3.2.4 Number of Locomotives

The number of locomotives is decided by preparing a locomotive rostering diagram based on a train diagram and considering depot access, time for inspection and rostering reserve into consideration. Since, however, the master plan did not contain any train diagram, the number of locomotives was decided by an approximate calculation.

(1) Calculation of number of electric locomotives

This number was calculated under the following conditions:

1) All trains in electrified sections are hauled by electric locomotives.

2) In the present train diagram, the number of express trains is overwhelmingly larger than that of local trains, but the Link average operation time was determined by assuming 2:1 as the future ratio between the number of express and fast trains and the number of local trains.

3) The average switchback time of locomotives at terminal stations is 40 minutes for passenger trains and 80 minutes for freight trains.

4) The daily average use time of locomotives is 16 hours. (The use time of the present CC201 diesel locomotives is 13 ∿ 14 hours, as indicated in Table 3.1.10.)

The number of electric locomotives assigned was determined under these conditions and by establishing the number of trains for the transportation demand in 2002, calculating the number of locomotives and using 15% as the reserve rate. The daily average per-vihicle running distance of locomotives assigned was determined to be 648.3 km. In determining the number of locomotives, therefore, 650 km was used as the running distance of each locomotive assigned.

(2) Calculation of number of diesel locomotives

The following was used as the conditions for this calculation:

1) The daily average per-vehicle running distance of the presently used CC201 diesel locomotives is 447.8 km. The CC201 type is mainly used to haul express trains.

2) The future ratio between the number of express trains and the number of local trains is 2:1 and the ratio between the time an express train takes to travel a single-track section and the time a local train takes to travel the same section is 1:1.5.

3) The time for a freight train takes is the same as for a local passenger train.

From the above conditions, the daily average per-vehicle running distance of diesel locomotives assigned is:

Passenger trains: 400 km
Freight trains : 300 km

(3) Number of locomotives

Table 3.2.6 shows the number of DC and AC electric locomotives and the number of diesel locomotives obtained each year after electrification, using the above per-vehicle running distance of electric and diesel locomotives assigned. Here, 1994 was used as the year electrification of the Merak Line will be completed. In 1994, a new AC electrified double-track line will be in use between Manggarai and Krawang and the DC electric locomotives that will have been used in this section will be unnecessary there and transferred for use on the Merak Line. The transfer will be smooth because the number of DC electric locomotives that will be in use in 1994 in both sections agree at 16. The total number of DC and AC electric locomotives in 2008 is 275. The number of diesel locomotives will peak at 82 in 1989 and gradually decrease thereafter. Since their number is not large, those which will become superfluous can probably used on branch lines.

3.2.5 Number of Passenger Cars and Freight Cars

More detailed conditions must be stipulated for passenger cars and freight cars to determine a highly accurate number because their conditions are complicated. However, about 2,500 passenger cars and about 3,900 freight cars will be necessary in 2008, as a general standard.

Passenger cars now used for express and fast trains can be used after electrification but almost all freight cars will have to be

Table 3.2.6 Number of Locomotives by Year after Electrification

Year	Electrified section	Electric locomotives			Diesel locomotives
		DC	AC	Subtotal	
1988	Mri ∿ Ckp Ckp ∿ Cn	14	25	39	68
1989	Ckp ∿ Bd	14	37	51	82
1991	Cn ∿ Yk	16	57	73	63
1992	Yk ∿ Slo	16	65	83	59
1994	New AC double-track line completed for Manggarai to Krawang: Jak ∿ Mer	16	92	108	72
1995	Slo ∿ Sb	16	127	143	58
1996	Sb ∿ Pro	16	138	154	54
2003	Cn ∿ Sbi, Bd ∿ Kya Pro ∿ Jr, Sm ∿ Slo Boo ∿ Si	19	237	256	8
2008	Jr ∿ Bw Kts ∿ Bg Si ∿ Pal	19	256	275	0

replaced by the new type provided with air brakes, which are desirable.

3.2.6 Number of Personnel

(1) Electric locomotive crew

Working conditions, train schedules, depot positions, etc. are necessary to accurately determine the necessary number of electric locomotive driver and assistant. Here, only the approximate number is determined. It is calculated under the following conditions:

1) An electric locomotive is manned by two persons: an engine driver and an assistant.

2) The per-capita average duty distance of engine driver and assistant including the reserve is as follows:

a)	Electric locomotives	160 kg/day
b)	Diesel locomotives	90 km/day

This is typical of the present diesel locomotive duties at the main depots, the per-capita average duty distance (including vacation time) being 101.6 km. The ratio between the present schedule speed and the schedule speed after electrification (maximum speed: 100 km/h) is generally 1:1.8. 15% is used as the reserve rate. Calculated from these conditions, the per-capita duty distance is as stated above.

Table 3.2.7 shows the number of personnel obtained from this calculation.

(2) Electric locomotive inspection/repair personnel

Two persons are necessary for the inspection and repair of a single electric locomotive. The approximate number of total personnel is shown in Table 3.2.7.

3.3 Train Dispatchers

According to transportation demand forecast, the number of trains will increase suddenly after electrification. Generally, the line capacity for single-track sections is said to be 80 ∿ 90 trains (both directions) and this is roughly the number of trains that will actual-

Table 3.2.7 Electric Locomotive Crew and Inspection/Repair Personnel

Year	Electric locomotive crew	Depot inspection/repair personnel	Remarks
1988	310	78	(1) Electric locomotive crew is the total of driver and assistant.
1989	418	102	
1991	592	146	(2) The "inspection/repair personnel" is for depots only and does not include workshop personnel.
1992	656	166	
1994	1,212	216	
1995	1,440	286	(3) The "inspection/repair personnel" here is only those who work on electric locomotives.
1996	1,508	308	
2003	2,072	512	
2008	2,222	550	

ly be operated. If as many as 80 ~ 90 trains are operated, pass-by between trains proceeding from both directions will be necessary at many stations and thus operation adjustment and operation arrangements by train dispatchers will be increasingly important.

The present three-stage system of Head Office, Regional Office and Inspection is an excellent organization but it is necessary to increase personnel and expand equipment in preparation for electric operation.

3.3.1 Work of Train Dispatcher

The following work is performed by train dispatchers:

(1) Routine operation adjustment necessary for normal train operation. (Instructions on matters including train operation time changes, coupled and divided operation of train set: changes of order of operation; changes in operating track and arrival/departure track; changes of pass-by and overtaking stations; changes of classification of running speed and release/connection restriction of cars; discontinuance of train operation in time of train delay; tentative train stop at station; change of turnround station; discontinuance of train operation; operation for recovering time delay.)

(2) Routine train operation arrangements necessary to cope with fluctuation in traffic demand.

(3) The following work is to be performed in case of an operation accident or occurrence of calamity:

1) Investigation of situation.

2) Discontinuance of train operation, turnround of train, cancellation of trains enroute and detouring train operation.

3) Operation of rescue train.

4) Other emergency actions.

(4) Knowledge of weather conditions and countermeasures.

(5) Investigation of train operation plan data and reporting.

3.3.2 Equipment

The following are necessary equipment for train dispatcher:

(1) Direct dispatching telephones (for connection with station and depot)

(2) Facsimile telegraphic apparatus

Further, it is desirable to have train telephones for directing operations (radio connection of train dispatcher and train).

CHAPTER 4 ELECTRIFICATION PLAN

CHAPTER 4 ELECTRIFICATION PLAN

4.1 Selection of electrification system

The electrification systems now adopted in various countries in the world are diverse, as illustrated by Table 4.1.1.

They can be classified into three major systems of direct current, single phase alternating current and three phase alternating current, and these systems can be further subclassified by voltage and frequency.

This variation is surmised to have been caused by differences in the historical development of electric railways in the respective countries. Some countries which already have large sections of 16-2/3 Hz AC electrification or DC electrification naturally promote electrification systems of the same kind with view of rolling stock operation. However, as a worldwide trend in recent years, many countries have been adopting commercial frequency single phase AC system.

Table 4.1.1 Situation of Railway Electrification in the World

1982.5

Direct current			Single phase AC										Three phase AC	Electrified kilometer (km)	Total operating kilometer (km)	Electrification rate (%)
Less than 1,500V	1,500V ~ less than 3,000V	3,000 V	60 Hz			50 Hz				25 Hz	16-2/3 Hz					
			20 KV	25 KV	50 KV	6.6 KV	20 KV	25 KV	50 KV	11 KV	11 KV	15 KV				
8,717	19,748	60,663	1,372	495	126	113	2,098	42,143	860	1,743	248	28,923	48 (0.03%)	167,297 (100%)	1,347,572	12.4%
89,128 (53.3%)			47,207 <60.4%>							30,914 <39.6%>						
			78,121 (46.7%)													

Information

Example of application of electrification systems

DC	1,500 V	Japan, France
	3,000 V	Soviet Union, Italy
AC	Commercial frequency (50/60 Hz) single phase	
	Simple feeding system	France, England, Soviet Union
	AT feeding system	Japan, France, Soviet Union
	BT feeding system	Japan, England, France
	16-2/3 Hz, 15KV single phase	West Germany
	3 phase	Switzerland

4.1.1 Direct Current System

In the direct current system, power transformation equipment such as silicon rectifiers, etc. to convert AC power received from a general electric power network into DC power are provided in substations of an electric railway, to feed DC power to the electric car line, to drive the DC motors of electric vehicles.

Since long ago, the DC system has been adopted in various countries in the world. In this system, the high tension DC motor for rolling stock is technically restricted with respect to insulation design, rectification, etc., so very high voltages are not adopted. In the world, the highest voltage is 3,000 V as shown in Table 4.1.1.

Since the contact wire current is larger in the DC system than in the AC system, the voltage drop increases, requiring substations at closer intervals than with AC systems.

Furthermore, the large current requires the current capacity of the contact wire to be large. Therefore in general, a feeder is provided in parallel to the contact wire, to reduce the voltage drop and to increase the current capacity.

On the other hand, a low voltage facilitates the insulation of overhead catenary system and apparatuses, and the insulation distance in tunnels, bridges, etc. can be kept small. Together with a long history and much experience, this system can be said to be technically simple.

4.1.2 Single Phase Alternating Current System

The single phase AC system includes several kinds, depending on voltages and frequencies, as shown in Table 4.1.1. Recently, commercial frequencies are being often adopted. The reason is that since electric power having a commercial frequency received from a general transmission line can be supplied to electric motor vehicles without having its frequency changed, only substations are required to have transformers resulting in an advantageous simplification of equipment.

Furthermore, since electric motor vehicles are mounted with transformers, voltages in the motor vehicle can be freely selected. For this reason, a relatively higher voltage can be adopted for the contact wire, and thus, the contact wire current can be smaller, with less voltage drop, allowing substations to be set at longer intervals and with fewer substations. Even when the voltage drop poses a problem, series capacitors can be installed in substations or overhead contact system, to compensate for the circuit impedance, allowing relatively easy conservation of voltage.

The speed control of the electric motor vehicle, is also simple when compared to the DC system, and the coefficient of adhesion between the wheel tread and the rail can be set at a high value. Furthermore, the starting force on the grade can be made large, relative to the output.

On the other hand, since a high voltage with a commercial frequency is used, it may interfere with a telecommunication line existing nearby, requiring preventive measures to reduce interference to be taken.

Moreover, since single phase power for electric railways is received from a general three phase transmission line, the three phase power supply system, if small in fault level, may cause a voltage unbalance or fluctuation, and therefore, the power source must be selected with due attention paid to this point.

Table 4.1.2 shows a comparison of the technical features of a DC system (1,500 V) and a single phase AC system (commercial frequency 25 kV).

Table 4.1.2 DC 1,500 V System and Commercial Frequency Single Phase 25 kV System in Comparison

		DC 1,500 V System	Commercial Frequency Single Phase AC 25 kV System
Fixed installations	1. Substation	1. Construction costs are high. (1) Intervals of substations are short (about 10 to 15 km) with a large number of substations. (2) Rectifiers for converting from AC to DC are required, to make substation equipment complicated.	1. Construction costs are low. (1) Substation intervals are large (about 100 km in autotransformer system), with a small number of substations. (2) Since the main equipment is transformers, substation equipments are simple.
	2. Transmission line	2. A large number of substations makes construction costs high.	2. A small number of substations lowers constructions costs.
	3. Overhead contact system	3. Since the load current is large, thick feeder is required. The contact wire wears heavily, and replacement is costly.	3. Since load current is small, a thin feeder can be used. The contact wire wears little, and little replacement is required.
	4. Signal installations	4. The commercial frequency AC track circuit can be used.	4. The commercial frequency AC track circuit cannot be used.
	5. Communication installations	5. If filters are installed in substations, inductive interference on telecommunication line does not occur.	5. Since load current contains higher harmonics, inductive interference on telecommunication line occurs, requiring a bare the communication line near, a railway track to be changed into a cable, and the installation autotransformers, booster transformers, etc.
	6. Quantity of copper	6. The required quantity of copper is large.(3.7)	6. The required quantity of copper is small. (1)
	7. Power source	7. The problem of three phase power source unbalance does not occur.	7. A single phase load causes a three phase power source unbalance, and preventive measure against it must be taken.
	8. Feeding voltage	8. High voltages cannot be used, being restricted by insulation design of the traction motor and converting equipment.	8. High voltages can be used with a transformer installed in the vehicle.
	9. Preventive measure against voltage drop	9. The additional feeder and the new construction of substations must be made according to increase in load.	9. This can be simply compensated for by the installing a series capacitor or automatic voltage regulator.
	10. Insulation spacing	10. The insulation distance can be small because the voltage is low.	10. A high voltage requires a large insulation distance, making the section of tunnels, etc. larger in general.

