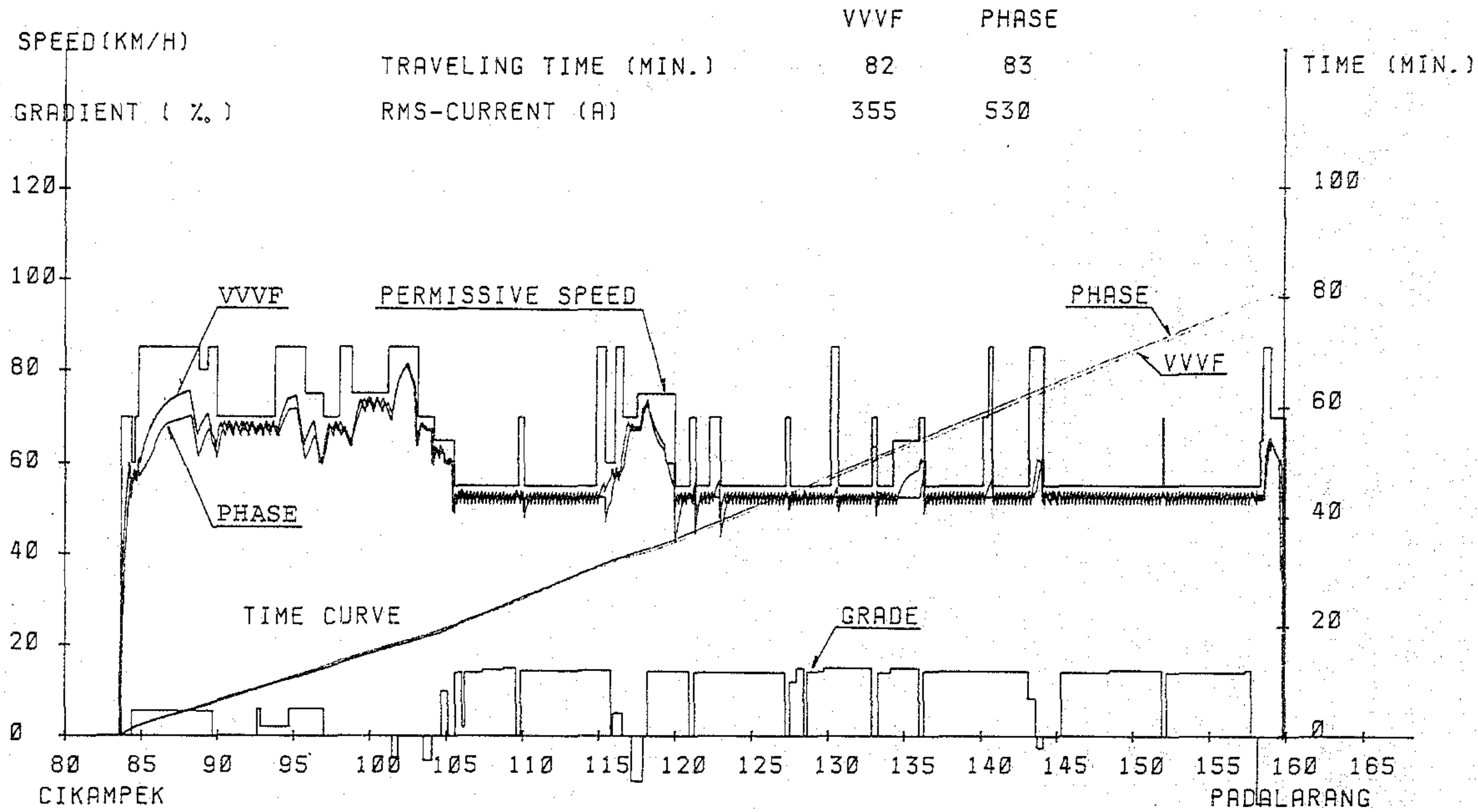


Fig. 8.2.3 Running Curve of Electric Locomotives in Cikampek-Padalarang Section

8-2-3 Selection of Electric Locomotive

In view of the above comparative study, VVVF shows better power performance than phase control. Furthermore, VVVF has the best adaptability for AC/DC dual current locomotive as well as high maintainability.

As for axle load, it will be reduced to less than 15 tons/axle by adoption of a trailing bogie. Hence, VVVF control system will be employed in this project.

8-2-4 Major Features of the VVVF Electric Locomotive

The major features of the VVVF electric locomotive are presented in Table 8.2.5.

Table 8.2.5 Features of VVVF Electric Locomotive

Type of locomotive			AC/DC dual current
Electric system			25 kV, 50 Hz
Control system			VVVF
Axle arrangement			B-2-B
Weight	Weight in working order		70 ton
	Axle load		15 ton
Size	Max. length between coupler		17,900 mm
	Max. width of the body		2,800 mm
	Max. height of the body		3,600 mm
	Length between bogie center		11,000 mm
	Pantograph folded height		4,050 mm
	Wheelbase	Driving bogie	2,500 mm
		Trailing bogie	1,600 mm
	Wheel diameter		1,120 mm
One hour rating	Output (kW)		2,600
	Tractive effort (kg)		21,800
	Speed (km/h)		46
Max. operating speed (km/h)			120
Drive system			Quill driving system
Gear ratio			5.466
Traction motor	Number		4
	Output (kW)		650
	Rated voltage (V)		800
	Rated current (A)		550

8-3 Electric MU Car

To minimize travelling time of super express passenger trains between JABOTABEK and Bandung, the following two measures were considered:

- Through operation of AC/DC dual current MU train over the Section and the JABOTABEK lines, and
- Speed increase in curves by introduction of tilting car.

8-3-1 Basic Control Performance

Two types of control systems, VVVF and rheostatic systems, are considered for AC/DC dual current car. Table 8.3.1 and Fig. 8.3.1 show control performance and speed vs. tractive effort of the two systems.

Table 8.3.1 Comparison of Control Performance of Electric MU Cars

Item/Control System		VVVF	Rheostatic
Unit make-up		1M1T	2M1T
Gear ratio		4.21	
Perform-ance	Rated output/Unit (kw)	600	960
	Rated speed (km/h)	80	77
	Max. speed (km/h)	120	
Traction motor	Type	Induction motor	Direct current motor
	Rated output (kw)	150	120
	Rated voltage (V)	1,100	375
	Rated current (A)	100	360
	Revolution (R.P.M.)	2,200	2,130
	Cooling system	Self ventilation	
Inver-ter	Thyristor	GTO 4,500 V, 2,000 A	
	No. of motors/1 inverter	4	

Legend: GTO: Gate turn-off thyristor

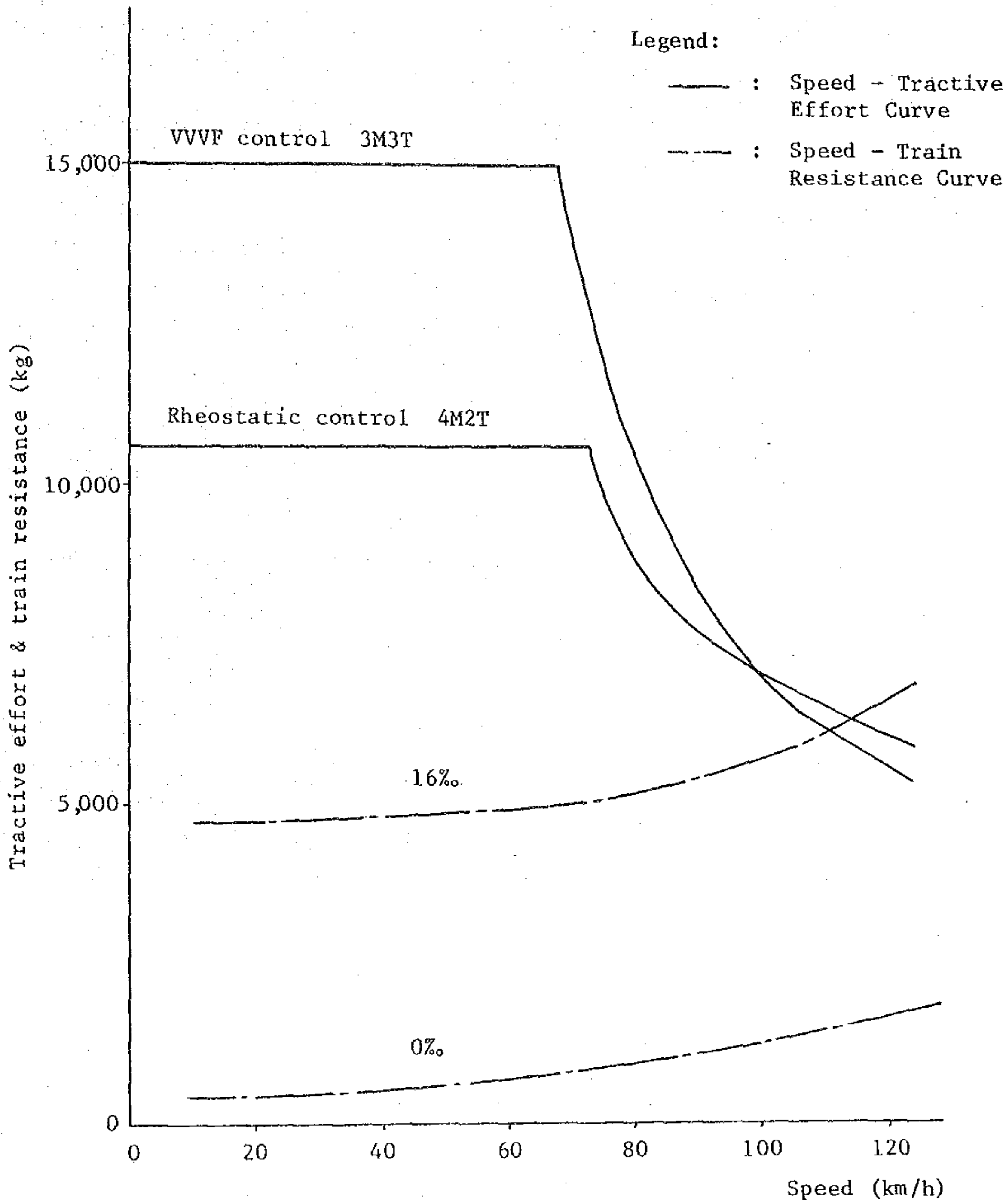


Fig. 8.3.1 Speed vs. Tractive Effort of Electric MU Train

8-3-2 Tilting Car

When a train passes over a curve, train and passenger are pushed outwards due to centrifugal force, which may cause discomfort to the passenger, and in the worst case, may lead to train derailment.

To reduce this effect, a superelevation is generally provided at the curve, tilting the train toward the inward side of the curve, thereby preventing derailment caused by the combined force of the centrifugal force and gravity. Thus, the greater the superelevation, the faster a train can pass the curve. However, the maximum superelevation value is limited to a certain degree, so that a train will not overturn when it slows down or stops on the curve.

On the other hand, by lowering the center of gravity of the car, train speed on the curve can be increased, although this will deteriorate riding comfort.

A tilting car is designed to solve this problem. By lowering the center of gravity of the car, the tilting car can pass the curve at a speed 15 - 20 km/h higher than the restricted speed (balancing speed determined by a given superelevation and conventional car). While a car runs on the curve at higher speed, increased centrifugal force acts on the tilting car, tilting its body further, while the bogie maintains its position. In this case, the combined force of the centrifugal force and gravity works vertically to the car-floor, thus diminishing the discomfort of passengers.