		DC 1,500 V System	Commercial Frequency Single Phase AC 25 kV System
Rolling stock equipment	1. Transformer and current transformer	1. Not required	1. A transformer and a rectifier must be mounted on the vehicle.
	2. Attached equipment	2. Since direct current machines are driven by catenary voltage, the structures are complicated. Power supply equipment such as fluorescent lamps and air conditioners, are also complicated.	2. Optional low voltage AC power sources can be obtained by a transformer, and a simple and robust induction motor can be used. Equipment with supplied power such as fluorescent lamps and air conditioners is simple.
	3. Speed control	3. In case of rheostat controlled cars, the speed is controlled by controlling the resistance or changing the motor connections making, control complicated. In the case of chopper control cars, the speed can be easily controlled by turning the thyristor on or off.	3. The speed can be controlled easily by tap change of transformer or phase controlled by a thyristor.
	4. Adhesive performance	4. Compared with AC cars, adhesive performance is low, requiring a large output. However, the adhesive performance of chopper cars is good.	4. Since adhesive performance is excellent, a large load can be pulled by a small size.

Also for single phase AC systems, various systems have been developed and put into practical use because of differences in the situation and historical background of the respective countries. Above all, due to the differences in preventive measures against inductive interference on telecommunication line, and in the feeding of large power to overhead contact system, various feeding systems have been put into practical use. These will be described below.

(1) Commercial frequency (50/60 Hz) single phase AC system

1) Simple feeding system

The simple feeding system is the most basic composition consisting of a contact wire and rails. As its variation, NF type simple feeding system is used, in which a negative feeder (NF) is provided in parallel to the rails, with the rails and NF connected every several kilometers by NF contactors.

The provision of a negative feeder facilitates the protection and detection in cases where insulator flashover occurs in a feeding circuit, and has the effect of decreasing the impedance of the feeding circuit.

A features of the simple feeding system, is its simple circuit configuration making the feeding circuit economical and easy to maintain, but since the return circuit current is fed through the rails in the section, the inductive interfence with telecommunication lines becomes large, and the rail potential becomes disadvantageously high compared to that of other feeding system.

2) Autotransformer feeding system

In the autotransformer feeding system, the feeding voltage from a substation is set higher than the contact wire voltage, and is lowered to the required contact wire voltage by autotransformers (AT) provided about every 10 km along the wayside, to feed power to electric motor vehicles.

In the ordinary autotransformer feeding system, the feeding voltage from the substation is double, and it can be raised further by changing the turn ratio of the autotransformers.

This system is suitable for feeding large power, since the feeding voltage from the substation is high (double the voltage fed to the electric motor vehicles). Furthermore, since the feeding current from the substation is small, being 1/2 of that of the simple feeding system, the voltage drop due to the impedance of the feeding circuit is small, allowing the substations to be set at greater intervals.

That substations can be set at long intervals is advantageous especially when the site of the power source is distant, and in such cases, the total construction costs including the transmission line are lower than for the simple feeding system.

Furthermore, since load current is boosted by autotransformers on both sides, the induced voltage for a long telecommunication lines is offset, and the current flowing in the rails is limited, effectively reducing the interference.

The intervals of autotransformers are decided in consideration of the effect of reduction in inductive interference on telecommunication line, rail potential, voltage drop of feeding circuit, etc., but is generally within 10 to 15 km.

On the other hand, autotransformers with a capacity corresponding to 1/3 to 1/4 of the train load capacity must be arranged at 10 to 15 km intervals along the wayside, and feeders with the same insulation class as contact wires must be provided throughout the wayside, making the circuit configuration complicated compared to the simple feeding system.

3) Booster transformer feeding systen

In the booster transformer feeding system, booster transformers are arranged at intervals of several kilometers (about 4 km) with booster sections provided in the contact wire, to boost the current flowing in the rails. This decreases the current flowing into the ground and effectively reduces inductive interference on telecommunication line.

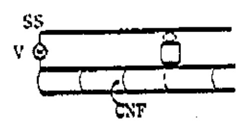
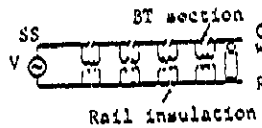
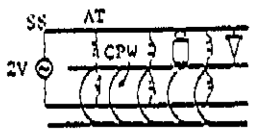
There are two kinds of booster transformer feeding systems a simple system with booster transformers inserted between the contact wire and the insulated rails, and another system with current boosted by an additional negative feeder provided.

The former is simple but is inferior to the latter in its effect of decreasing inductive interference on telecommunication line. However, it is better than the simple feeding system. Furthermore, since the secondary terminal voltage of the booster transformer appears between the insulated rails to repeatedly short circuit and open each time a train passes, the maintainability of the insulated parts is low. For this reason, it is only when load current is not so large.

As regards disadvantages, the booster transformer sections make the feeding circuit configuration complicated, and the impedance of the feeding circuit larger than that of the simple feeding system. Furthermore, if the load current is large, a large arc is generated in the booster section, requiring a special arc suppressing measure to be taken.

Table 4.1.3 compares the technical features of the three feeding systems.

Table 4.1.3 Kinds and Features of Feeding Systems for Commercial Frequency Single Phase AC Systems

Name		System diagram	Characteristic features
Simple feeding system	① Basic type (T·R)		1. Simplest in feeding circuit configuration. 2. No such sections as booster transformer sections. 3. Inferior in communication interference characteristics. 4. Protective measures against insulator flashover, etc. must be taken. 5. The rail potential is theoretically high when compared to that of other feeding systems.
	② With negative feeder (T·R NF)		1. The provision of a negative feeder lowers the line impedance and the rail potential to some extent compared to that of the basic type ①. 2. No such sections as "booster transformer sections" is required. 3. A large screening effect against communication interference than that of the basic type ①.
Booster transformer feeding system	③ With negative feeder		1. High in its effect of reducing communication interference. 2. Booster transformer sections are required. 3. Booster transformers are usually set at about 4 to 6 km intervals.
	④ Without negative feeder		1. The characteristics of booster transformers can be utilized while the negative feeder is omitted. 2. The effect of reducing communication interference is rather lower than that of the negative feeder type booster feeding system ③. 3. Booster transformer sections are required. 4. Rails must be insulated. 5. Protective measures against insulator flashovers, etc. must be taken.
⑤ Autotransformer feeding system			1. Since the feeding voltage (voltage on outgoing from substation) can be made higher than the contact wire voltage, this system is suitable for feeding to a large capacity load. 2. The SS intervals can be longer than those of other feeding systems. 3. Large in the effect of reducing communication interference. 4. No such sections as "booster transformer sections" is required. 5. Autotransformers are set at intervals of about 10 to 15 km. 6. A feeder of the same insulation class as the contact wire must be provided throughout the system of lines.

(2) Special frequency (25 Hz or 16-2/3 Hz) single phase AC system

A feature of this system is that electric motor vehicles can be directly driven by AC power, using a commutator motor, without a rectifier.

With regard to the history of electrification using this system from the production of rectifiers with large capacity and mounting them on cars was difficult in the beginning of railway electrification, and the production of 50 Hz commutator motors with good rectification was also difficult. Furthermore, at 50 Hz, the generation of a critical voltage to a bare communication line was feared. For these reasons, a special low frequency of 16-2/3 Hz (1/3 of 50 Hz) having good rectification and small in its interference with the communication line was adopted for single phase AC systems, and 25 Hz was also adopted in the same concept.

In this system, a special frequency is used, making the provision of special generator or equipment for converting commercial frequency and a special transmission line necessary. For this reason, this system is now adopted only in countries where the special frequency single phase AC electrification already has wide spread use.

4.1.3 Three Phase AC System

A feature of this system is that since a three phase induction motor can be used in the electric motor vehicle, uniform operation can be made, allowing the speed drop on upward gradients to be kept small and regenerative brake operation on downward gradients to be easily made.

However, the large number of phases makes overhead contact system installations complicated, involving difficulty in composition and maintenance of the crossing portions. Furthermore, the current collecting device of the electric motor vehicles, also becomes complicated.

This system is adopted in mountainous railways having steep gradients, but recently, this system is being substituted by single phase AC systems or by DC systems, and is not being newly adopted.

Fig. 4.1.1 outlines the respective electrification systems.

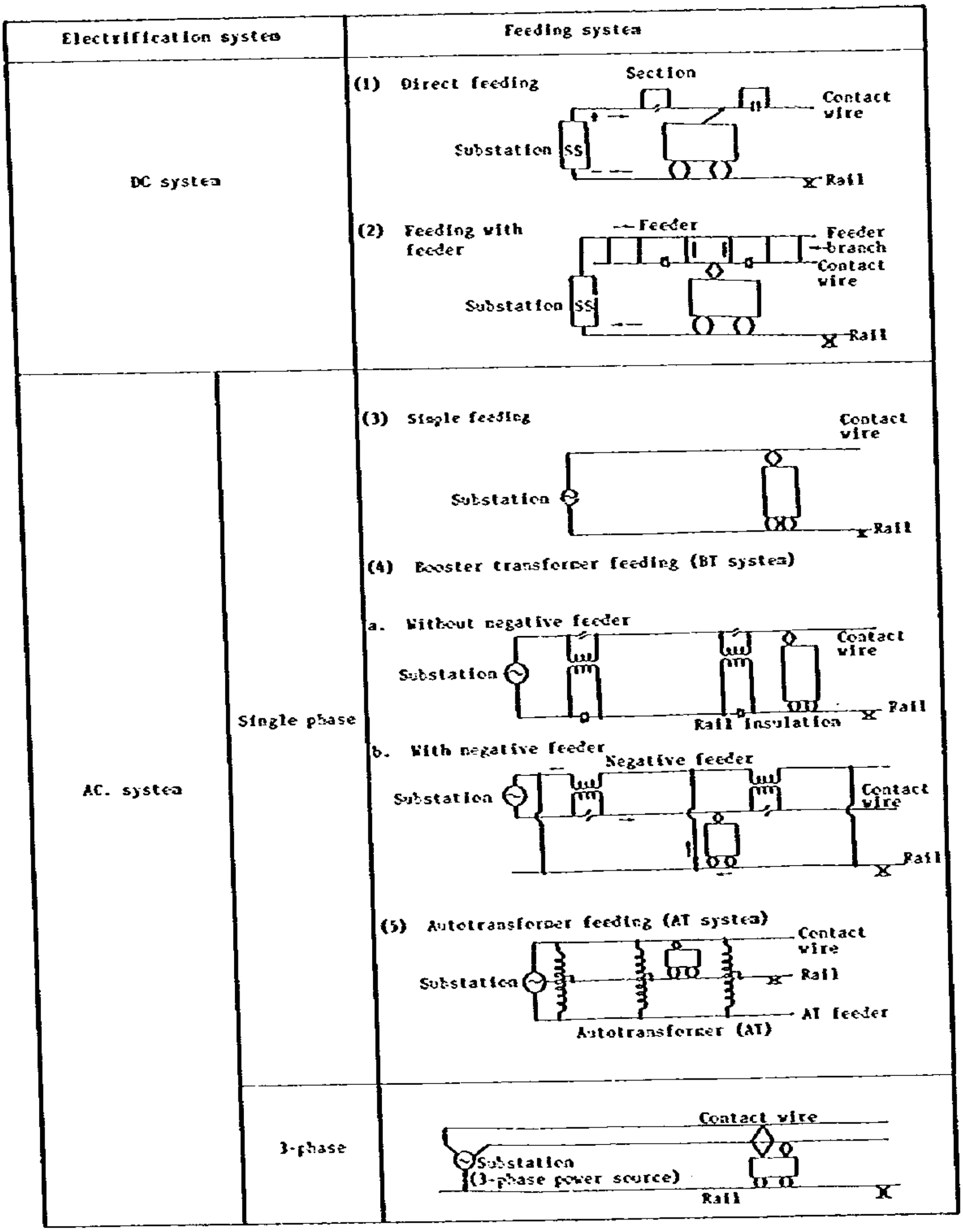


Fig. 4.1.1 Outline of Each Electrification System

4.1.4 Selection of Electrification System

The features of various electrification systems have been described so far. For the electrification system of the main railway lines in Java, the commercial frequency (50 Hz) single phase AC 25 kV system will be selected. The reasons are described below.

(1) Electrification installation costs (for transmission lines, substations, overhead contact system, etc.) are low, compared with those for the DC electrification system.

(2) Since an AC system will be adopted for the first time for the main railway lines in Java, it is not necessary to consider its relation to any existing AC electrification system, for example, as in case where an AC 16-2/3 Hz system is existing.

For this reason, it is both general and advantageous in view of the production of electric locomotives, construction of ground installations, etc., to adopt an AC 25 kV 50 Hz system which is mainly and very commonly adopted in other parts of the world.

(3) Over almost the entire area of Java, a transmission network of 50 Hz 150 kV and 70 kV is being completed as the base of general commercial electric power. For this reason, there are few problems with respect to power supply for electrification under the AC 25 kV 50 Hz system.

The commercial frequency (50 Hz) single phase AC 25 kV electrification system, too, includes the simple feeding system, autotransformer feeding system and booster transformer feeding systems as mentioned above. Which feeding systems to be selected must be decided, after considering of many factors including the condition of the power supply network, measures to be taken to prevent communication interference, construction costs, and maintainability of installations.

General deliberation will be made on the main railway lines in Java.

1) The substation intervals (possible feeding distances) of the respective feeding systems are about 60 km with the simple feeding system, about 110 km with the autotransformer feeding system, and about 50 km with the booster transformer feeding system.

If the substation intervals are long, the number of substations can be small by that, and the degree of freedom in selecting the power receiving points is large, requiring low costs in the construction of transmission lines and substation installations.

On the other hand, with regard to the condition of the power supply network in Java as a whole, of PLN (State Electric Corporation) which supplies general commercial electric power, in most regions, the power receiving points for traction substations can only be obtained at distances of about 100 km from the 150 kV or 70 kV transmission line along each main railway line. This is necessary so as not to cause problems of voltage unbalance, voltage fluctuation, etc. due to the single phase load of electric railway and in order to minimize the transmission line construction costs.

Therefore, from the condition of the power network, the autotransformer feeding system can be said to be most preferable.

2) With regard to inductive interference on telecommunication lines, most of the land along the main railway lines is paddy fields, plowed fields, banana and coconut plantations, etc., and as for the condition of general communication line equipment nearby, a bare communication line of PERUMTEL (Telegraph and Telegram Public Corporation) erected together with a railway communication line are laid mostly along the waysides. Thus, the communication lines are not so dense.

Therefore, if the bare communication lines along the waysides are converted into cables together with the electrification, there does not seem to arise so much difference among the respective feeding systems with respect to inductive interference on telecommunication line.

3) With regard to the maintenance of facilities, the simple feeding system has the simplest circuit configuration and is easy to maintain.

In the autotransformer feeding system, when compared with the simple feeding system, the circuit configuration becomes complicated because autotransformers are required throughout the wayside and because a feeder at the same as the contact wire in insulation class is required.

In the booster transformer feeding system, the feeding circuit configuration is complicated since booster transformers and booster transformer sections are required. If any measure is required to suppress the arc generated in the booster transformer section, the overhead contact system becomes even more complicated, and maintenance becomes most troublesome.

4) The electrification installation construction costs of the autotransformer feeding system and simple feeding system were estimated and the result are shown in Tables 4.1.4 and 4.1.5 for comparison. Figs. 4.1.2 to 4.1.5 shows the schematic drawings of the respective equipment.

As shown in Table 4.1.4, in view of the equipment units required the simple feeding system is lower in cost than the autotransformer feeding system.

On the other hand, as shown in Table 4.1.5, the trial calculation assuming an electrification section of 400 km shows, the autotransformer feeding system is more advantageous.

These example results of the estimate are given only for reference, and the values would change, depending on various conditions. However, the results clearly show the features of both the feeding systems as mentioned before. Namely, that the autotransformer feeding system with long substation intervals is lower in transmission line and substation construction costs, and that the simple feeding system is lower in overhead catenary system construction costs because of the simpler equipments.

Comprehensively considering the above matters, electrification by the autotransformer feeding system is concluded to be the more advantageous for the main railway lines of Java.

However, if in the future the power sources condition becomes favorable enough to allow the locations for substations of electric railway lines to be secured easily (depending upon the region) a re-examination of the adoption of the simple feeding system will be required, generally comparing the investments to be made for electrifying the ground installations.

Table 4.1.4 Comparison of Construction Costs by Electrification Systems

1. 150 kV Substation

	Autotransformer feeding system	Simple feeding system
Receiving equipment Primary of transformer	30	30
Transformer	35	30
Secondary of transformer Feeding equipment Common equipment	35	32
Total	100	92

2. 70 kV Substation

	Autotransformer feeding system	Simple feeding system
Receiving equipment Primary of transformer	30	30
Transformer	33	28
Secondary of transformer Feeding equipment Common equipment	37	34
Total	100	92
Cost ratio for 150 kV substation of autotransformer system	[97]	[89]

3. Sectioning Post

	Autotransformer feeding system	Single feeding system
Feeding equipment	81	28
Common equipment	19	9
Total	100	37
Cost ratio for 150 kV substation of autotransformer system	[17]	[6]

4. Sub-sectioning Post

	Autotransformer feeding system	Single feeding system
Feeding equipment	74	15
Common equipment	26	25
Total	100	40
Cost ratio for 150 kV substation of autotransformer system	[8]	[3]

5. ATP

	Autotransformer feeding system	Single feeding system
ATP	100	0
Cost ratio for 150 kV substation of autotransformer system	[5]	[0]

6. Transmission Line (per 1 km)

	Autotransformer feeding system (150kV)	Simple feeding system (70kV)
Structure	75	45
Wire	25	15
Total	100	60
Cost ratio for 150 kV substation of autotransformer system	[16]	[9]

7. Overhead contact System (per 1 km)

	Autotransformer feeding system	Simple feeding system
Structure	44	41
Feeder	12	0
Contact wire	39	39
Common equipment	5	5
Total	100	85
Cost ratio for 150 kV substation of autotransformer system	[1.8]	[1.5]