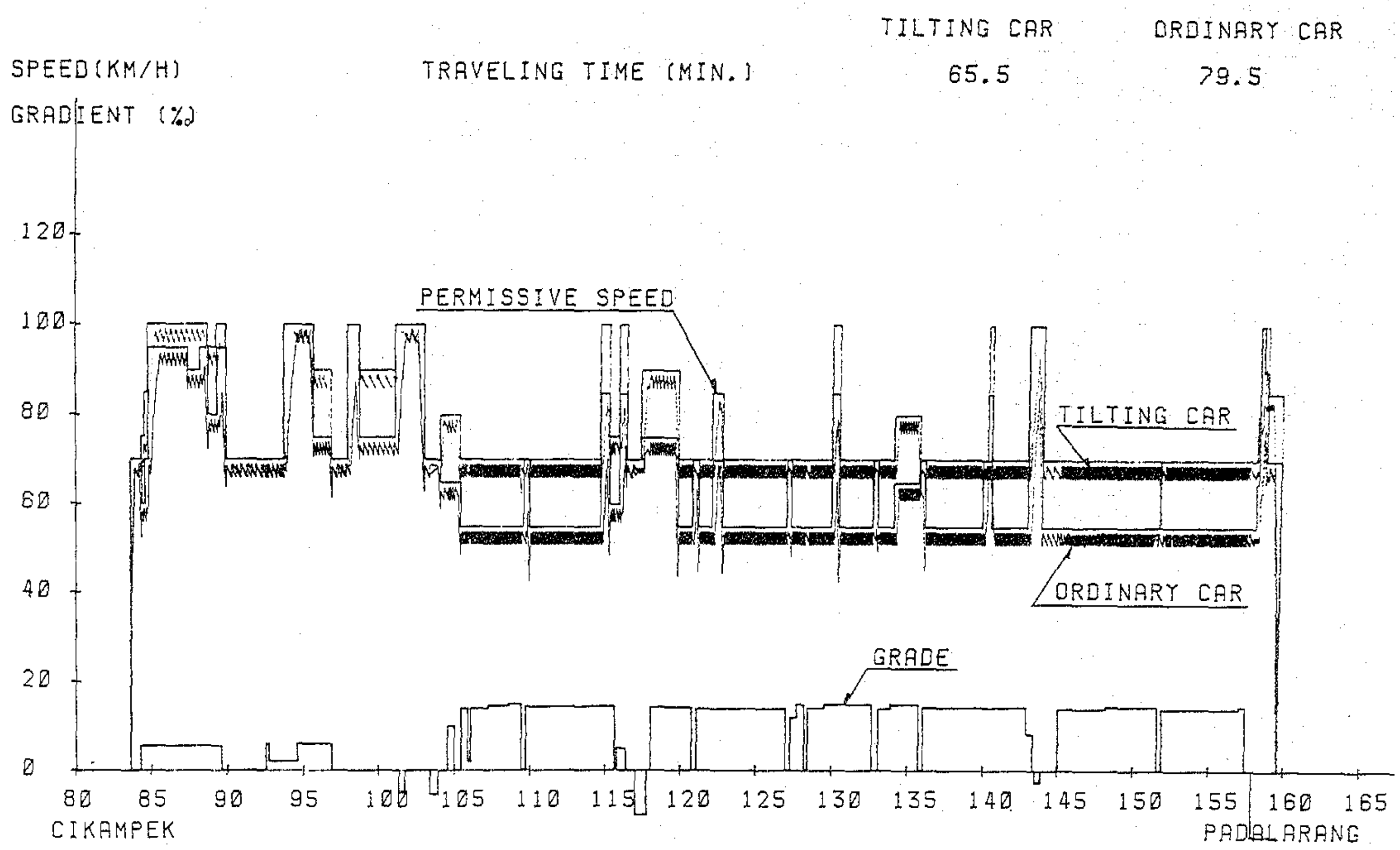


Fig. 8.3.2 Running Curve of Electric MU Trains in Cikampek-Padalarang Section

Table 8.3.2 Travelling Time

Train \ Section	Cikampek - Padalarang
Ordinary	79.5 min.
Tilting	65.5 min.

Note: Passing speed at curves

Radius (m)	200	250	300	400	500	600	700	800	900
Ordinary (km/h)	55	60	65	75	85	90	95	95	100
Tilting (km/h)	70	75	80	90	100	100	100	100	100

8-3-3 Summary of the Study Results

(1) Adoption of VVVF control system

In case of the rheostatic control, train make-up will become 4M2T, with 16 DC motors and 128 brushes. On the other hand, in case of the VVVF control, owing to the larger output of the induction motor, train make-up will become 3M3T, with 12 brush-less induction motors. Consequently, maintenance will become easier and the manufacturing cost is expected to become lower.

(2) Introduction of tilting railcar

By use of tilting railcar, travelling time between Cikampek and Padalarang can be shortened by approximately 14 minutes. But it must be taken into account that maintenance of its tilting device will be somewhat troublesome.

8-3-4 Conclusion

Although adoption of the tilting MU trains could reduce the travelling time between Cikampek - Padaralang by approximately 14 minutes, it requires an extra investment (approximately 6.7 billion Rp. for 4 make-ups). On the other hand, the difference in travelling time between non-tilting VVVF type MU train and locomotive hauled train is no more than 4 minutes.

Hence, the electric car, whether tilting or non-tilting, will not be adopted in this project.

8-4 Inspection and Repair of Motive Power Unit

Motive power unit should be maintained in accordance with the following system, to satisfy operating and safety requirements at all times.

Table 8.4.1 Types, Cycle and Places of Inspections

Types	Details	Cycle	Places
Daily check	Check of working conditions of main parts	72 hours	Depot
Monthly check		90 days	
Intermediate inspection	Inspection of principal equipment	36 months	Workshop
General inspection	Overhaul inspection	72 months	

CHAPTER 9 GROUND FACILITIES

CHAPTER 9 GROUND FACILITIES

9-1 Basic Requirements and Criteria

9-1-1 Climatic Conditions

(1) Climate data of the Section

a. Temperature (monthly average)
Max. 35.0°C (September); Min. 16.2°C (March)

b. Precipitation (monthly average)
Max. 936 mm (March)

c. Wind velocity (monthly average)
Max. 13.0 m/s (November)

d. Thunderstorms (per year)

Jakarta	85 days	Cikampek	135 days
Bandung	115 days	Cirebon	100 days

(2) Design criteria

On the basis of the above data, design criteria for the railway facilities and structures are established as follows:

a. Max. temperature: 40°C; Min. temperature: 15°C;
Temperature variation: 25°C

b. Max. wind velocity: 20 m/s

c. Measures against lightning will be provided for the railway facilities and equipment.

d. Max. seismic intensity: 0.1 kh scale

9-1-2 Clearance for Tunnel and Overpass Structure

The Sasaksaat tunnel and some of the road overpasses and aqueducts in the Section do not have sufficient clearance for constructing overhead line equipment.

In this project, the minimum clearance (H) is set at the lowest possible height in order to minimize the necessary reconstruction work: 4,600 mm for the tunnel; and 4,550 mm for overpass structures, while 4,400 mm will be employed for structures where non-live operation is possible (see Figs. 9.1.1 - 9.1.3 and Table 9.1.1).

Table 9.1.1 Minimum Clearance for Tunnel and Overpass Structure

(Unit: mm)

Height \ Structure		Tunnel	Overpass (live)	Overpass (non-live)
H:Minimum electrical clearance		4,600	4,550	4,400
T:Contact wire height		4,250	4,250	4,250
A:Rolling stock gauge		3,800	3,800	3,800
Breakdown	A': Pantograph folded down height	4,050	4,050	4,050
	B: Passing clearance (between live part and ground)	--	150	--
	C: Insulation clearance (between contact wire and folded pantograph)	200	200	200
	D: Height of contact wire supporting fixture	300 (500)	--	--
	E: Sag of contact wire	--	50	50
	F: Dynamic uplift of pantograph	--	50	50
	G: Tolerance	50	50	50
	Total	4,600	4,550	4,400

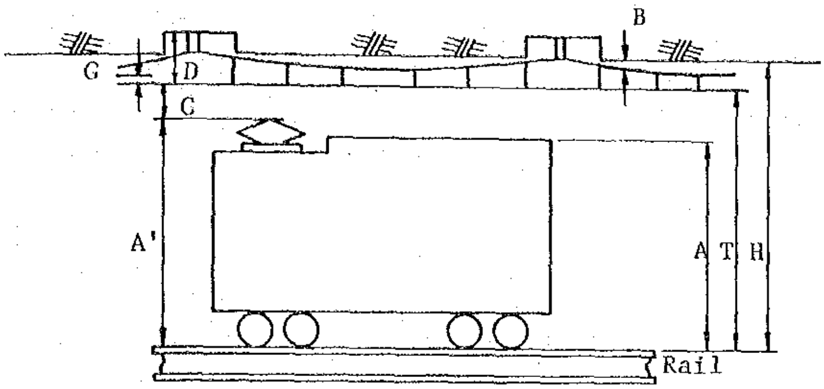


Fig. 9.1.1 Min. Clearance for Sasaksaat Tunnel

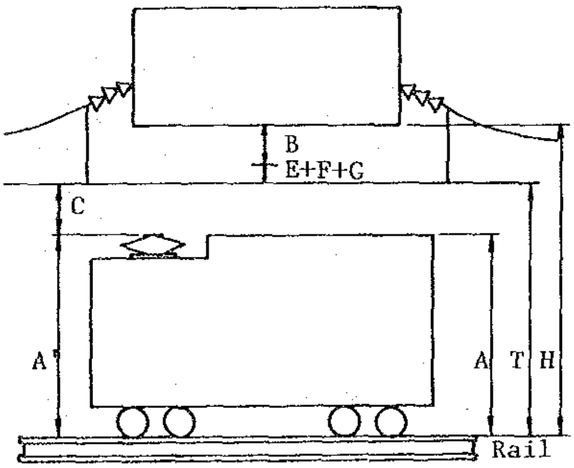


Fig. 9.1.2. Min. Clearance for Overpass Structure (Live)

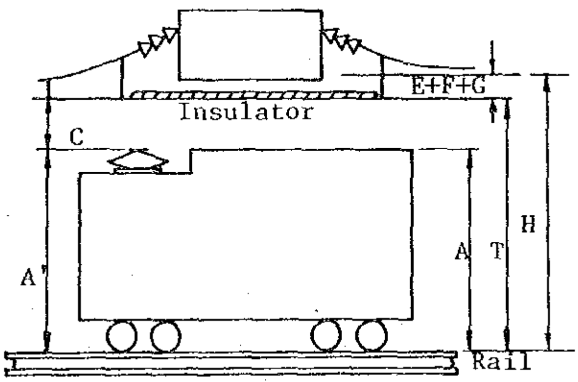
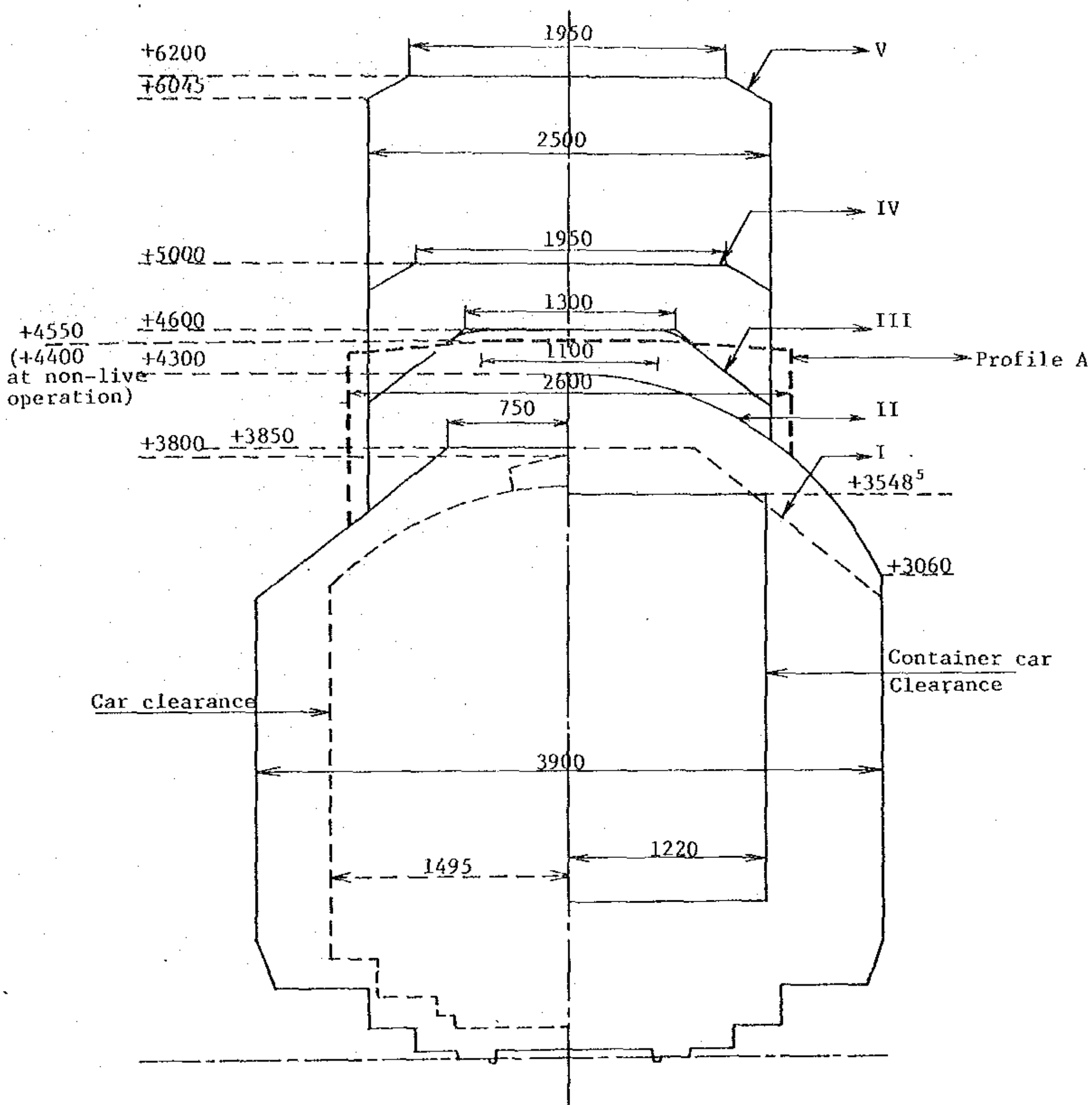


Fig. 9.1.3 Min. Clearance for Overpass Structure (Non-Live)

Note: Abbreviation in Alphabets, see Table 9.1.1.