Note: Cost ratios of equipment of autotransformer feeding system are given

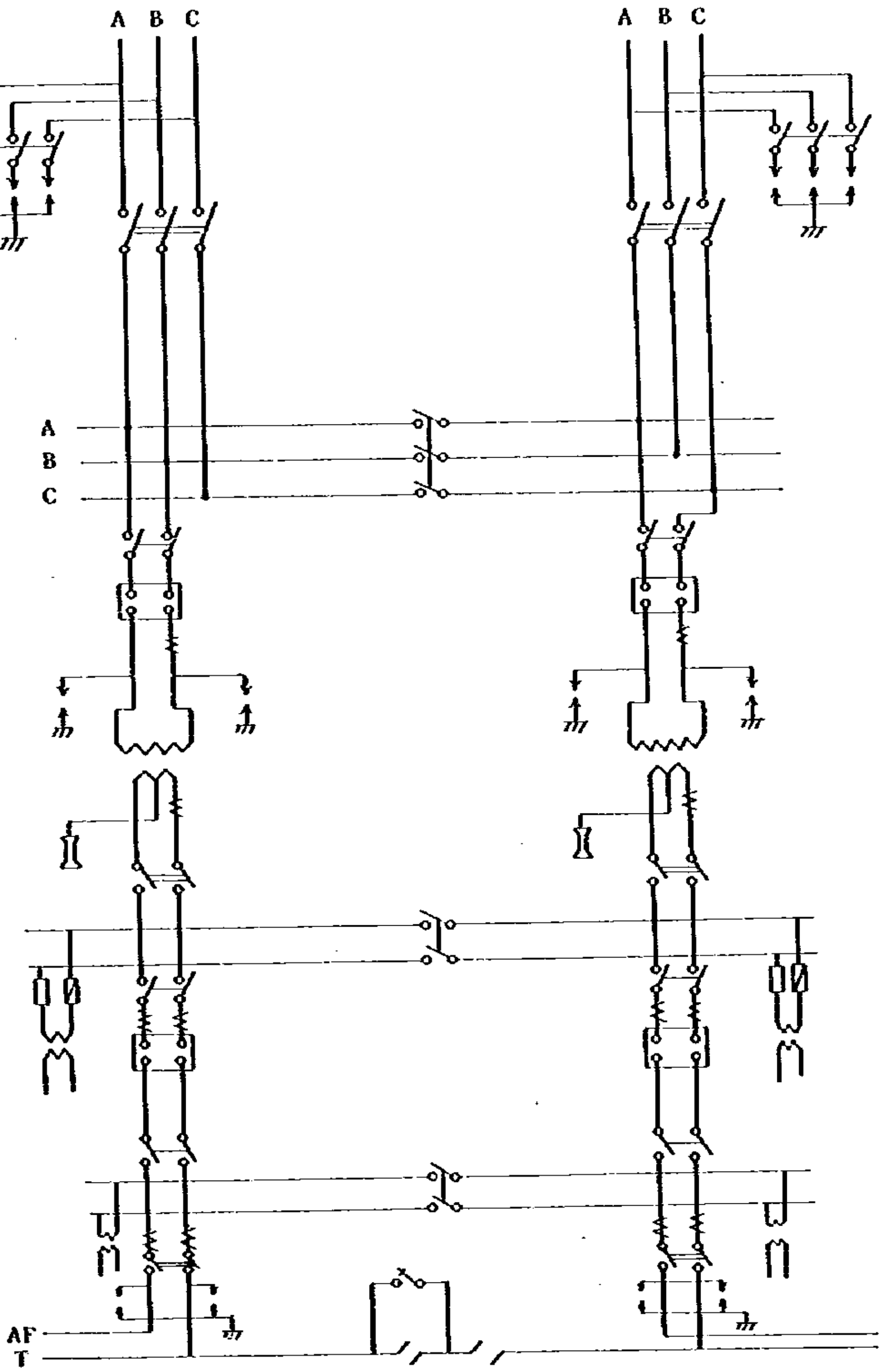


Fig. 4.1.2 Schematic Drawing of Autotransformer Feeding System Substation

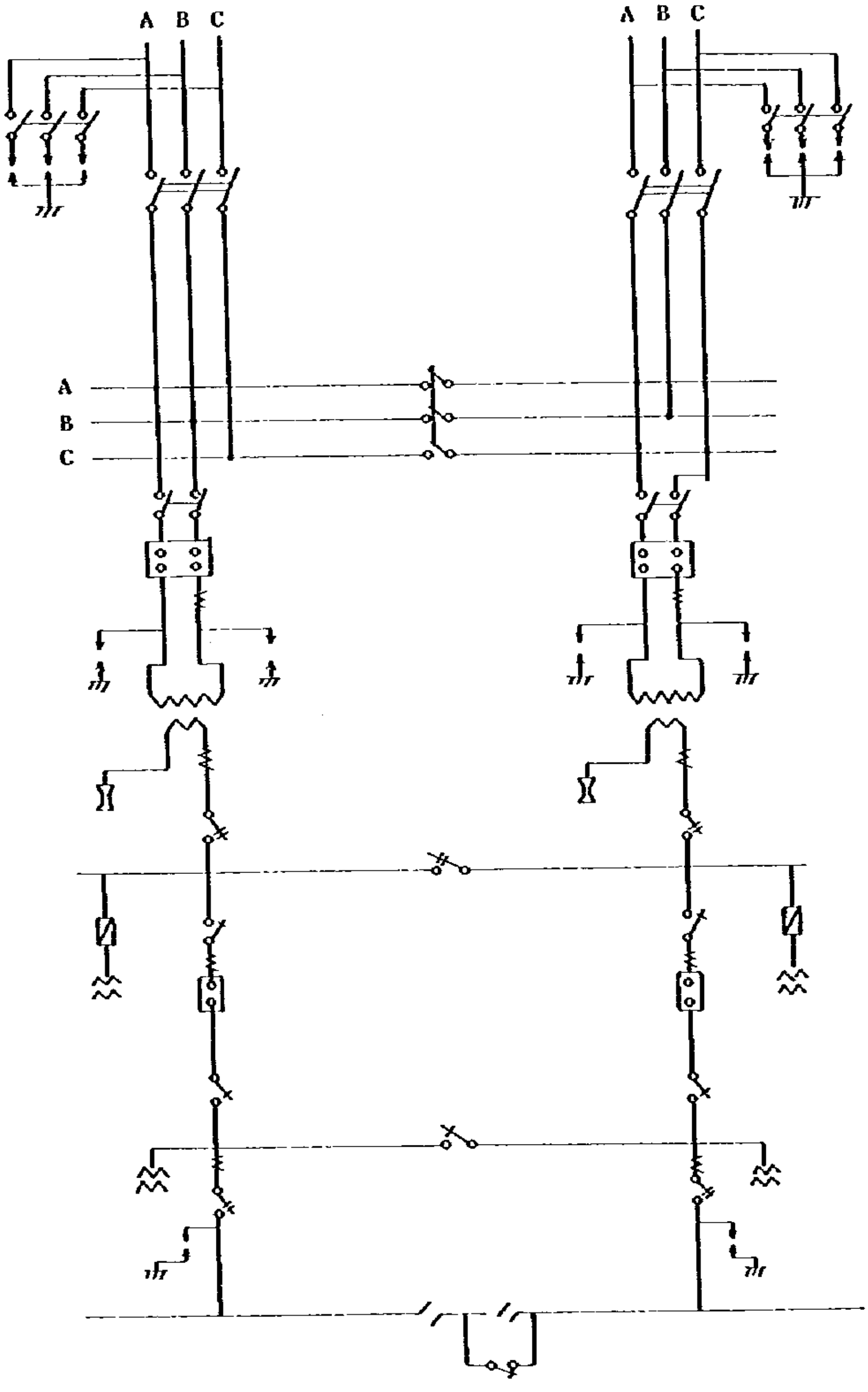


Fig. 4.1.3 Schematic Drawing of Simple Feeding System Substation

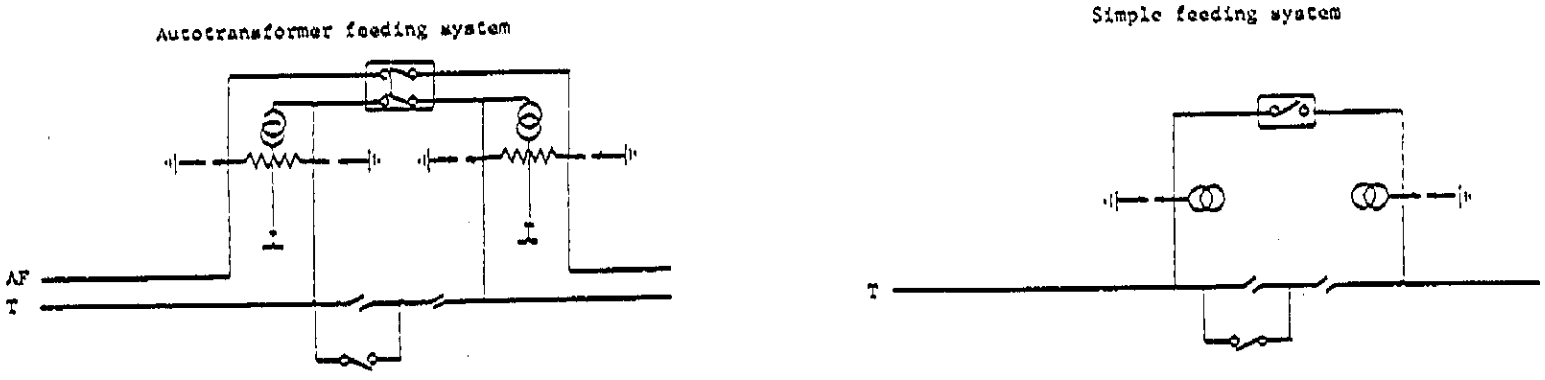


Fig. 4.1.4 Schematic Drawing of Sectioning Post

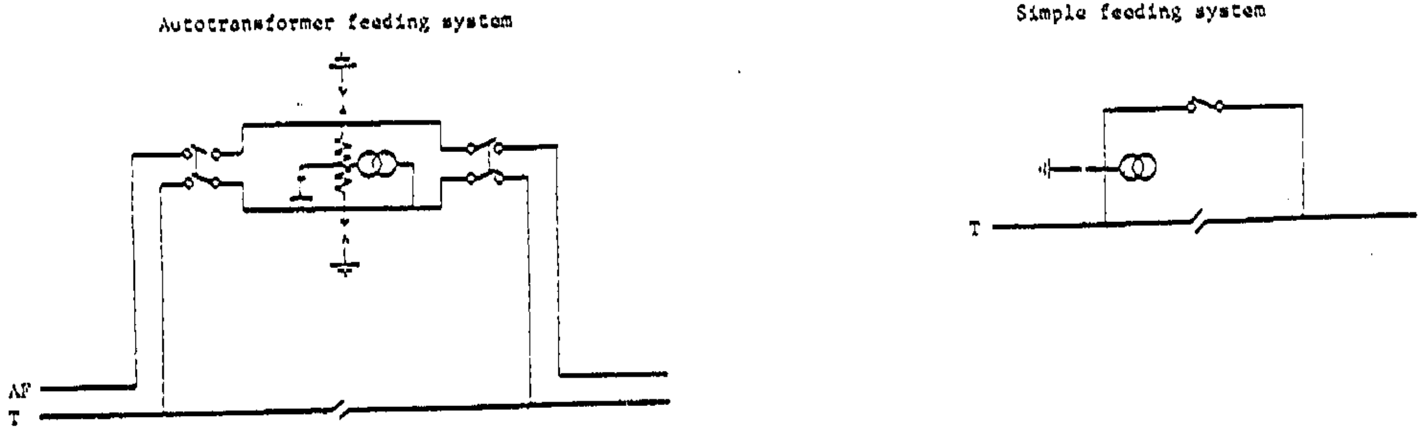


Fig. 4.1.5 Schematic Drawing of Sub-sectioning Post

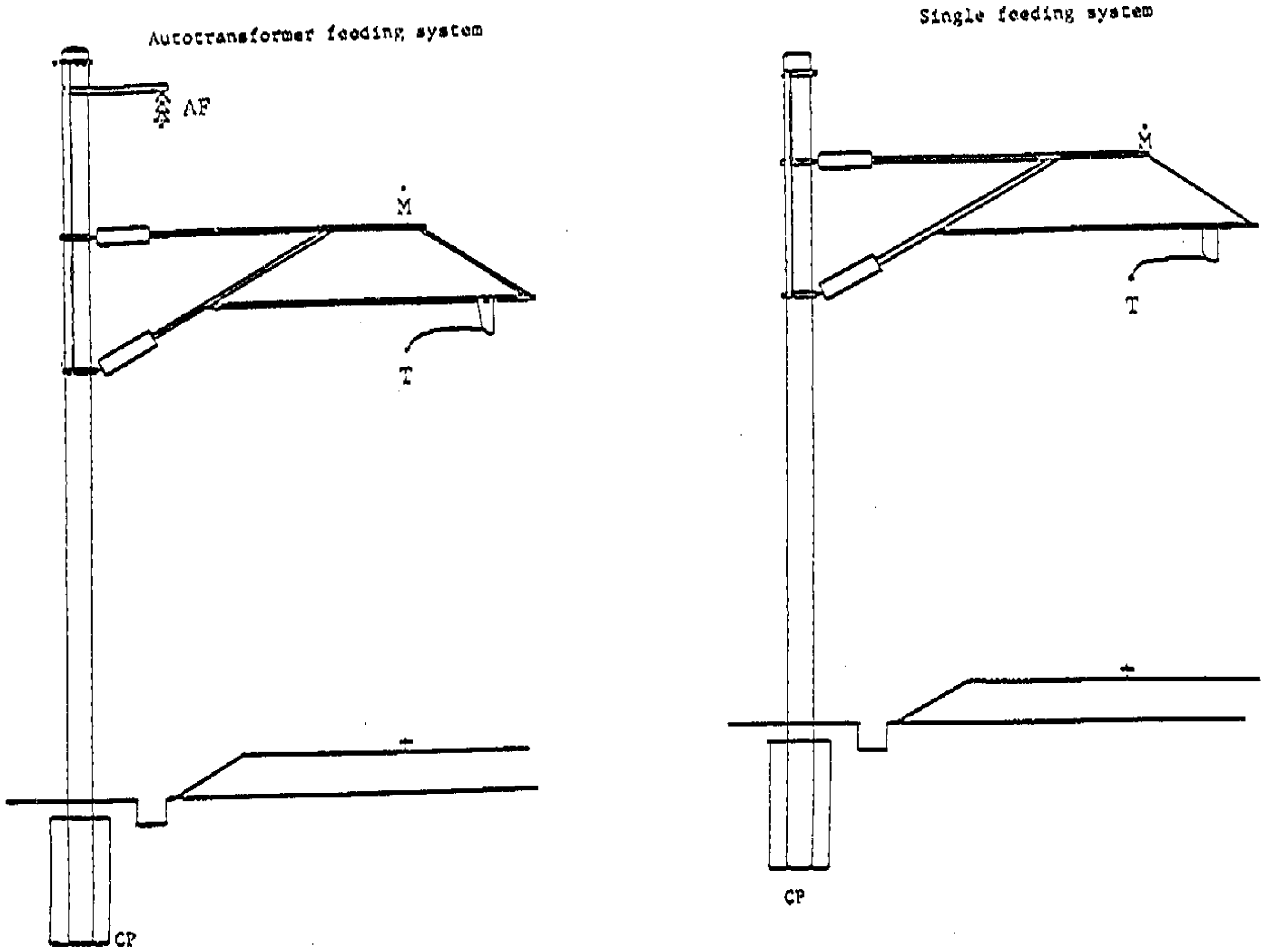


Fig. 4.1.6 Schematic Drawing of Overhead Contact System

Table 4.1.5 Construction Costs for an Assumed Section of 400 km by Electrification Systems in Comparison

	Autotransformer feeding system	Simple feeding system
Transmission line	192	216
Substation	400	712
Sectioning post	85	54
Sub-sectioning post	64	48
ATP	80	0
Overhead contact system	936	780
Total	1,757	1,810

Notes: 1) Each transmission line is 3 km.

2) Substation installations are as follows:
Autotransformer system: 4 SS, 5 SP, 8 SSP, 16 ATP, SS intervals 100 km
Booster transformer system: 8 SS, 9 SP, 16 SSP, SS intervals 50 km

3) Each overhead contact system includes an allowance of 30%.

4) The respective installations show the values obtained by adding "the cost of the ratio 150 kV substation of autotransformer system".

4.2 Power Supply Network and the Influence of Electrification on the Power Source

4.2.1 Power Supply Network

(1) Present situation

The present situation of PLN (State Electric Public Corporation) in Java in 1981/1982 can be generally represented by installed capacity of 2,229 MW, system peak of 1,306 MW and gross generation of 7,825 GWH.

The transmission network is based on 150 kV transmission lines, with the power distributed by 70 kV and 20 kV transmission lines. In the west of Java, mainly in the two major cities of Jakarta and Bandung, the sufficient transmission lines of the respective classes are provided. Also in the east of Java, they are sufficiently provided mainly in Surabaya. However, while the middle area of Java is connected with the west of Java by a 150 kV transmission line, the area is connected with the east of Java only by a 70 kV line. Main power stations generate respective 50 MW by machines 1 and 2 in Semarang Harbour Power Station, and 3 units in Semarang Timur Power Station, located in the north total about 60 MW. Thus, the wide middle area of Java is insufficient power supply, and especially the south area is very poor.

(2) Future planning

At present, the PLN is planning to improve the power supply network on a large scale over the whole of Java. If this improvement plan progresses, they will have installed capacity of 6,235 MW, a system peak of 4,301 MW and a gross generation of 25,620 GWH in 1988/1989, and 12,809 MW, 9,510 MW and 56,649 GWH respectively in 1993/1994.

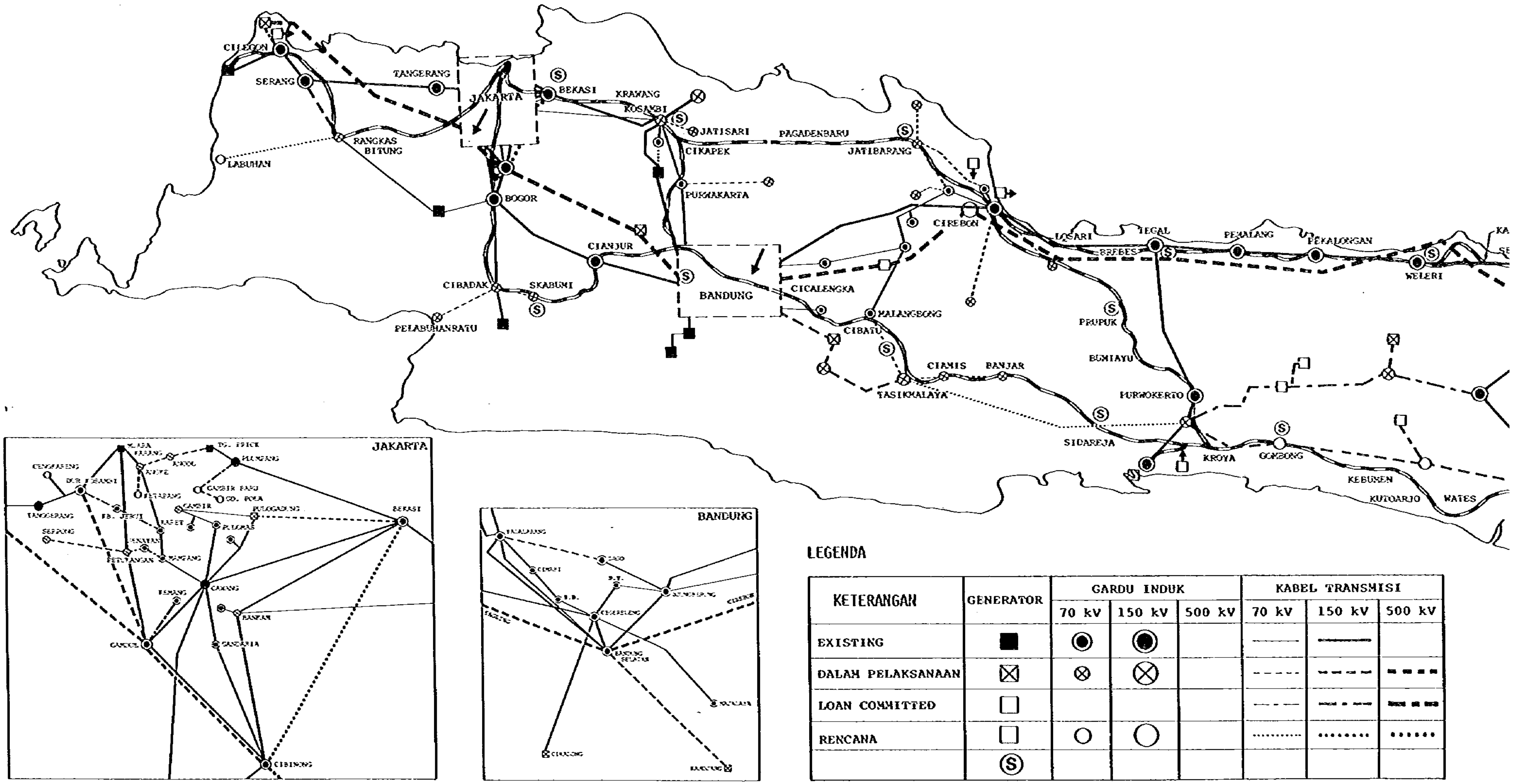
According to this plan, the improvement of the power supply network in Java will be made at the rapid rate of 20% per year, and the power supply network is expected to rapidly become substantial.

As for transmission installations and substations, too, those which are now being constructed are scheduled to be completed by 1984, and those which are now being planned are expected intended to be completed by 1990, as shown in Fig. 4.2.1. In particular especially, a 500 kV superhigh tension transmission line is going to be constructed across the north of Java, connecting Suralaya, Gundul, Bandung Selatan, Cirebon, Ungaran and Krian in each section by 1990. If this is completed, the power supply network will be greatly improved.

The south central section of Java is also going to be connected by a 150 kV transmission line.

Therefore in the long run, the locations for supplying the required power for electrification of the main railway lines in Java should be secured with hardly any trouble, though there may be some places which require long distance transmission lines.

Presumed locational relationships between substations for electric operation and PLN power sources are shown in Fig. 4.2.1.


CILEGON
SERANG
TANGERANG
JAKARTA
BEKASI
KRAWANG
KOSAMBI
JATISARI
CIKAPEK
PAGADENBARU
JATIBARANG
RANGKAS BITUNG
LABUHAN
BOGOR
PURWAKARTA
CIREBON
LOSARI
TEGAL
BREBES
PEMALANG
PEKALONGAN
WELERI
CIANJUR
BANDUNG
CICALENGKA
CIBADAK
SKABUMI
PELABUHANRATU
MALANGBONG
CIBATU
CIAMIS
BANJAR
TASIKMALAYA
PRUPUK
BUMIAYU
PURWOKERTO
SIDAREJA
KROYA
GOMBONG
KEBUMEN
KUTOARJO
WATES
JAKARTA
TANGERANG
BEKASI
GANDUL
CAWANG
CIBINONG
BANDUNG
LEGENDA
KETERANGAN
GENERATOR
GARDU INDUK
70 kV
150 kV
500 kV
KABEL TRANSMISI
70 kV
150 kV
500 kV
EXISTING
DALAM PELAKSANAAN
LOAN COMMITTED
RENCANA

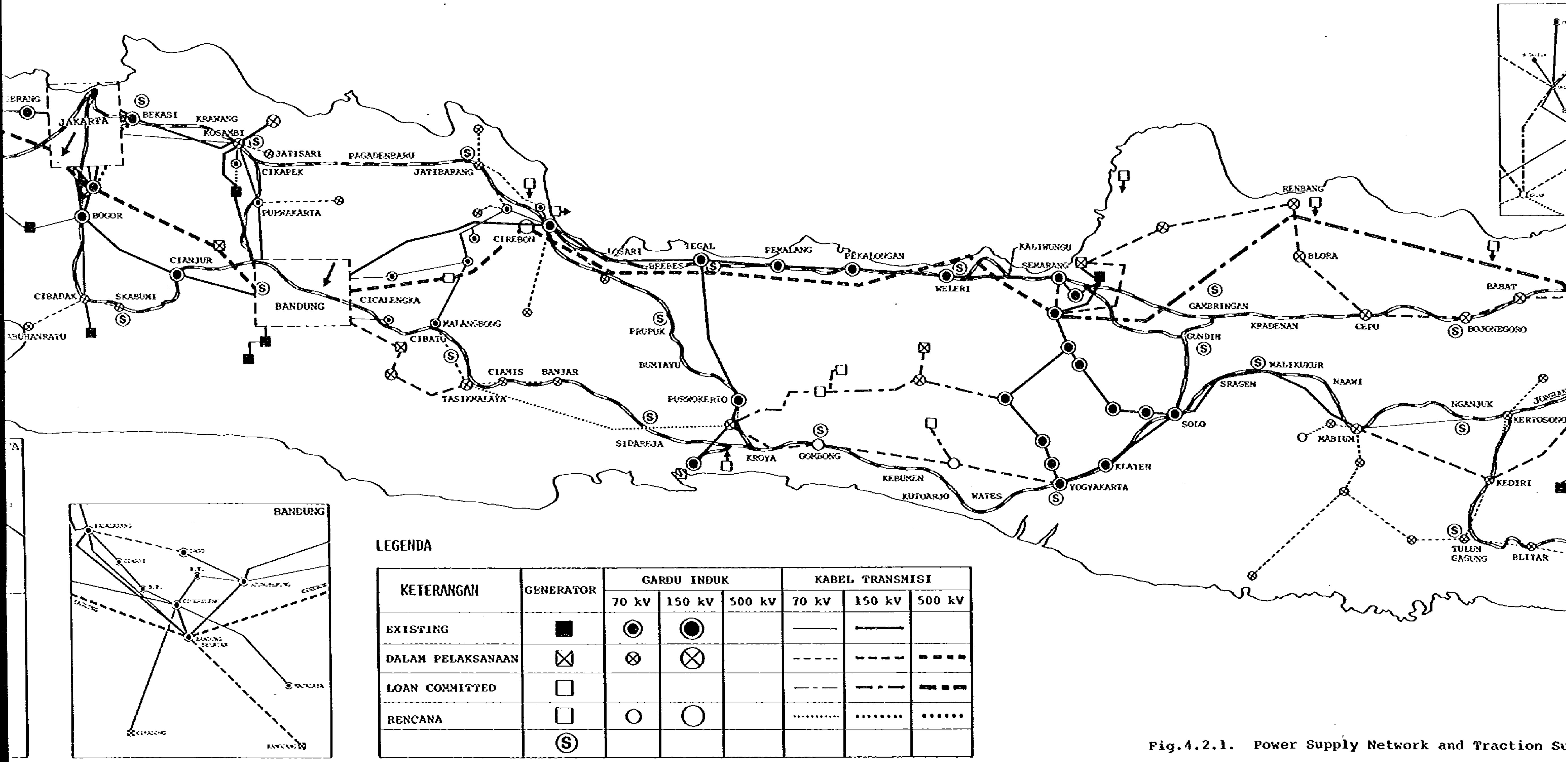


Fig.4.2.1. Power Supply Network and Traction Su

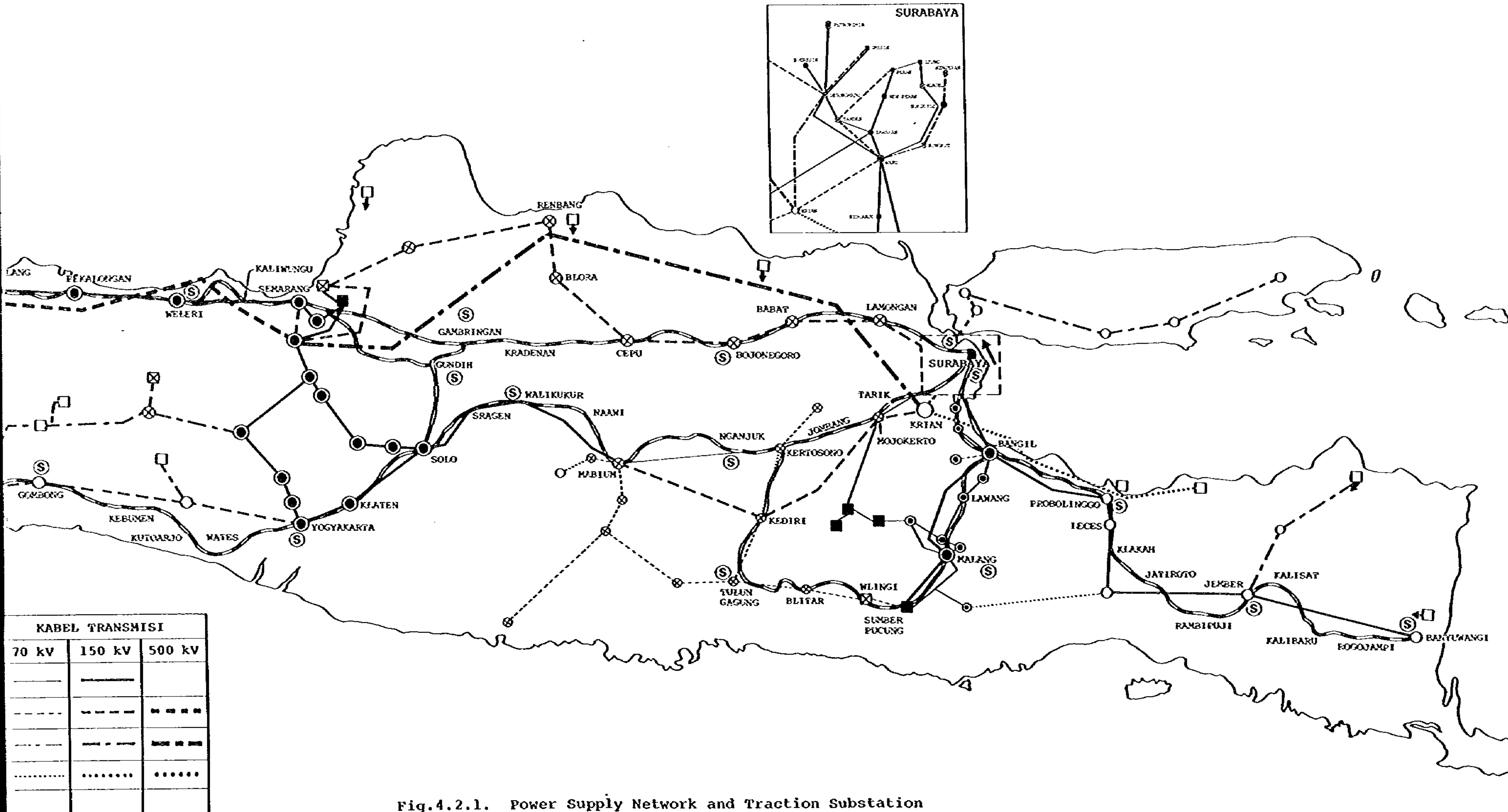


Fig.4.2.1. Power Supply Network and Traction Substation

4.2.2 Influence of Electrification on the Power Source

(1) Voltage unbalance

In single phase AC electric railways using commercial frequencies, the electric power is in principle supplied to the single phase load of an electric motor vehicle from a single phase circuit consisting of overhead contact wires and rails. Thus unbalances occur in the three phase power supply network.

The degree of unbalance is generally expressed as a ratio of the negative-phase-sequence component to positive-phase-sequence component and may affect rotary devices, integrating watthour meters, etc.

1) Influence of voltage unbalance

a. The negative-phase-sequence impedance of three phase induction motors widely used by general consumers is usually less than 20%, being very small compared to the positive-phase-sequence impedance. For this reason, even a relatively small negative-phase-sequence voltage causes a high negative-phase-sequence current to flow. The negative-phase-sequence current generates a reversely revolving magnetic field, decreasing the effective rotary force and increase copper loss, threatening to cause the temperature rise of the windings, partial heating of stators, etc.

However, if the voltage unbalance factor is 5% or less, the decrease of rotary force, drop of power factor, increase of copper loss, temperature rise, etc. do not pose any practical problem.

b. The single phase current coming from a single phase load point into a three phase power network may flow into a rotary machine on the power supply side such as a generator or rotary condenser, to generate a reversely revolving magnetic field, to make worse the waveform of generator voltage and generating heat in the metal portion of the rotator.

These phenomena depend greatly on the design of individual AC generators, and cannot be discussed generally. However, because of appearance as a heat generation phenomenon, it is not a large restriction for rotary machine windings with large thermal time constants, considering the fluctuating short time loads as in the electric operation.

c. It can be considered to cause an error in the integrating watthour meter or the mal-function of a protective relay, but does not cause any practical problem unless in very bad conditions.