9-1-3 Construction Gauge

The minimum construction gauge adopted in this project is shown in bold dotted lines (profile A) in Fig. 9.1.4 (See Appendix 9-1-1).



I: Minimum profile for bridge with speed restriction 60 km/hour

II: Minimum profile for tunnel and viaduct with speed restriction 60 km/hour and for bridge no restriction

III: Minimum profile for new viaduct and new construction, except tunnel and bridge

IV: Normal profile for DC Electrification

V: Normal profile for new viaduct

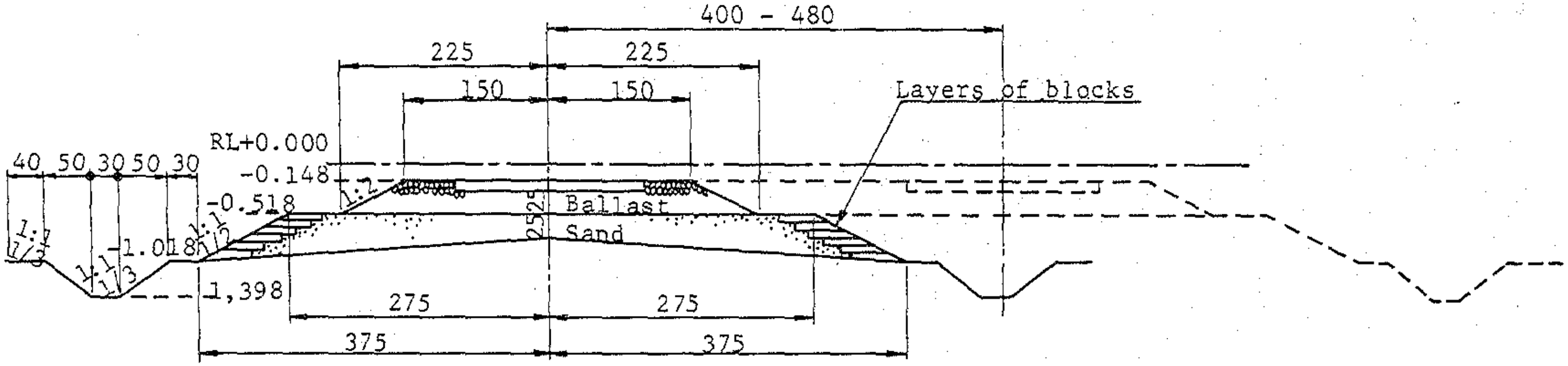
Profile A: Minimum profile for AC electrified section in this project

Source (I - V): Indonesian State Railways Construction Standards

Fig. 9.1.4 Construction Gauge

9-1-4 Standard of Roadbed Structure

The roadbed structure employed by PJKA is shown in Fig. 9.1.5.



Unit: cm

Fig. 9.1.5. Standard of Roadbed Structure

9-2 Electrification Facilities

9-2-1 Railway Substation (SS)

(1) Basic requirements

a. Power receiving equipment

Receiving voltage of the substation will be 150 kV or 70 kV. The power receiving equipment will employ a two-line system, with one as standby, to keep high reliability and maintainability.

b. Feeding transformer

Two single-phase transformers will be employed with one as standby.

c. Standard of substation facilities

SS facilities will be designed in accordance with the feeding voltage standard stipulated in *Union Internationale des Chemins de Fer* (UIC) code.

Table 9.2.1 Feeding Voltages

Category	Feeding voltage (kV)
Standard	25.0
Maximum	27.5
Minimum	19.0
Instantaneous voltage drop	17.5

d. Sectioning post (SP)

SPs to control power from different SS will be installed between SSs.

e. Sub-sectioning post (SSP)

To limit de-energized section, SSPs will be installed between SSs and SPs.

f. Autotransformer post (ATP)

To reduce voltage drop and inductive interference, ATPs will be installed at approximately 15 km spacing.

g. Control and maintenance

SSs will employ man-attended system. Maintenance depots for electrification facilities will be located in the substation compounds. The SPs and SSPs will be remote-controlled from the SSs.

h. Installation type

The SSs and other facilities will be of outdoor type.

i. Location

The SSs and other facilities will be located near the stations to facilitate construction and maintenance works (see Fig. 9.2.1).

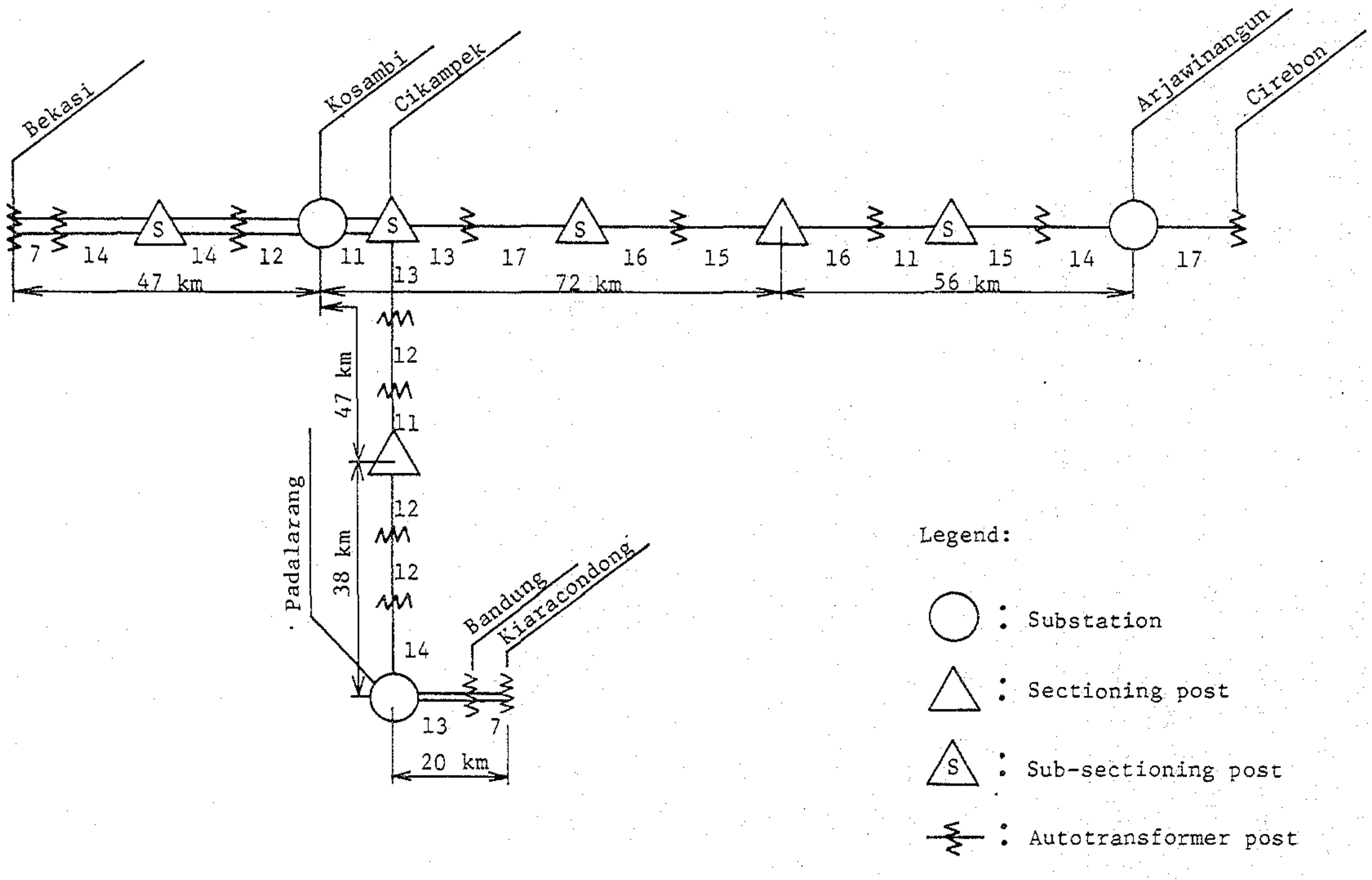


Fig. 9.2.1. Schematic Feeding System

(2) Substation equipment

a. Equipment in SS, SP and SSP

The main features of the equipment to be installed in SS, SP and SSP are listed in Tables 9.2.2 - 9.2.3.

b. One-line diagram and equipment layout

Standard one-line diagrams of SS, SP and SSP are shown in Figs. 9.2.2 - 9.2.4; equipment layout is shown in Fig. 9.2.5.

Table 9.2.2 Main Feature of the Equipment at Each Substation

Substation		Kosambi	Padalarang	Arjawinangun
Power receiving equipment	Voltage	150 kV	70 kV	150 kV
	Phase	Single-phase	Single-phase	Single-phase
	Number of lines	2 (Standby system)	2 (Standby system)	2 (Standby system)
Feeding trans-former	Voltage ratio	150/55 kV	70/55 kV	150/55 kV
	Phase	Single-phase	Single-phase	Single-phase
	Capacity quantity	20 MVA 2 (Standby system)	5 MVA 2 (Standby system)	15 MVA 2 (Standby system)
Feeding equipment	Number of lines	4	3	2
	Circuit breaker	One unit/line	One unit/line	One unit/line
	Auto-trans-former	One unit/line	One unit/line	One unit/line

Table 9.2.3 Major Equipment at SP and SSP

Facility	Equipment to be installed
SP	Circuit breaker x 1, Disconnecting switch x 2, AT x 2
SSP	Disconnecting switch x 2, AT x 1

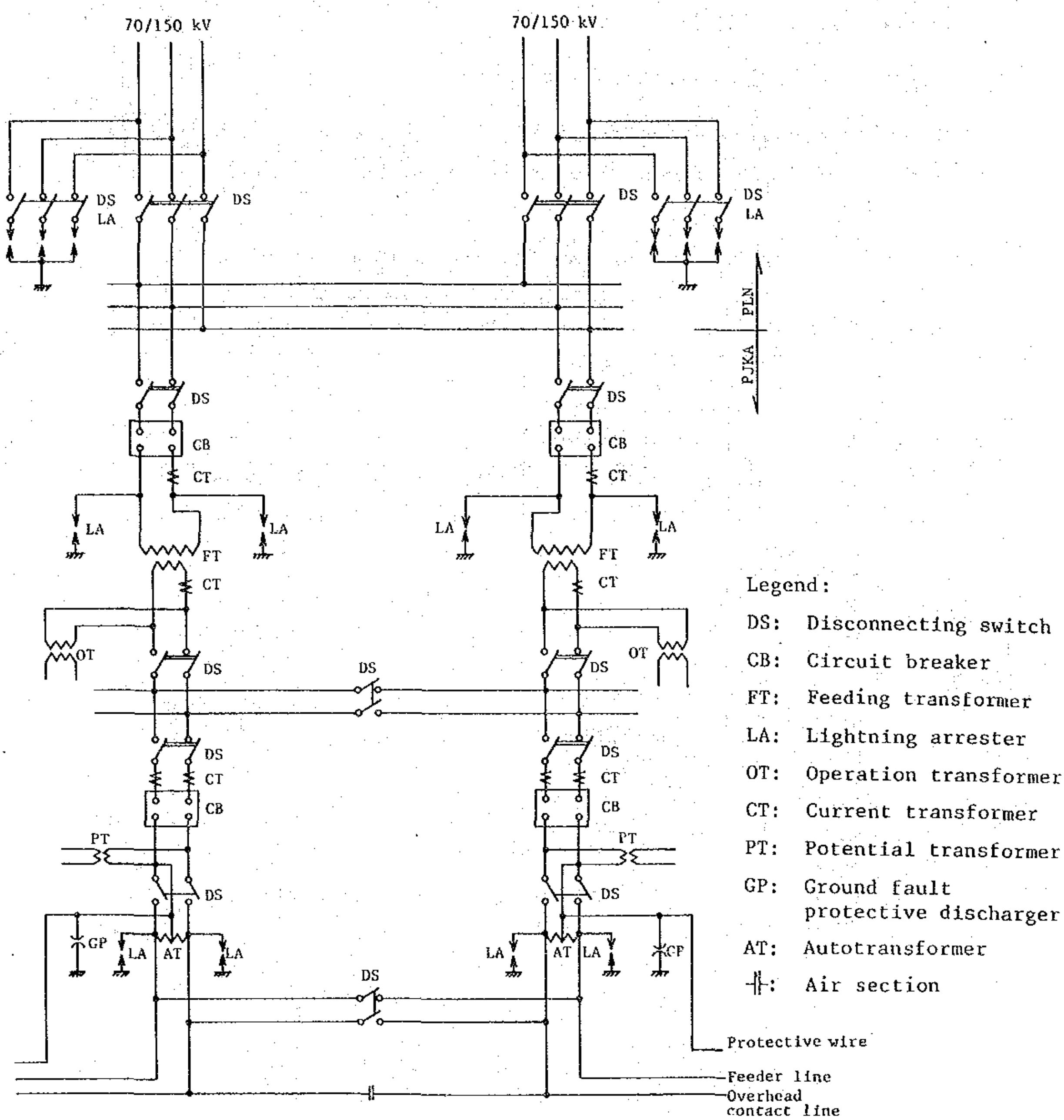


Fig. 9.2.2 Schematic Drawing of Substation

Legend:

AT: Autotransformer
DS: Disconnecting switch
CB: Circuit breaker
LA: Lightning arrester
OT: Operation transformer
PT: Potential transformer
GP: Ground fault protective discharger
-||-: Neutral section

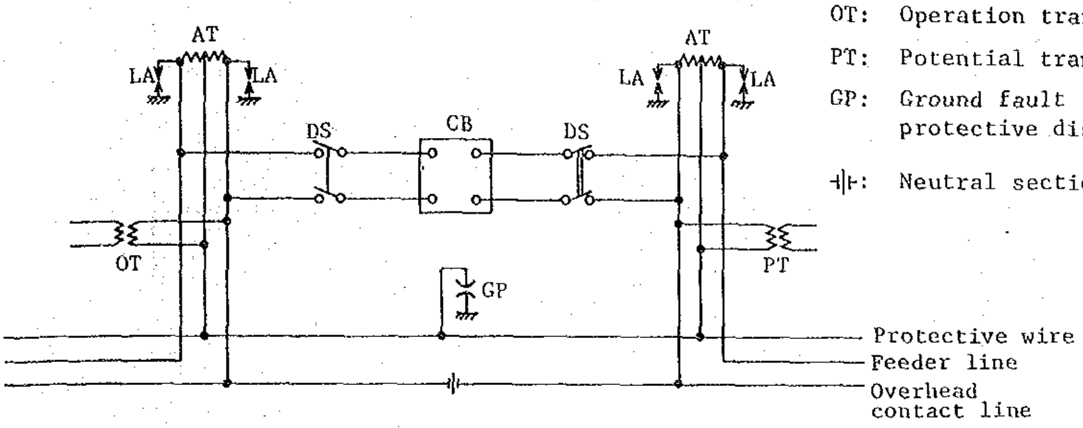


Fig. 9.2.3 Schematic Drawing of Sectioning Post

Legend:

AT: Autotransformer
DS: Disconnecting switch
LA: Lightning arrester
OT: Operation transformer
PT: Potential transformer
GP: Ground fault protective discharger
-||-: Air section

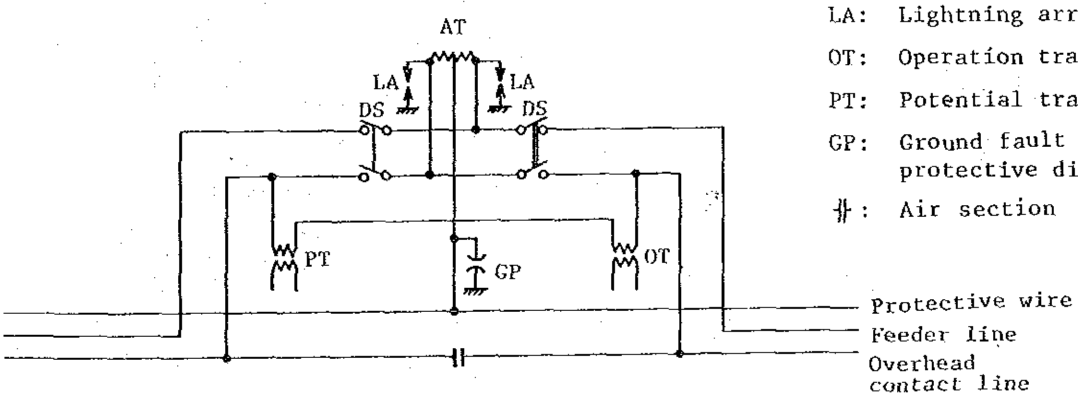


Fig. 9.2.4 Schematic Drawing of Sub-Sectioning Post

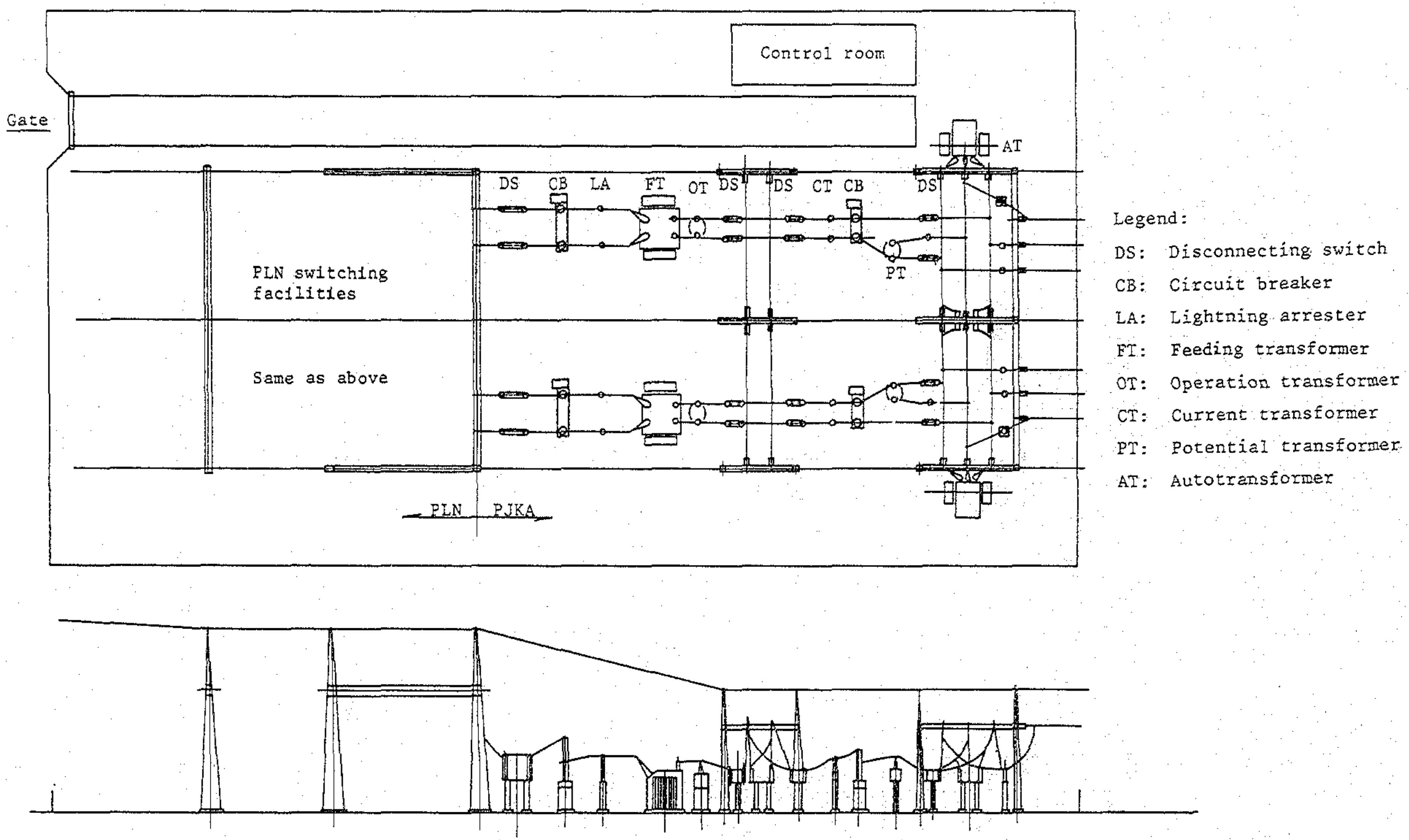


Fig. 9.2.5 Schematic Layout of Substation

9-2-2 Overhead Line Equipment

(1) Track to be electrified

Track to be electrified will be limited to the minimum extent necessary for operation of electric motive power unit.

(2) Overhead contact line

a. Catenary system

A simple catenary system, which allows the maximum operating speed of 120 km/h, will be employed for most of the Section.

A direct suspension system will be employed for mountainous sections between Purwakarta and Padalarang (50 km).

b. Types and usages of the overhead contact lines

They are summarized in Table 9.2.4.

Table 9.2.4 Types of Overhead Contact Lines and Related Tracks

Type	Description	Track	Cross secton (mm^2)
Catenary	Galvanized steel wire	Main and side tracks	90
Contact wire	Hard-drawn grooved contact wire	Main track Side track	110 85

c. Height of contact wire

Based on the JABOTABEK standard, the minimum height of the contact wire in AC electrified section is decided taking into account the increase in the height of the pantograph supporting insulator.

Table 9.2.5 Height of Contact Wire

Category	Height above the rail level (mm)
Standard	5,300
Maximum	5,900
Minimum	4,250

d. Standard wire tension and one tension length

They are determined in consideration of temperature changes, as shown in the table below.

Table 9.2.6 Standard Wire Tension and One Tension Length

Catenary system		Standard wire tension (ton)	One tension length (km)
Simple catenary system	Catenary	1.0	2.0
	Contact wire	1.0	
Direct suspension system		1.3	1.5

Tensioning devices will be installed at anchorage posts to keep the wire at a certain tension by absorbing the expansion and contraction due to changes in the ambient temperature.

e. Separation of traction current

The traction current will be separated as follows:

(a) Neutral section will be provided at the junction point between DC and AC electric traction systems.

(b) Neutral section to divide traction current from adjacent substations will be provided in front of a sectioning post.

In the neutral section in both (a) and (b), catenary will be separated by insulators, and contact wire will be separated by insulating bar that allows pantograph passing.

(c) Air section will be provided in front of substation and sub-sectioning post.'

(3) Feeder line

Feeder line to supply electric power to the overhead contact line will be fixed to a pole by cross-arm.