2) Allowable value of voltage unbalance

It is theoretically proper to consider the allowance of voltage unbalance actually at the terminals of induction motors, turbo-generators, synchronous rotary condenser, etc. However, in general, for the sake of safety, the value at the receiving buses of substations for an electric railway is restricted.

For loads to be largest in short times like electric railway loads, the allowance is almost 5%. However, if there is a general load with a low allowance nearby a receiving substation with single phase loads, for the sake of safety, 3% is considered to be an allowance for a mean load of continuous 2 hours.

The formula for estimating the voltage unbalance are as shown in Fig. 4.2.2, according to the various connections of the receiving transformers of substations for electric railways adopted to decrease the unbalance.

For cases of using a single phase transformer, the approximate values of the voltage unbalance factor K are obtained from the fault level Ps and the single phase load P in Fig. 4.2.3.

As can be seen from it, the basic measure to be taken to prevent voltage unbalance is to receive from a power source with a high fault level.

(2) Voltage fluctuation

Voltage fluctuation can be classified in view of periods, into long time fluctuation in the order of hours of general loads, short time fluctuation in the order of seconds or minutes due to the load fluctuation of electric railways, rolling mills, etc., and momentary fluctuations in the order of cycles due to the load fluctuation of arc furnaces and welding machines.

The large load fluctuation in an electric railways occur due to the start, powering, coasting, stop, section passage, etc. of eletric motor vehicles.

The load fluctuation of a train at the time of starting are relatively gentle in the order of 30 seconds to a minute, but the load fluctuations at the time of coasting and dead section passage are almost momentary.

In general, a voltage fluctuation factor at a load point is expressed by the following equation:

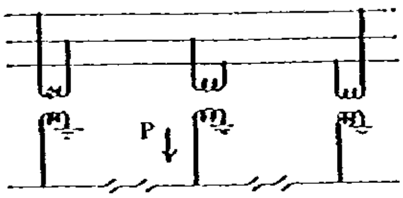
$\varepsilon = xQ/Ps \times 100(\%)$
ε : Voltage fluctuation factor
Q : Reactive power of fluctuating load
Ps: Fault level
x : Coefficient

As can be seen from the above, if the fault level of power source is small with a fluctuating load removed, the voltage fluctuations are large, and may affect the other general customers connected to the same power network.

The allowance of voltage fluctuations depends upon the equipment and machines of plants, etc. covered by the same power supply network, but in general if the voltage fluctuations are gentle, it is about 10%. For momentary voltage fluctations, it is about 3 to 5%. Fig. 4.2.4 shows the relations between the voltage fluctuation factor and the fault level Ps with a single phase transformer used.

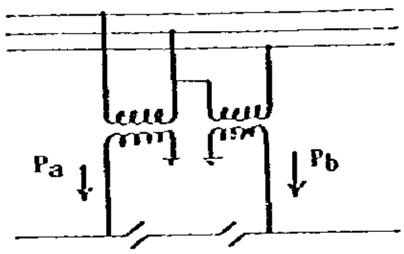
(a) $K \doteqdot \frac{P}{P_s} \times 100$

P_s: Fault level



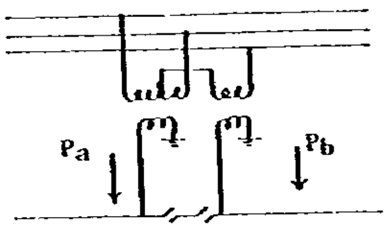
(a) Single phase transformer system

(b) $K \doteqdot \frac{\sqrt{P_a^2 - P_a P_b + P_b^2}}{P_s} \times 100$



(b) V-connection transformer system

(c) $K \doteqdot \frac{P_a \sim P_b}{P_s} \times 100$



(c) Scott connection transformer system

Fig. 4.2.2 Estimation of Voltage Unbalance Factor

$$K = \frac{P}{Ps} \times 100 \text{ ----- } (\%)$$

P: MAX POWER FOR 2 HOURS

Ps: FAULT LEVEL

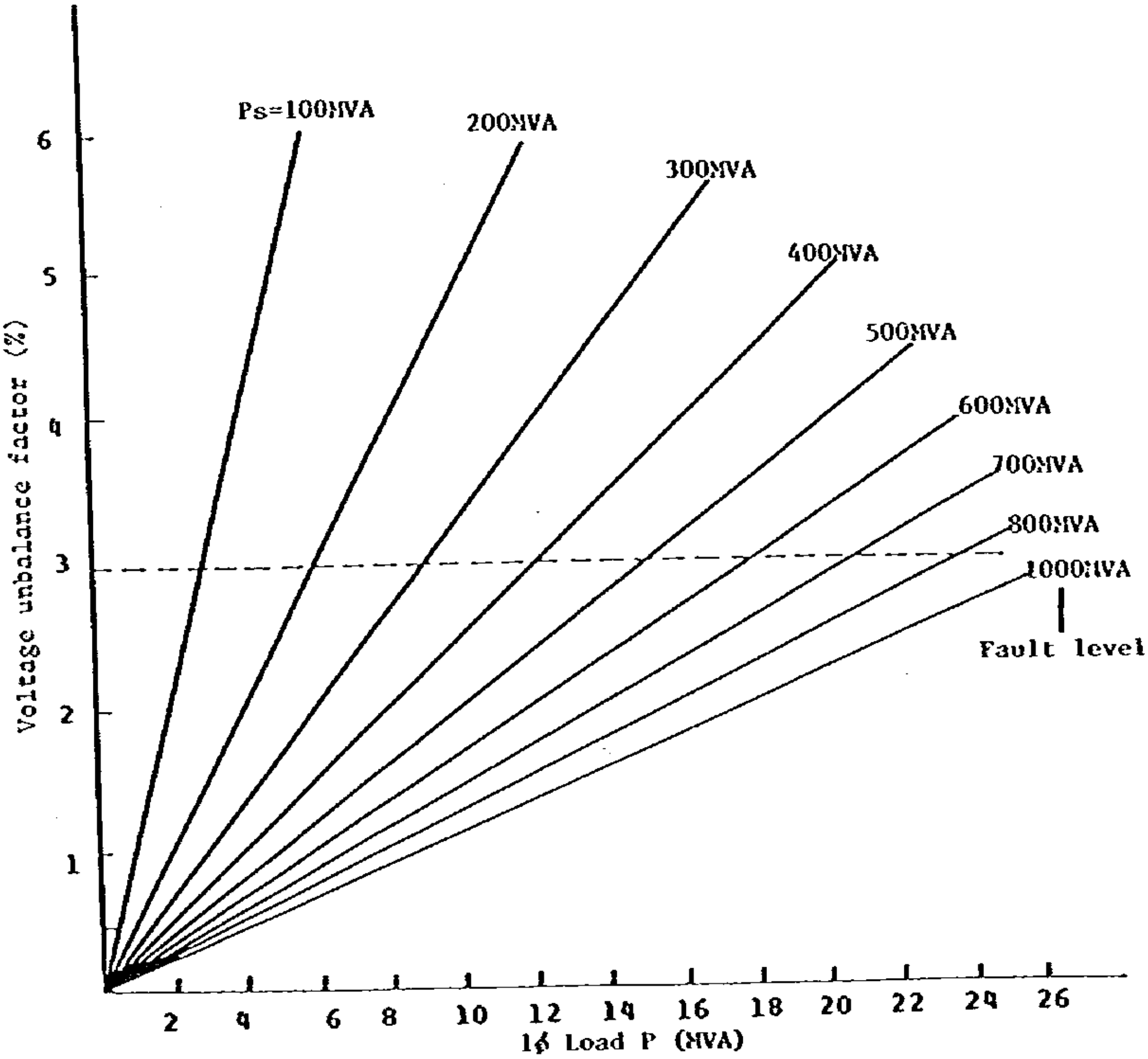


Fig. 4.2.3 Voltage Unbalance Factor

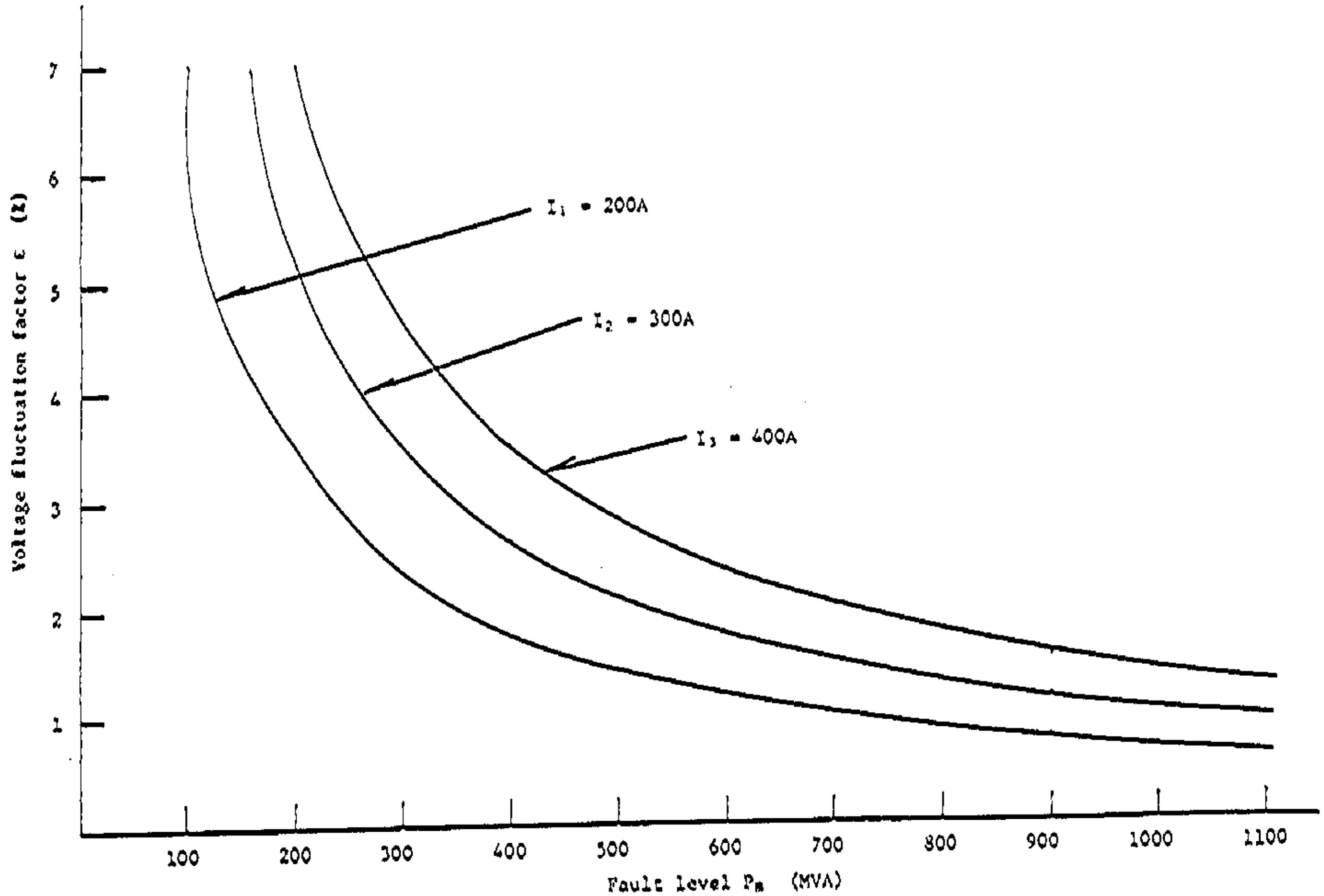


Fig. 4.2. 4 Voltage Fluctuation Factor

4.3 Configuration of Feeding Circuit

4.3.1 Voltage and Frequency

The variable ranges of voltage and frequency are important factors in designing rolling stock and ground installations. In the electrification project of the main railway lines in Java of this time, UIC codes will be adopted, considering the commonness with 25 kV system now highly adopted in various countries in the world.

(1) Voltage

Standard voltage	25 kV
Variable range	27.5 ∿ 19 kV
Short time voltage drop	17.5 kV

(2) Frequency

Standard frequency	50 Hz
Variable range	51 ∿ 48 Hz

4.3.2 Configuration of Feeding Circuit

An electric railway, from an electric viewpoint, makes one electric circuit by substations, overhead contact system, electric motor vehicles and rails, and this is called a feeding circuit.

Fig. 4.3.1 shows the flow of current in an autotransformer feeding circuit.

(1) Circuit configuration

The range in which a substation supplies trains with power is normally upto a central point (sectioning post) of the distance between the two adjacent substations and it is a very long section (in case of autotransformer feeding system, about 50 km on one side). Therefore, if the feeding range of a substation is arranged as a sole continuous circuit, service interruption due to a contact wire accident or maintenance causes the feeding to be stopped over a long section, greatly affecting train operation.

For this reason, in an AC electrification in general, the feeding circuit configuration as shown in Fig. 4.3.2 is adopted.