(4) Protective wire

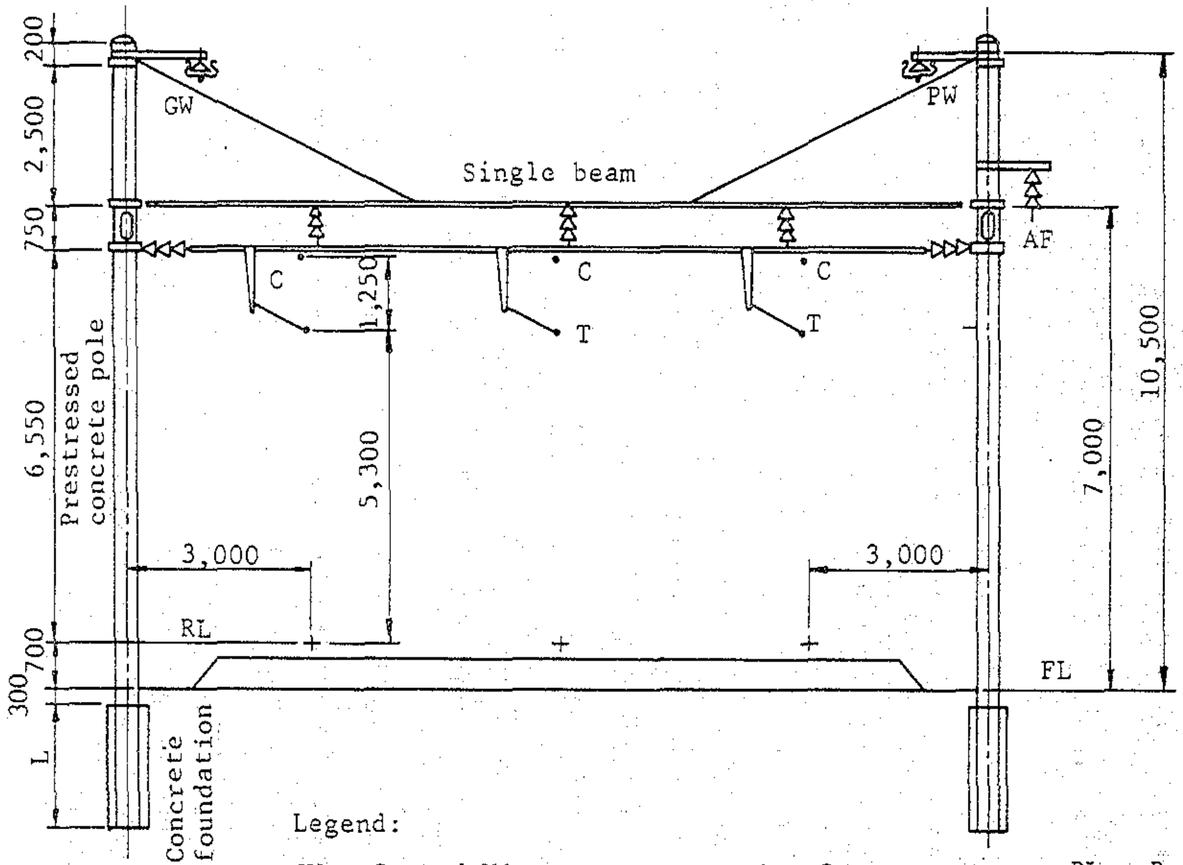
Protective wire will be installed to prevent fatal damage caused by flashover of insulators of the overhead line equipment (by instantaneously opening circuit breaker at the substation) as well as to protect it from earth fault accident (see Appendix 9-2-1).

(5) Supporting structure

a. Supporting method

Overhead line equipment will be generally supported by hinged cantilevers. Rigid beams or head-span catenary will be used in station yards with many tracks.

Direct support by stem insulator will be employed for the Sasaksaat tunnel to minimize reconstruction required. The standard configurations of each support type are shown in Figs. 9.2.6 - 9.2.8.



Legend:

GW: Ground Wire
PW: Protective Wire
AF: Autotransformer Feeder
C: Catenary
T: Contact Wire
RL: Rail Level
FL: Formation Level

Fig. 9.2.6 Standard of Overhead Line Equipment (In Big Station Yard)

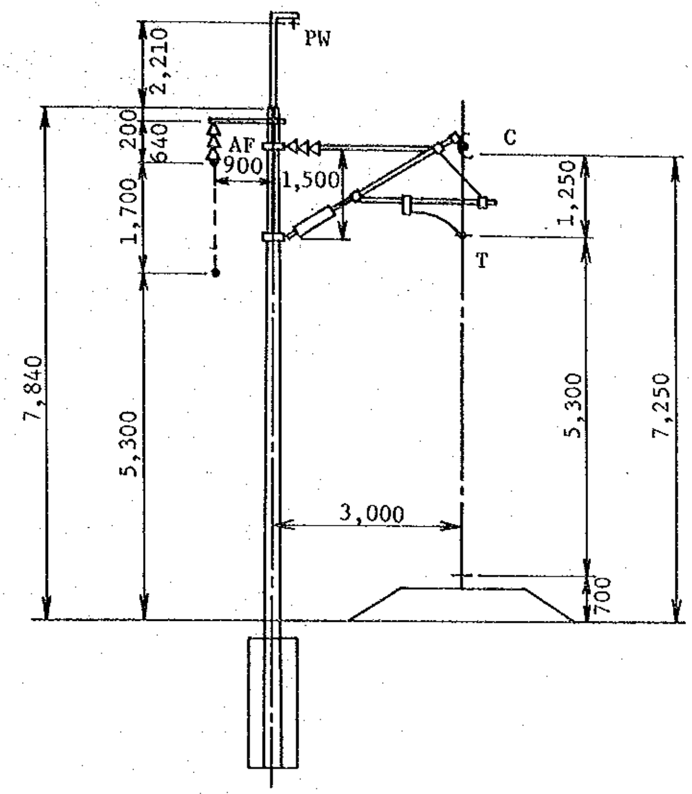


Fig. 9.2.7 Standard of Overhead Line Equipment (Simple Catenary System)

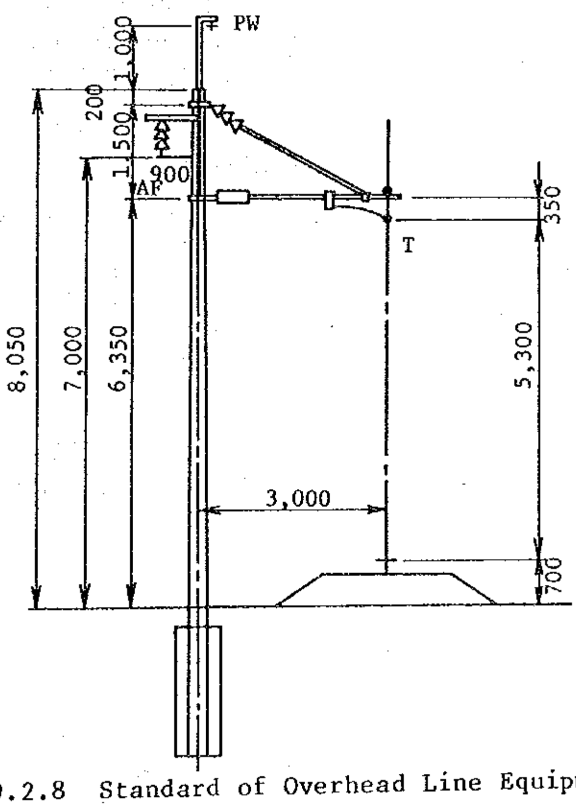


Fig. 9.2.8 Standard of Overhead Line Equipment (Direct Suspension System)

b. Types of pole

In general, concrete poles will be used. Steel masts will be installed for points subject to heavy equipment loads or restricted construction gauge.

c. Span of poles

The standard span of poles is described in the table below.

Table 9.2.7 Standard Span of Poles

Min. curve radius (m)	Span (m)
3,000	70
1,500	60
800	50
500	40
300	30
200	20

Each pole will be supported by either a concrete foundation or crushed stone foundation depending on the load, topography and soil conditions.

9-3 Modification of the Existing Facilities

9-3-1 Track

(1) Track structure

a. Single-track section

Existing track structure allows an operating speed of 100 km/h, so track renewal is not planned in this project.

b. Curve section

In the mountainous area between Purwakarta and Bandung, curves that necessitate speed limits extend approximately over 40 km.

c. Double-track section

Existing track structure allows operating speeds of 100 to 120 km/h, so track renewal is not necessary.

(2) Replacement of steel ties

Turnouts at all stations use steel ties. To introduce relay interlocking system, the steel ties (which cause short-circuits between rails) must be replaced by wooden ties.

The number of turnouts are summarized in Table 9.3.1.

Table 9.3.1 Number of Turnouts which Require Tie Replacement

Type of turnouts / Section	10# (set)	Scissors crossing 10# (set)	Double slip switch 10# (set)	Diamond crossing 10# (set)
Bekasi - Cikampek	61	1	13	2
Cikampek - Cirebon	67	0	2	0

9-3-2 Structure

(1) Sasaksaat tunnel

To increase the clearance of the tunnel, a roadbed lowering method will be employed in view of economy and safety. Its reconstruction work must be carried out while keeping the trains in operation, as it is located in a single-track section in the mountainous terrain without any alternative service. The work sequence is shown in Appendix 9-3-1.

Seeping water in the tunnel will be led outside through conduits, thereby preventing possible damage or disturbance to the operation of the electric train.

(2) Bridge

Railway bridges, road overpasses and aqueducts which will interfere with the electric train operation due to insufficient height must be reconstructed.

In this project, the minimum height between rail level and over-bridge is set at 4,550 mm while 4,400 mm clearance will be employed for structures where non-live operation is possible in order to minimize the reconstruction work required.

Structures to be reconstructed and their reconstruction methods are described below.

a. Railway bridge

Railway bridges with upper lateral or sway bracings that will interfere the electric train operation are listed in Table 9.3.2.

Table 9.3.2 Railway Bridges to be Reconstructed

Section	Location	Bridge No.	Span (m)	Clearance (m)	Deficiency of clearance (cm)	Type
Bekasi - Cikampek	26 km 970 m	134	70	—		2
Cikampek - Cirebon	193 km 900 m	540	30	4.05	50.0 	1
"	210 km 196 m	643	40	3.97	58.0 	1

The reconstruction method is shown in Appendix 9-3-2.

b. Road overpass

The road overpasses that will interfere with the electric train operation are shown in Table 9.3.3.

Table 9.3.3 Road Overpass to be Reconstructed

No.	Section	Location	Bridge No.	Width (m)	Clearance (m)	Deficiency of clear-ance (cm)
1	Cikampek - Kiaracondong	154 km 643 m	721C	11.0	4.20	35.0
2	"	155 km 360 m	—	2.25	4.10	45.0

For reconstruction, beams will be raised to obtain the required clearance.

c. Aqueduct

The aqueducts that will interfere with the electric train operation are shown in Table 9.3.4.

Table 9.3.4 Aqueducts to be Reconstructed

No.	Section	Location	Aqueduct No.	Clear-ance (m)	Deficiency of clear-ance (cm)	Other
1	Cikampek - Kiaracondong	123 km 413 m	411	4.20	35.0	
2	"	123 km 639 m	412	4.20	35.0	
3	"	124 km 838 m	421	4.10	45.0	
4	"	125 km 306 m	424	4.10	45.0	Width 2.9 m
5	"	125 km 432 m	425	4.07	48.0	
6	"	126 km 438 m	434	4.07	48.0	
7	"	129 km 529 m	449	4.09	46.0	
*8	"	143 km 800 m	677	4.50	5.0	
*9	"	150 km 753 m	713	4.40	15.0	Width 5.5 m

Note:* Aqueducts No. 8 and No. 9 are excluded from reconstruction by non-live train operation.

Aqueduct No. 4 will be reconstructed by lowering the roadbed, and other aqueducts will be remodeled into siphon-like water channels.

9-3-3 Station

(1) Effective track length

Passenger train:	Make-up of 10 cars	:	260 m
	6 cars	:	180 m
Freight train :	Bekasi - Cirebon Section (1,000 t trailing)	:	460 m
	Cikampek - Bandung Section: (600 t trailing)		300 m

(2) Station to be improved

a. Station facilities

Fig. 9.3.1 shows stopping stations for each train type and number of passing tracks required. The number of stations which require extension of effective track length, construction of passing tracks, and extension of platforms are listed in Table 9.3.5.

Table 9.3.5 Stations to be Improved

Section	Extension of track effective length		Construction of passing track		Extension of platform		Construction of new platform		Remarks
	No. of stations	No. of tracks	No. of stations	No. of tracks	No. of stations	No. of tracks	No. of stations	No. of tracks	
Bekasi-Cirebon	1	3	2	3	21	27	9	10	Including Cikampek
Cikampek - Kiaracondong			2	2	12	12	7	8	Excluding Cikampek
Total	1	3	4	5	33	39	16	18	

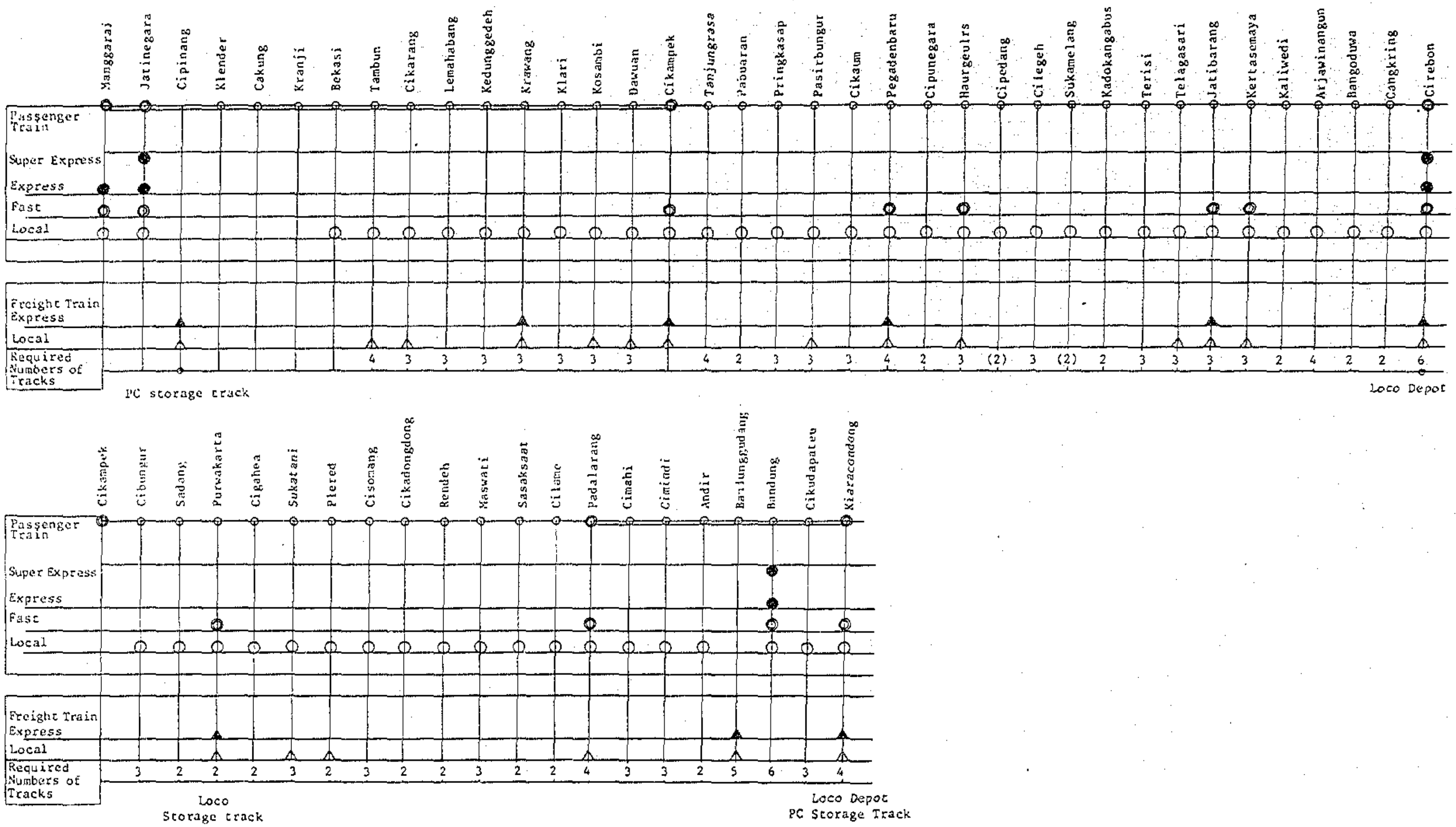


Fig. 9.3.1 General Information for Station Yards

b. Passing facilities

To increase track capacity between Cikampek and Cirebon, passing tracks will be constructed at Cipedang and Sukamelang stations in 1997 to allow trains to pass through.

9-3-4 Rolling Stock Depot

The following locomotive depots will be constructed to inspect the AC/DC dual current locomotives.

Table 9.3.6 Proposed AC/DC Electric Locomotive Depots (1992)

Depot	No. of locomotive	Type of inspection
Cirebon	42	Daily check Monthly check
Kiaracondong	16	Daily check

Passenger cars will be stored in Jakarta Kota depot for the time being. New storing tracks should be constructed in Cipinang when JABOTABEK EMU trains will be operated with shorter headway and the terminal for some long distance trains will be changed to Manggarai.

9-3-5 Inspection and Repair Workshop

(1) Selection of workshop

Utilization of existing workshops for repairing the electric locomotive is considered most advantageous, for equipment investment can be saved and skilled workers can easily be obtained. These workshops are expected to have enough capacity to cope with future increase in electric locomotive due to expansion of the electrification.

Comparative evaluation conducted from above viewpoints on the existing workshops are summarized in Table 9.3.7.

Table 9.3.7 Conditions of Existing Workshops

Workshop	Work space	Workshop location	Availability of existing facilities and maintenance personnel	
			Facilities	Personnel
Manggarai (EC, PC)	C	A	D	B
Yogyakarta (DL)	A	B	A	A
Surabaya (FC)	C	C	D	D
Semarang (PC)	B	C	D	D

Legend: A; Better, B; Good, C; Not good, D; Bad

Table 9.3.7 indicates that the Yogyakarta workshop is most suitable for maintaining electric locomotives.

(2) Workshop facilities

Electric locomotives will be repaired together with diesel locomotives at the Yogyakarta workshop. Therefore, the following facilities must be added, while utilizing the existing ones to the maximum extent.

a. A new body shop will be constructed to allow electric and diesel locomotives to be disassembled and repaired in an assembly-line system.

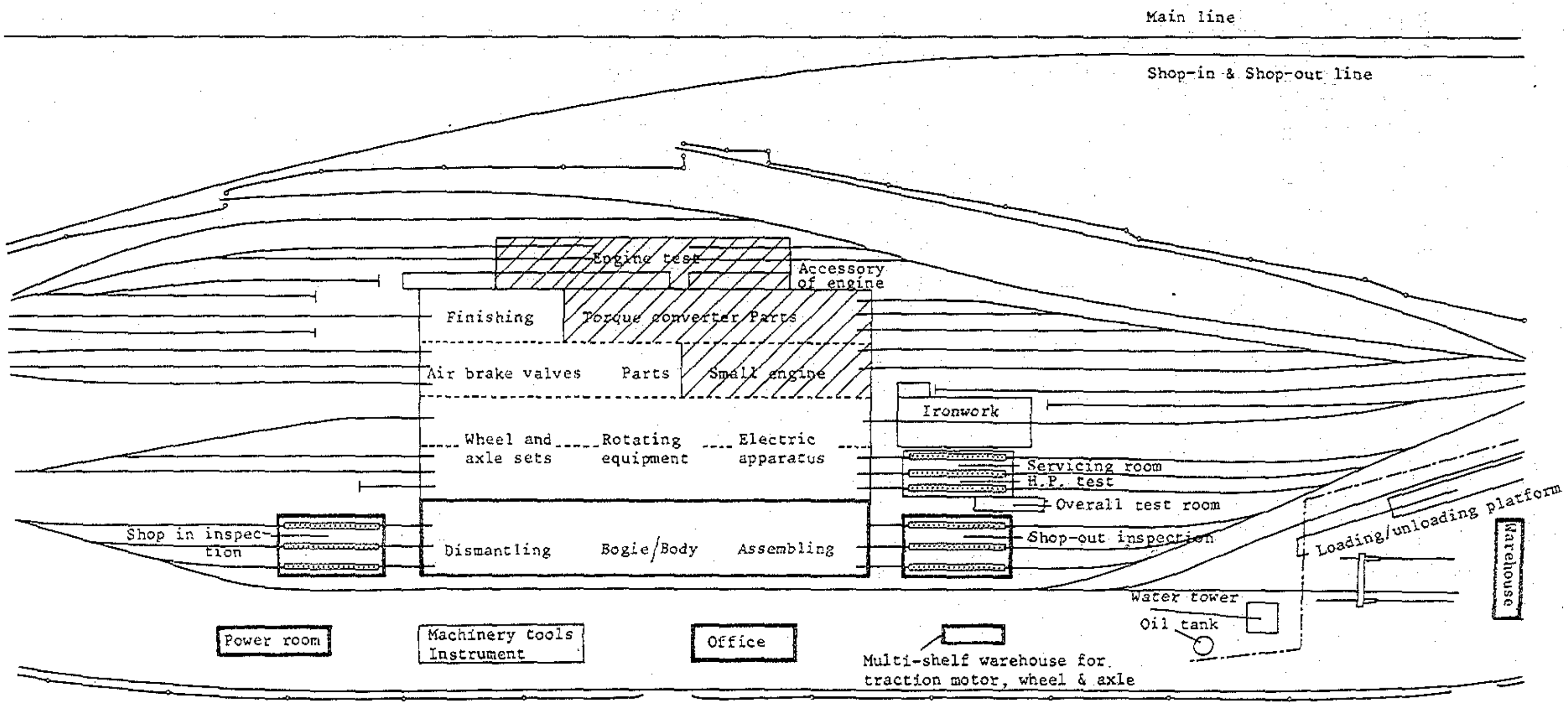
b. In the old body shop, facilities will be arranged parallel to the new body shop to enable repair work for bogies, traction motors and electrical equipment in an assembly-line system.

c. Locomotive shop-in/out inspection rooms will be provided at both ends of the new body shop.

d. Boilers and power receiving/distribution equipment will be installed to improve cleaning/washing capacity.

e. A multi-shelf warehouse for storing wheels, axles and traction motors will be constructed to facilitate spare parts control.

The above plans are illustrated in Fig. 9.3.2.



Remarks; Heavy line shows newly constructed building.
Striped buildings are for repairing of *Diesel locomotives*.
Other buildings are for repairing of both Diesel and Electric locomotives.

Fig. 9.3.2 Improvement Plan of the Yogyakarta Workshop

9-3-6 Power Distribution Equipment

(1) Reconstruction of power distribution euipment

The following power distribution equipment will be reconstructed to facilitate electrification:

a. Overhead power transmission lines crossing over the railway will be replaced with underground cables if insulation clearance from the overhead contact line is insufficient.

b. The lighting equipment at each station yard will be rearranged, if necessary.

c. Lighting equipment and power supply facilities will be constructed at depots.

(2) Installation of line transformer

Line transformers (25 kV/220 V) will be attached to the overhead contact line to provide power for stations, wayside signals and major level crossings.

9-3-7 Signalling Facilities

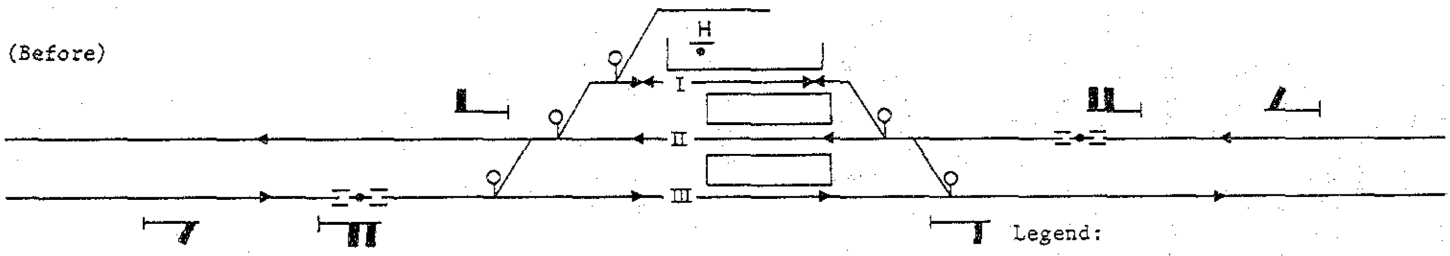
To ensure high speed and frequent train operation, signalling facilities will be improved in accordance with the following principles:

a. To increase traffic density.
b. To ensure safety of high-speed train operation.
c. To improve maintainability and reliability.

In addition, the signalling facilities will be improved considering overall train operation and maintenance.

Typical signalling facilities at a station before and after the project are shown in Fig. 9.3.3.