In the feeding configuration of a substation, in general, feeding is made differently in the respective directions, and when there is a supply voltage phase difference between the respective directions, a dead section is provided to prevent any contact fault.

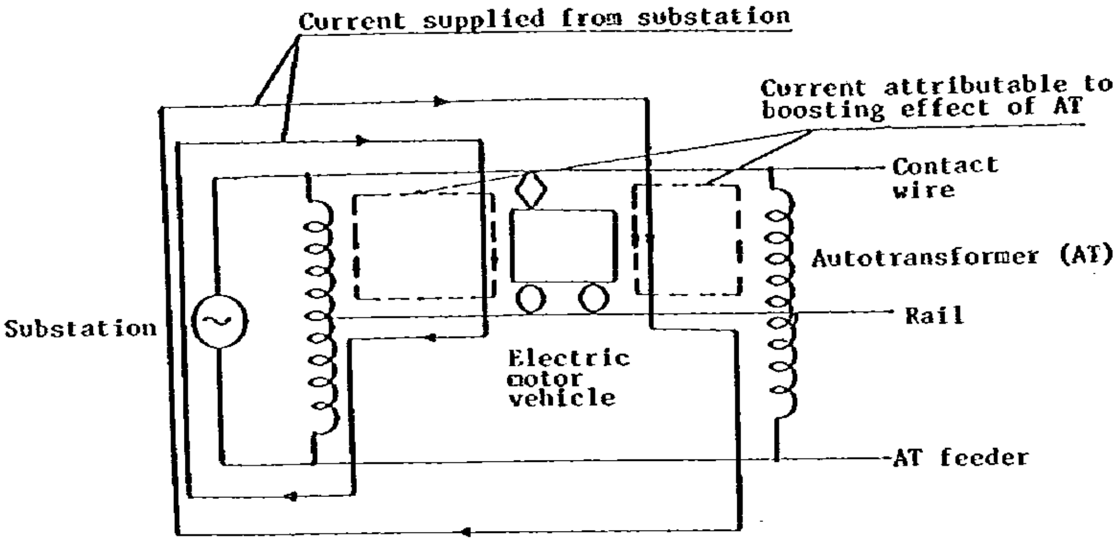


Fig. 4.3.1 Autotransformer Feeding Circuit

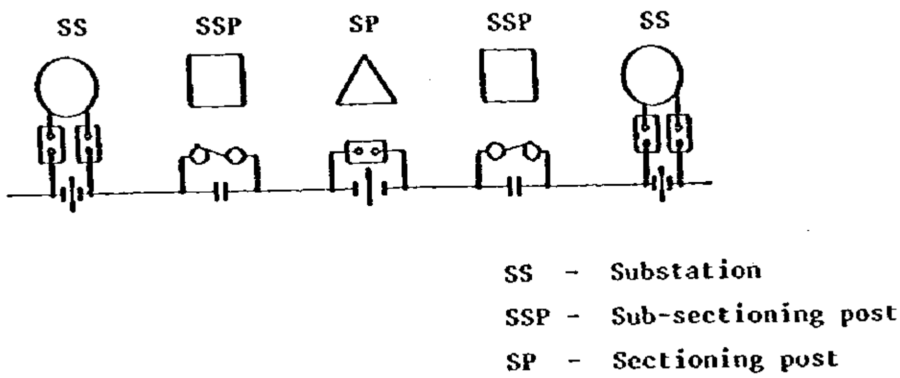


Fig. 4.3.2 Configuration of AC Feeding Circuit

A sectioning post positioned at an intermediate point between substations is provided with a dead section since there is a voltage phase difference between the two adjacent substations, not to cause any contact between different power sources.

Furthermore, at an intermediate point between a substation and a sectioning post, a sub-sectioning post is provided for limited sectioning for correction of a fault or maintenance. However, this is not required when the number of trains is small.

In case of autotransformer feeding system, a sectioning post or sub-sectioning post is provided according to the location of the autotransformer, for collective arrangement of apparatuses, to attain economization.

Fig. 4.3.3 shows the configuration and names of autotransformer feeding circuit. Figs. 4.1.2 to 4.1.5 show connection diagrams of standard substation, sectioning post and sub-sectioning post of autotransformer feeding system.

4.3.3 Feeding Network and Arrangement of Substations

The positional relations between the PLN power supply network and the substations of autotransformer 25 kV 50 Hz feeding system in the electrification project for the main railway lines in Java are shown in Fig. 4.2.1.

Figs. 4.3.4 (1) to (9) show the approximate locations of substations for electric operation, sectioning posts and sub-sectioning posts for the respective sections of main railway lines in Java in the respective stages of electrification.

For substations for electric operation, locations which can be connected to the buses of PLN substations as high as possible in fault level were selected. However, depending on regions, there are points which require branching from a PLN transmission line.

The PLN power supply network intensifying projects obtained at present cover only upto 1990's, and the power supply situation in 2000 is surmised to be improved further.

Therefore, the locations of substations for electric operation in the respective stages must be deliberated in detail in relation with the power source situations, including the possibility of adopting the simple feeding system.

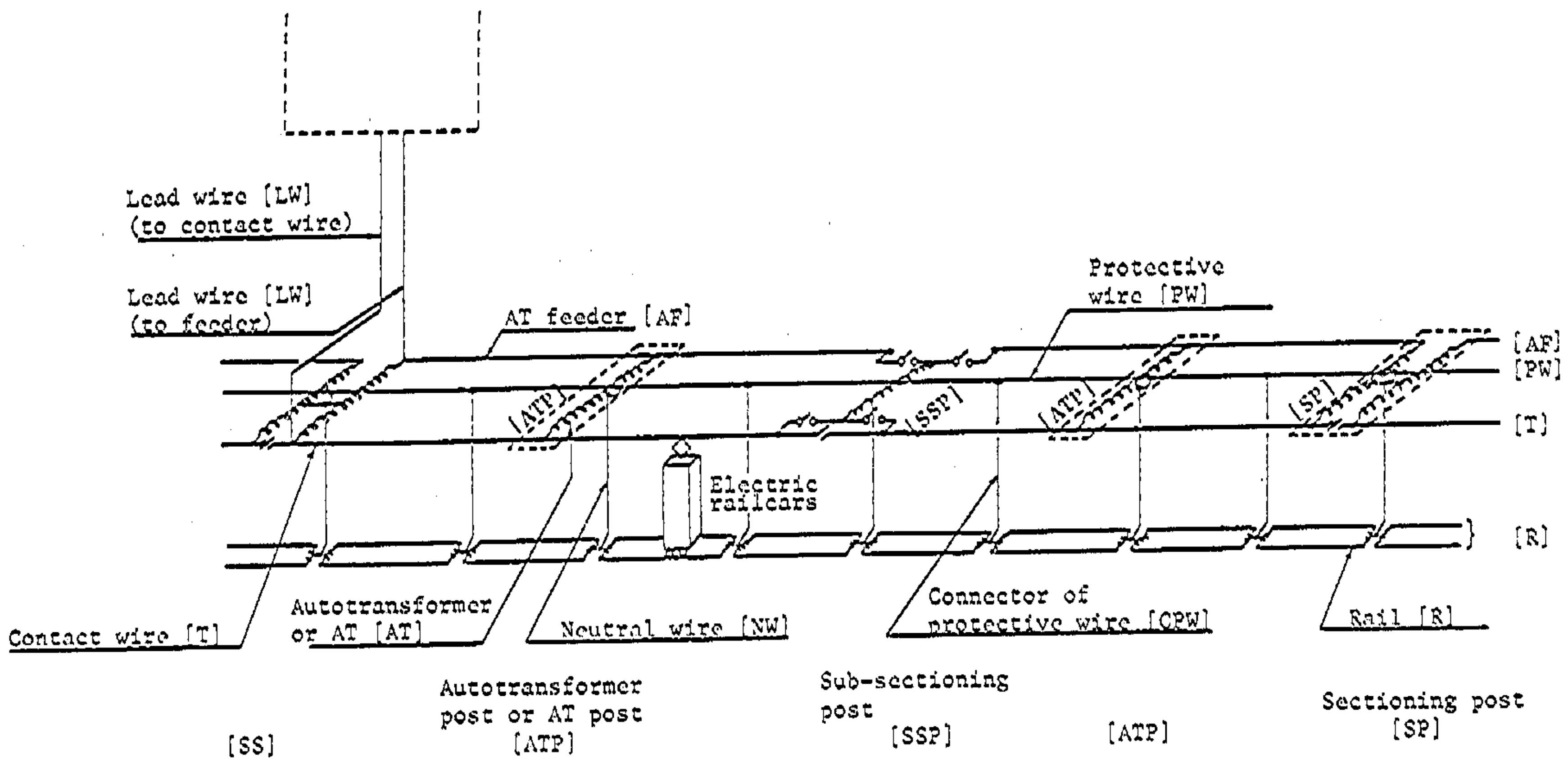


Fig. 4.3.3 Name of AT Feeding Circuit Components

THE FIRST STAGE ELECTRIFICATION PLAN

BEKASI ∿ CIREBON (1,988)

CIKAMPEK ∿ KIARACONDONG (1,989)

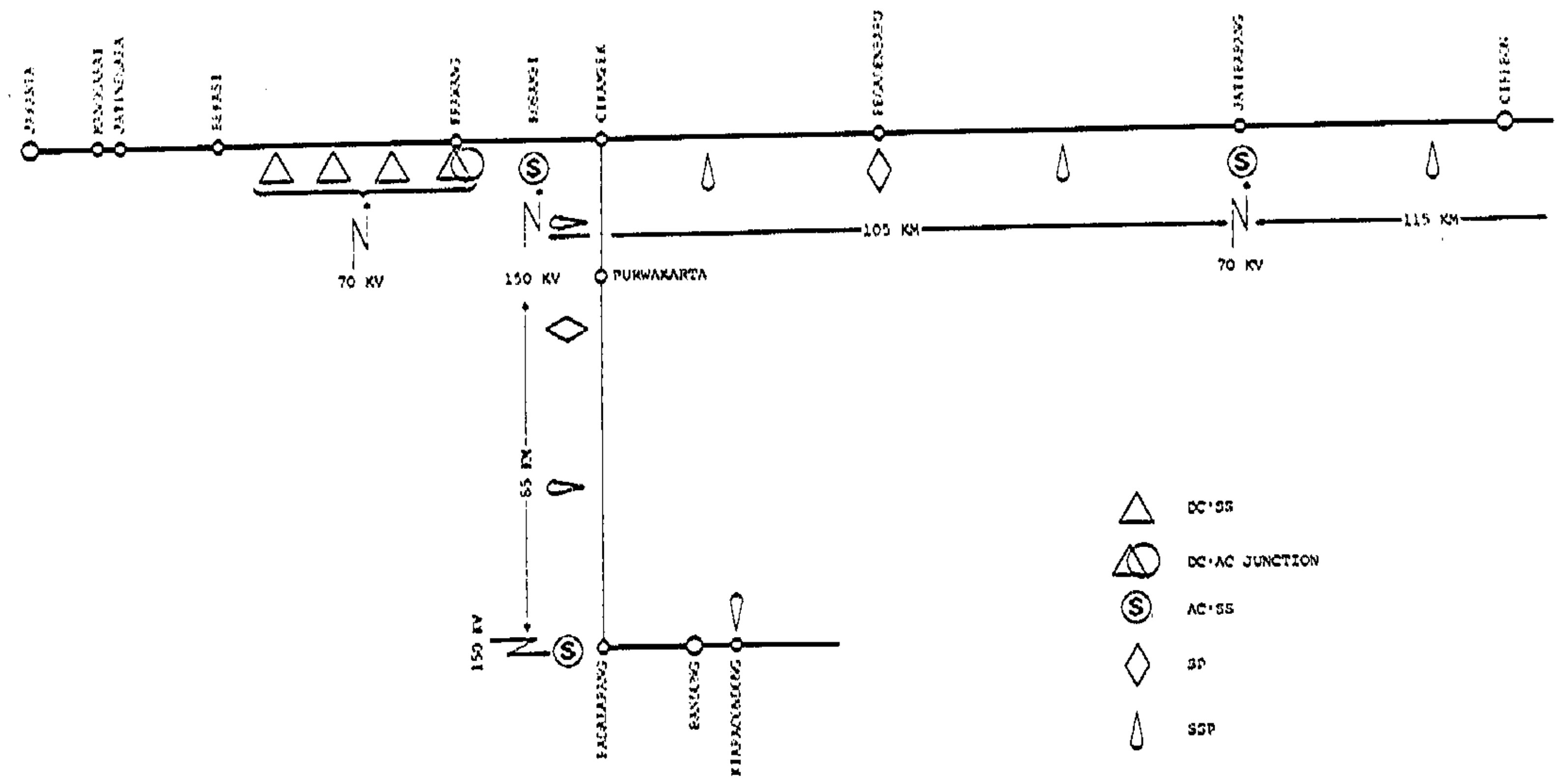


Fig. 4.3.4-1

THE SECOND STAGE ELECTRIFICATION PLAN

CIREBON ∿ YOGYAKARTA (1,991)