(Before)

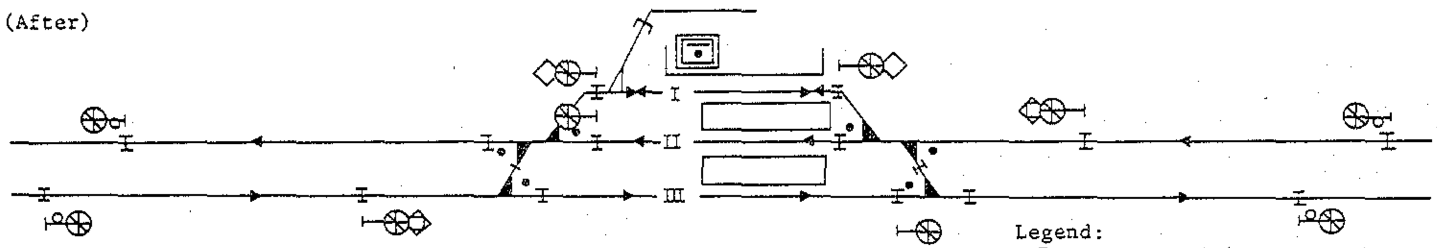


Block system	:	Electro-mechanical tokenless block (S & H type)
Interlocking device	:	Mechanical Interlocking
Signal device	:	Mechanical signal
Point machine	:	Mechanical point machine
Train detection device	:	Rail contact
Power source	:	PLN or none

Legend:

- : Starting signal
- : Home signal
- : Distant signal
- : Mechanical point machine
- : Rail contact

(After)



Block system	:	Automatic block
Interlocking device	:	Relay/Electronic
Signal device	:	Color light signal
Point machine	:	Electric point machine
Train detection device	:	Track circuit
Power source	:	Overhead contact line

Legend:

- : Starting/home signal
- : Block signal
- : Electric point machine
- : Mechanical point machine (Field operation)
- : Insulated rail joint (Section of track circuit)
- : Insulated rail joint (End of track circuit)

Fig. 9.3.3 Improvement Plan of the Signalling System

(1) Block system

The S & H type tokenless system currently used will cause the following drawbacks in terms of safety and track capacity due to increase in train speed and traffic density.

a. In sections with heavy traffic, the required train headway can not be achieved by using existing single block system between stations.

b. Block handling by hand generator and mechanical lever is time-consuming.

c. The system cannot guarantee sufficient safety, as train detection function, which is vital for block setting, is not reliable and needs to be supplemented by the station master.

Thus, the existing block system will be replaced by other systems in accordance with the traffic density on each of the three sections.

a. Bekasi - Cikampek (double-track section)

   Block signals will be installed between stations to allow successive train operation. Continuous track circuits will be installed between stations to detect train position and to control the block signals automatically. Each block length will be approximately 2 - 2.5 km long (see Appendix 9-3-3).

b. Cikampek - Cirebon (single-track section)

   Like the Bekasi - Cikampek section, block signals and continuous track circuits will be provided between stations. Block length will be approximately 2 - 2.5 km.

c. Cikampek - Karacondong (single/double-track section)

   As a relatively small number of trains is operated, block signals will not be provided between stations.

Instead, each inter-station section will constitute a single block, where trains can be detected by check-in/check-out devices at approaches to each station.

However, this section will be converted to a block signalling system after electrification when the traffic volume will reach approximately 50 trains per day.

The block system for each section is illustrated in Fig. 9.3.4.

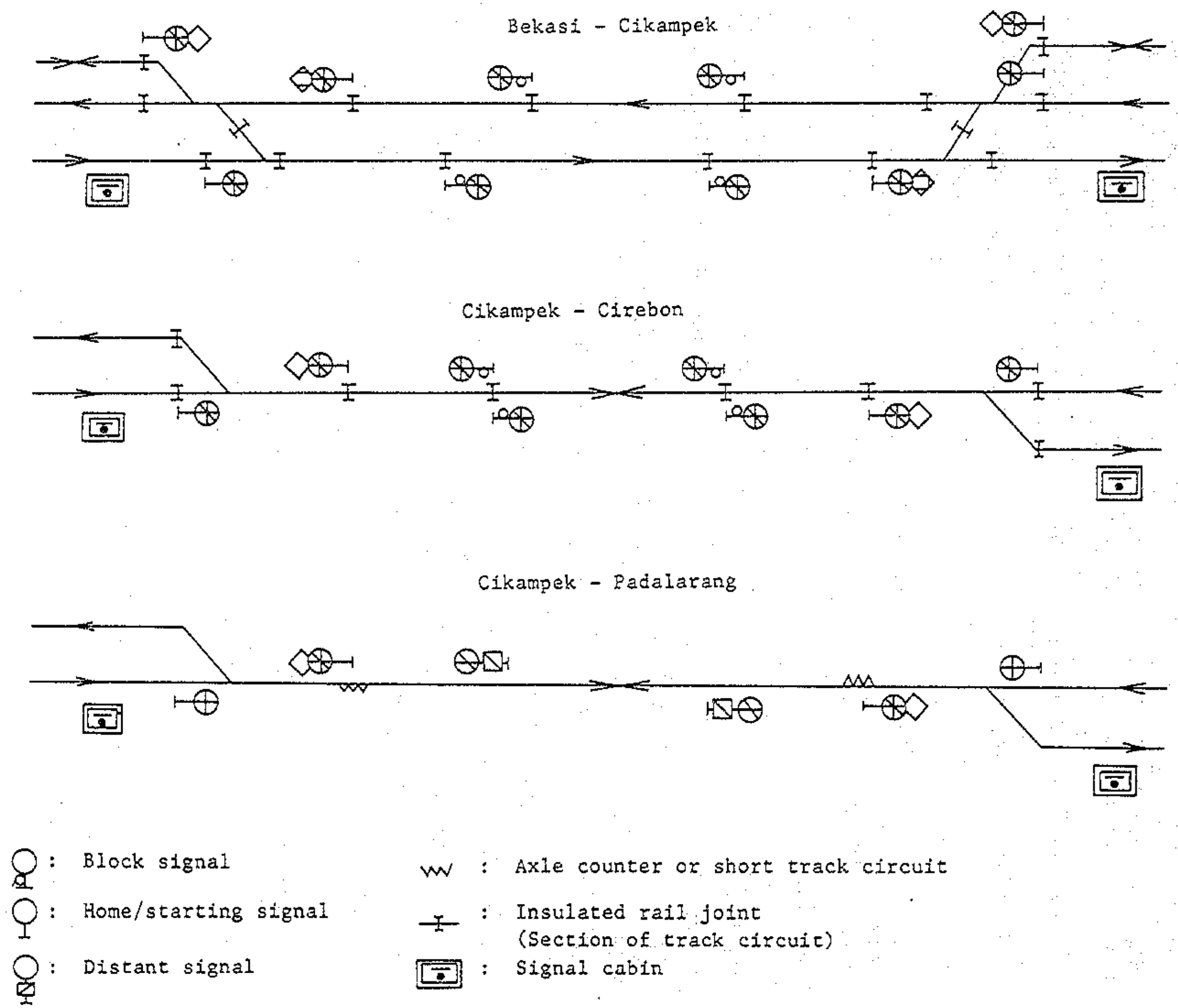


Fig. 9.3.4 Block System Plan

(2) Interlocking device

a. Bekasi - Cirebon

In view of the increased train speed and traffic density, the present mechanical interlocking devices will be replaced by either relay interlocking devices or electronic interlocking devices, due to the following reasons:

(a) Because of the lack of train detection function, incorrect point switching may happen possibly leading to a train collision or derailment.

(b) Manual handling of levers and related devices takes considerable time and manpower.

Meanwhile Cikampek and Cirebon stations, where relay interlocking devices are being installed under other projects, will not be included in this plan.

b. Cikampek - Bandung

In view of the relatively light traffic, existing mechanical interlocking devices will be utilized with minor modification until the stage when traffic volume will reach approximately 50 trains per day.

(3) Signal device

a. Signal device

Being hand-operated through lever and wire, existing semaphore signals, especially distant signals, are hard to operate, and signal indications are difficult to identify at night. Also, visibility of semaphores may be hindered by electrification poles and other equipment. For these reasons, they must be replaced with color light signals.

b. Signal indication

Unification of signal indication is preferable to facilitate long distance train operation. Also, it should be as simple as possible to prevent misunderstanding by engine driver. Taking into account the above requirements, a 3-aspect signal system which will be employed in the JABOTABEK lines will also be employed.

Turnout speed limit will be indicated on a special indicator to be attached to the related signals.

(4) Point switching device

a. Bekasi - Cirebon

Electric point machines will be employed for turnouts on the main tracks. For turnouts in side tracks that are not frequently used, field-operated mechanical point machines with interlocking functions will be used.

b. Cikampek - Kiaracondong

Existing mechanical points will be used as long as mechanical interlockings are utilized.

(5) Track circuits

a. Bekasi - Cirebon

(a) Track circuit in station yard

DC track circuit will be used, for the reasons given in 7-3.

(b) Track circuit between stations

LF code track circuit will be used, for the reasons given in 7-3.

(c) Track modification

At present, track circuit cannot be fully installed in the station yard because steel ties are used for the turnouts. This can be solved either by insulating the rails (inserting insulation material between ties and rails) or by replacing the steel ties with wooden ones. For this project, the latter method will be taken, in consideration of the deterioration of the existing crossties, and the stability and maintainability of the track circuits.

In addition, the following improvements will be required to ensure reliable train detection functions in each track circuit:

(i) Insulation of through girders of railway bridge

(ii) Preservation of track circuit characteristics (leakage conductance of less than 0.5 s/km) by maintaining roadbed and ballast conditions

(iii) Flood prevention by providing water drains

b. Cikampek - Bandung

No track circuit except short track circuit for block system will be installed until the stage when relay/electronic interlocking devices will be introduced.

(6) Level crossing facilities

At present, train departure is notified to all manned level crossings by means of hand generators operated by station attendants. So each crossing receives notification simultaneously, which makes it difficult to block road traffic at the appropriate timing, possibly causing unnecessary traffic jam or accident. This situation will worsen after completion of the project, when train speed will be increased.

To improve this situation, the level crossings will be provided with devices that detect approaching trains and automatically alarms gate keepers, pedestrians and vehicles. This improvement will be done for all manned level crossings except those which are located in the mountainous section between Purwakarta and Padalarang where train speed remains relatively low.

The installation of crossing barriers for manned level crossing will be carried out in another PJKA project, and thus will not be included in this project.

(7) Power source

Electric power supply from PLN network is not available at some stations between Cikampek - Padalarang and Cikampek - Cirebon. Furthermore, the reliability of the low voltage PLN power supply is not sufficient.

Hence power for the signalling system will be obtained primarily from the overhead contact line as shown in Table 9.3.8.

Table 9.3.8 Signalling Power Sources

Power source / Place	Main	Sub
Station	Overhead contact line	PLN or engine generator
Block signal	Overhead contact line	—
Level crossing	Overhead contact line or PLN	Battery

The signalling power source plan is shown in Fig. 9.3.5.

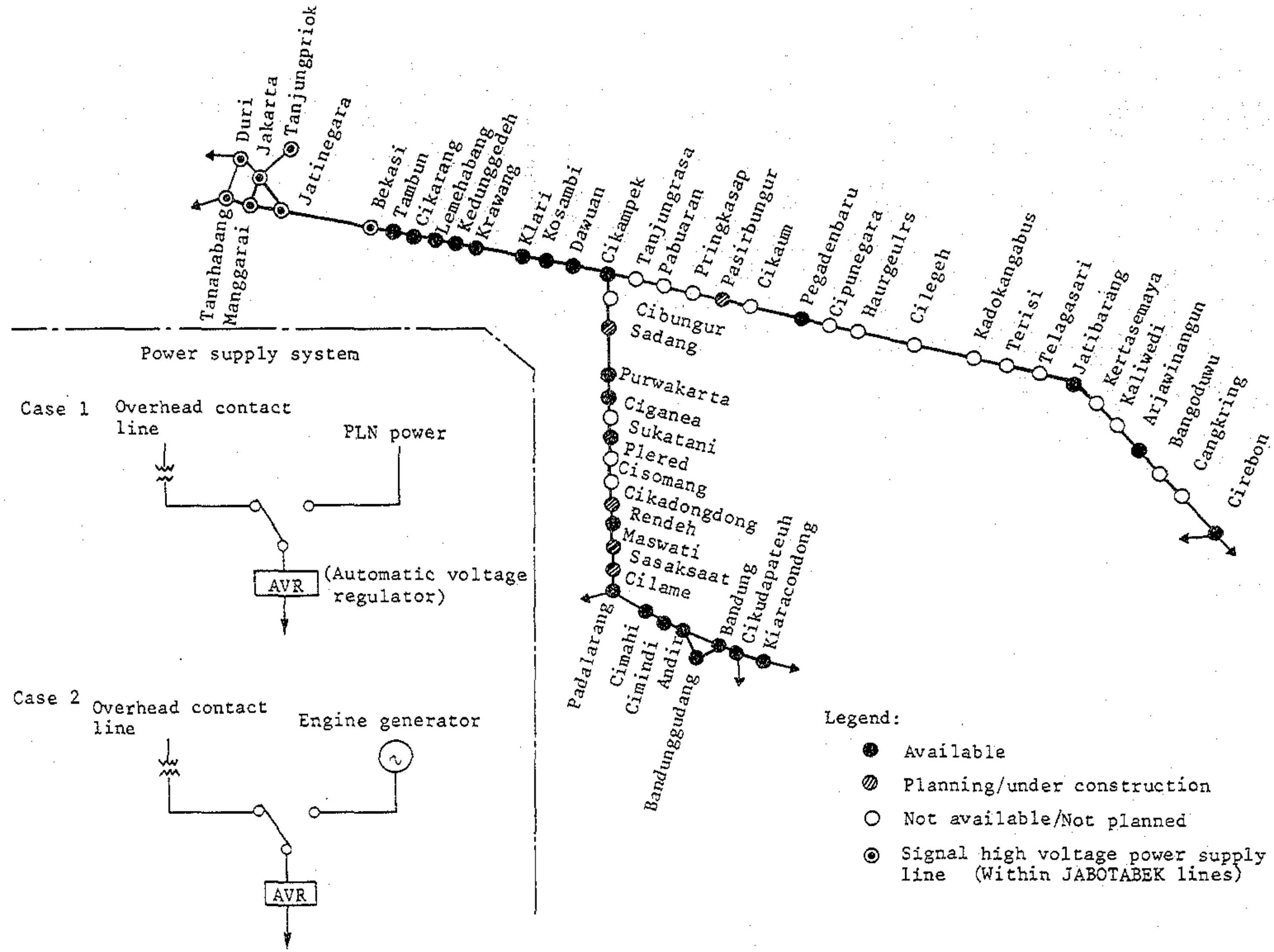


Fig. 9.3.5 PLN Power Supply Availability at Each Station

9-3-8 Communication Facilities

In order to cope with needs for improved information capacity to facilitate increased train operation and communication interference caused by AC electrification, the existing communication system must be upgraded in accordance with the following principles:

a. To provide inductive interference countermeasures for PJKA and PERUMTEL open wires,

b. To maximize use of the existing communication system, while ensuring coordination between the existing and new communication system, and

c. To improve the efficiency and maintainability of the communication system.

The improvement plan for the communication system is shown in Fig. 9.3.6.

(1) Communication line

a. Long distance communication line

As shown in 3-3-3, at present, only 24 to 36 channels of the 72 UHF link channel capacity are in use. The long distance communication line capacity can be improved by increasing the number of the UHF channels. Thus, the UHF radio link will accommodate channels for dispatcher/exchange/direct telephone, teleprinter, CTC, etc. In future, beyond the present capacity of 72 channels, fiber optics will be considered.

b. Short distance communication line

Two screened conductor cables immune to inductive interference will be burried along the rail.

One cable will accommodate PJKA communication channels such as block telephone, party telephone, subscriber line, block circuit, etc. The other cable will accommodate PERUMTEL communication channels for telephone and telegraph.

The capacity of PJKA cable will be 30 p for the Bekasi - Cikampek section and 20 p for other sections, while that of PERUMTEL cable will be 20 p.

For reference, communication system based on fibre optics is shown in Appendix 9-3-4.

(2) Communication equipment

a. Automatic exchange telephone

Automatic exchange telephones will be installed at each station to facilitate exchange of increased business information.

b. Dispatcher telephone

The existing system will still be used after electrification.

c. Replacement of telegraph by telephone

Existing Morse-telegraph will be replaced by telephone to improve work efficiency.

(a) T-telegraph (block telegraph)

Block telegraph for communication between adjacent stations will be replaced by block telephone, to which a voice recorder will be attached to record oral block-arrangement.

(b) B-telegraph (party telegraph)

Party telegraphs will be replaced by party telephone.

(c) A-telegraph (direct telegraph)

A-telegraph will be replaced by direct telephone at stations where super-express/express passenger trains and express freight trains will stop (see Fig. 9.3.6).

d. Teleprinter

Additional teleprinters will be installed at Bandung, Cirebon and Cikampek, and newly installed at Bekasi and Kiaracondong.

e. Wayside telephone

To facilitate communication between station and inter-station section, wayside telephone (magnetic) will be installed at inter-station section (every 1 km) and level crossings.

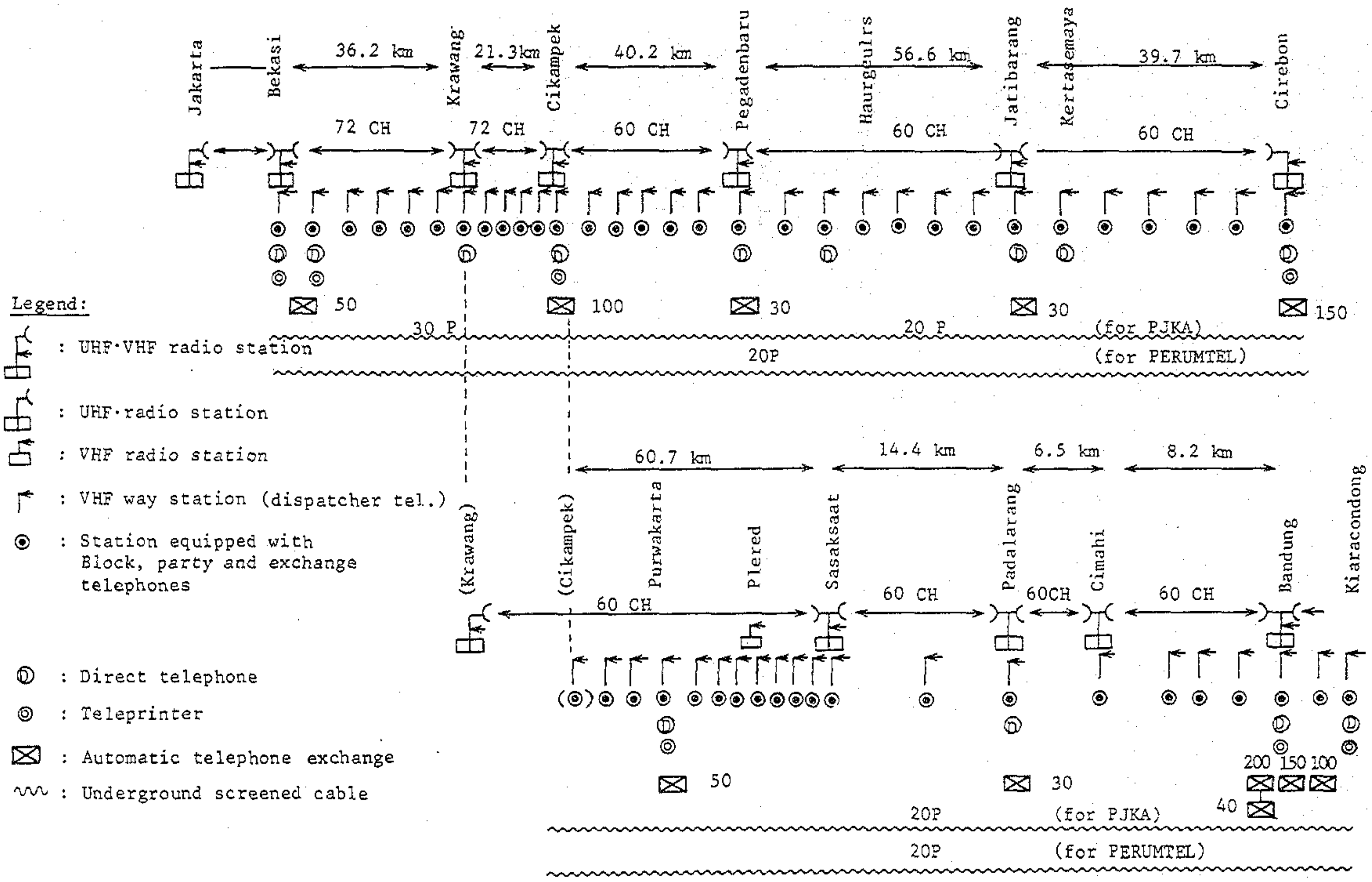


Fig. 9.3.6 Improvement Plan for the Communication System

9-3-9 Train Dispatching System

CTC system will be employed in Cikampek - Cirebon section to increase efficiency in train operation. The CTC will have the following functions;

(1) To indicate the train location,
(2) To indicate the train route,
(3) To record the actual train diagram, and
(4) To remote-control train routes of each station.

Remote-route-control and rescheduling of train diagram will be conducted timely and appropriately by a train dispatcher, facilitated by overall traffic information, provided through CTC and other dispatcher communication equipment.

In this context, the following improvements are expected to make full use of the CTC system.

(1) To devolve the train control authority from the station master to the train dispatcher.

(2) To introduce a system to detect every train before it enters the Cikampek - Cirebon section.

Duplex communication lines will be provided between central and local CTC devices, using metallic cables and UHF radio as shown in Fig. 9.3.7.

Legend:

DPU: Data processing unit

DTU: Data transmission unit

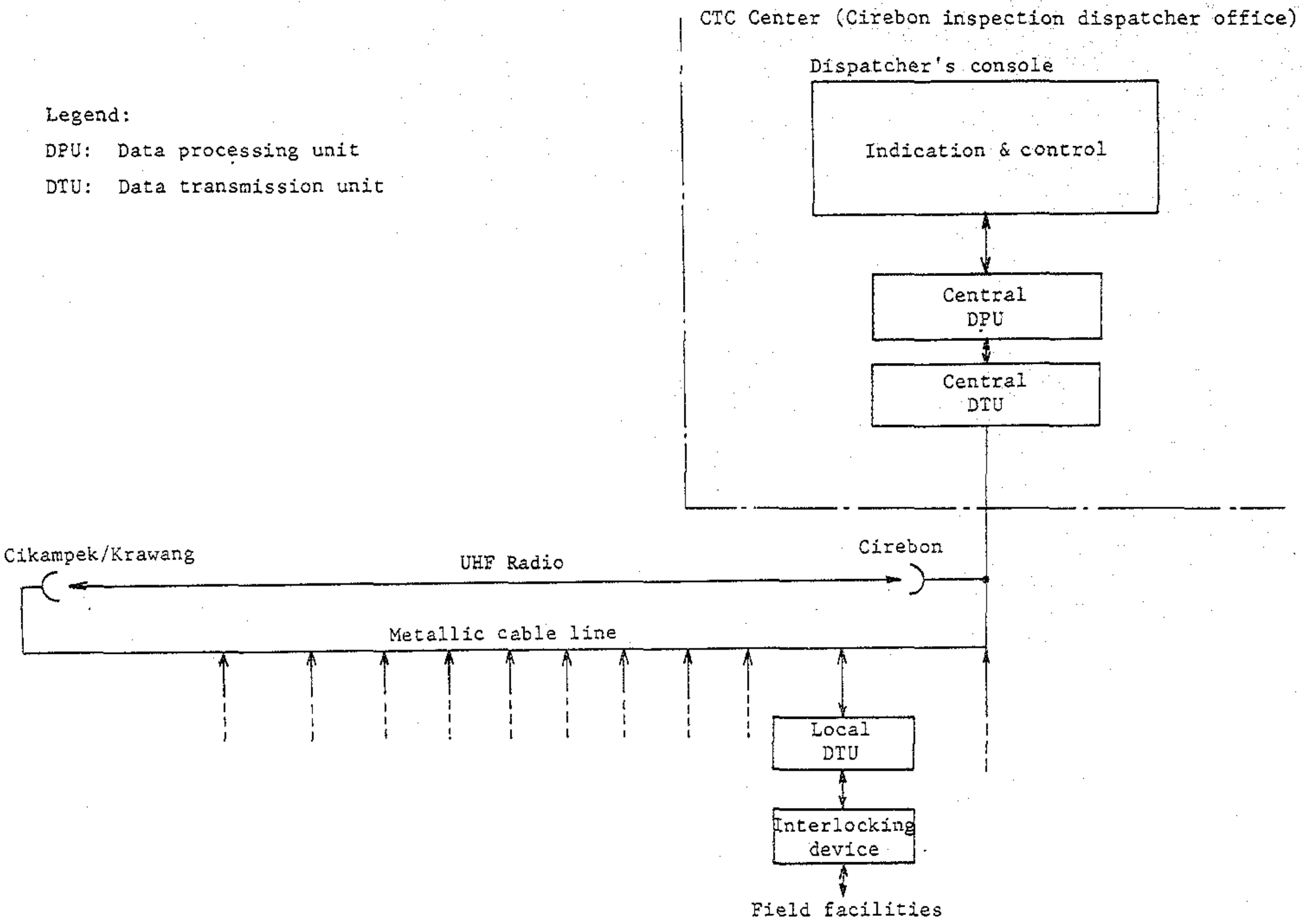


Fig. 9.3.7 CTC System Plan