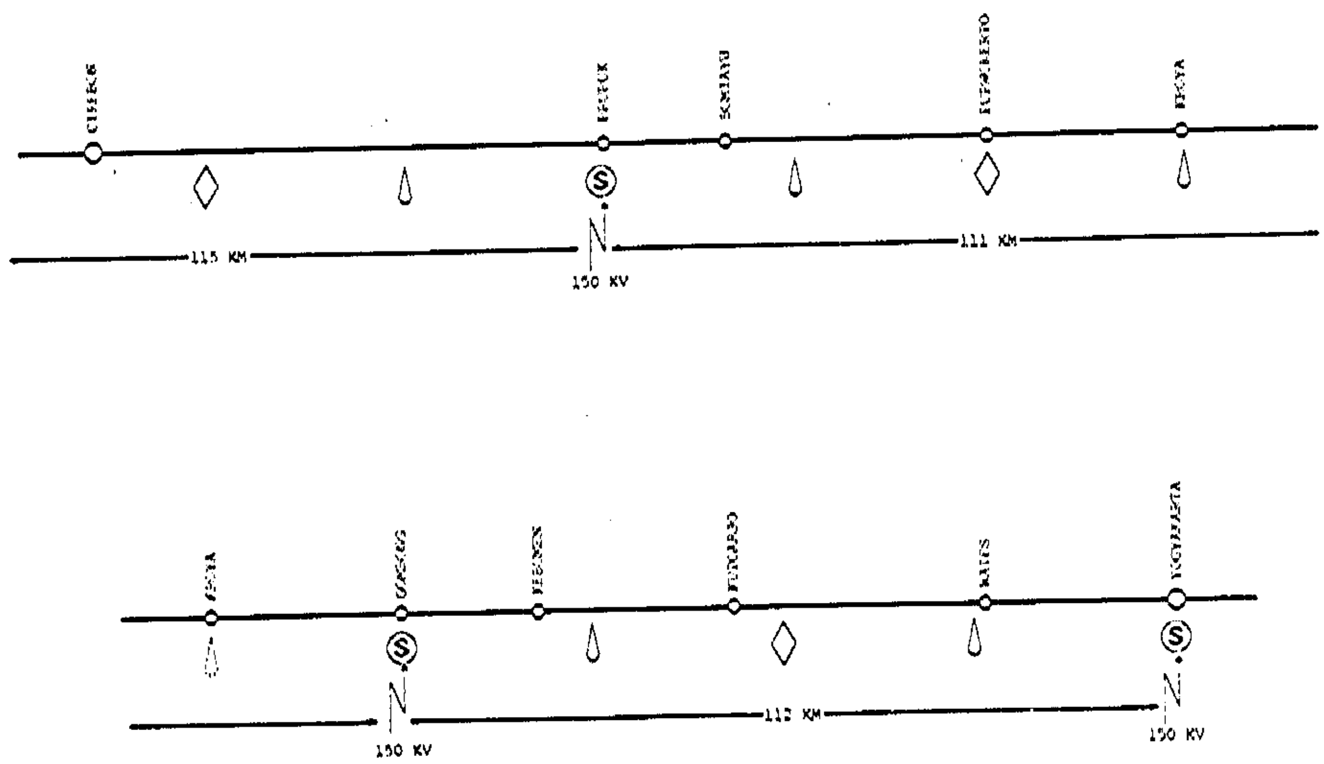


Fig. 4.3.4-2

THE SECOND STAGE ELECTRIFICATION PLAN

YOGYAKARTA ∿ SOLOBALAPAN (1,992)

SOLOBALAPAN ∿ SURABAYAKOTA (1,995)

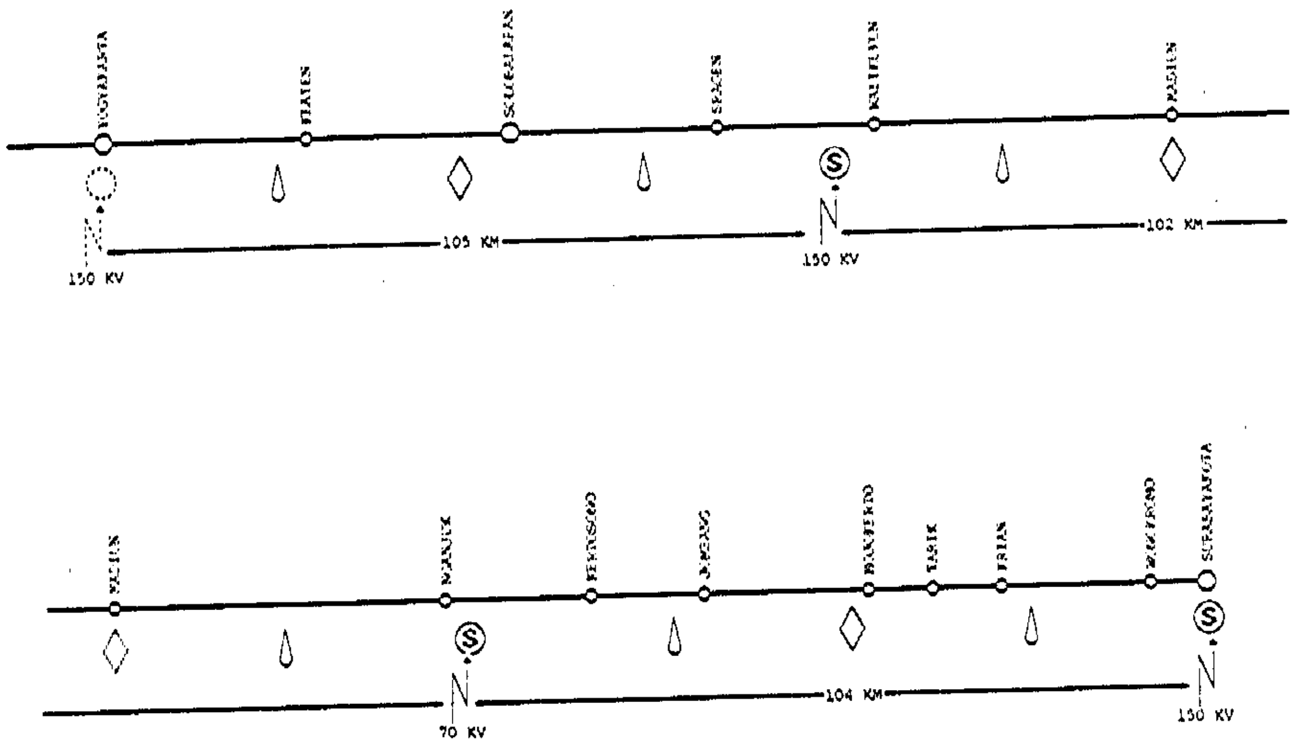


Fig. 4.3.4-3

THE SECOND STAGE ELECTRIFICATION PLAN

(JAKARTAKOTA) MANGGARAI ∿ KRWANG (1,994)

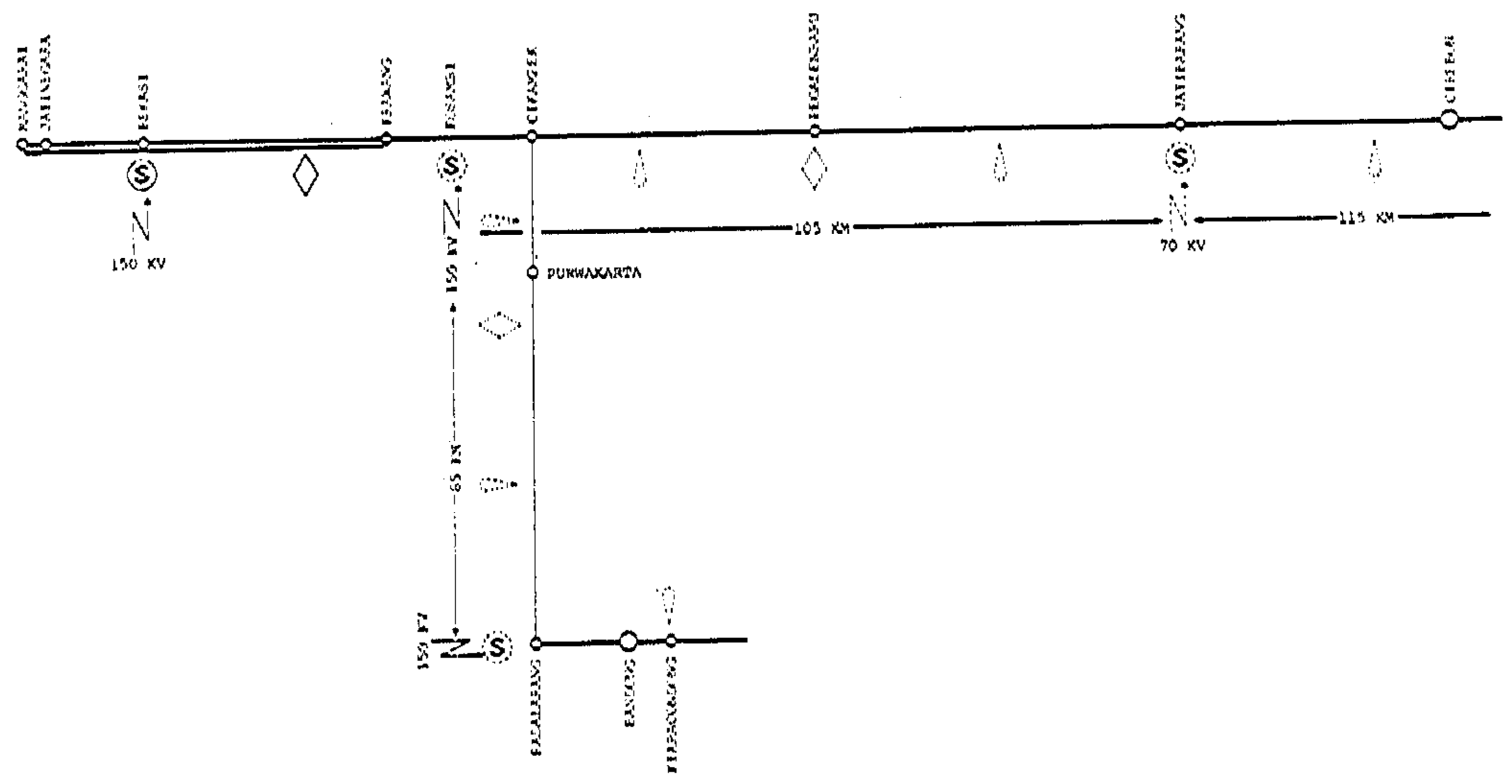
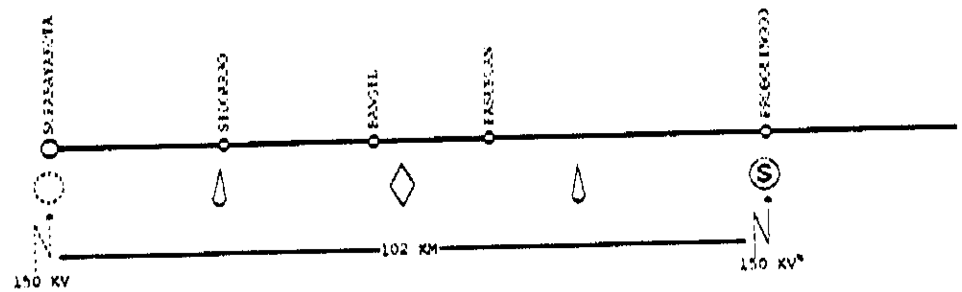


Fig. 4.3.4-4

THE SECOND STAGE ELECTRIFICATION PLAN

SURABAYAKOTA ∿ PROBOLINGGO (1,996)



SERPONG ∿ MERAK (1,998)

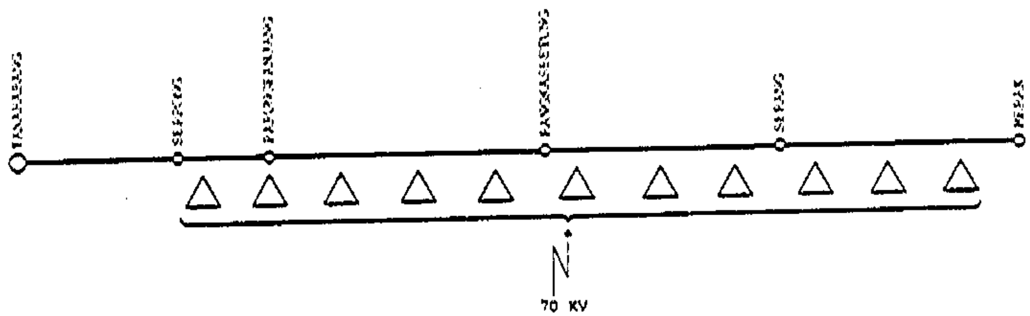


Fig. 4.3.4-5

THE THIRD STAGE ELECTRIFICATION PLAN

CIREBON ∿ SEMARANGTAWANG (2,003)

SEMARANGTAWANG ∿ SURABAYAPASARTURI (2,003)

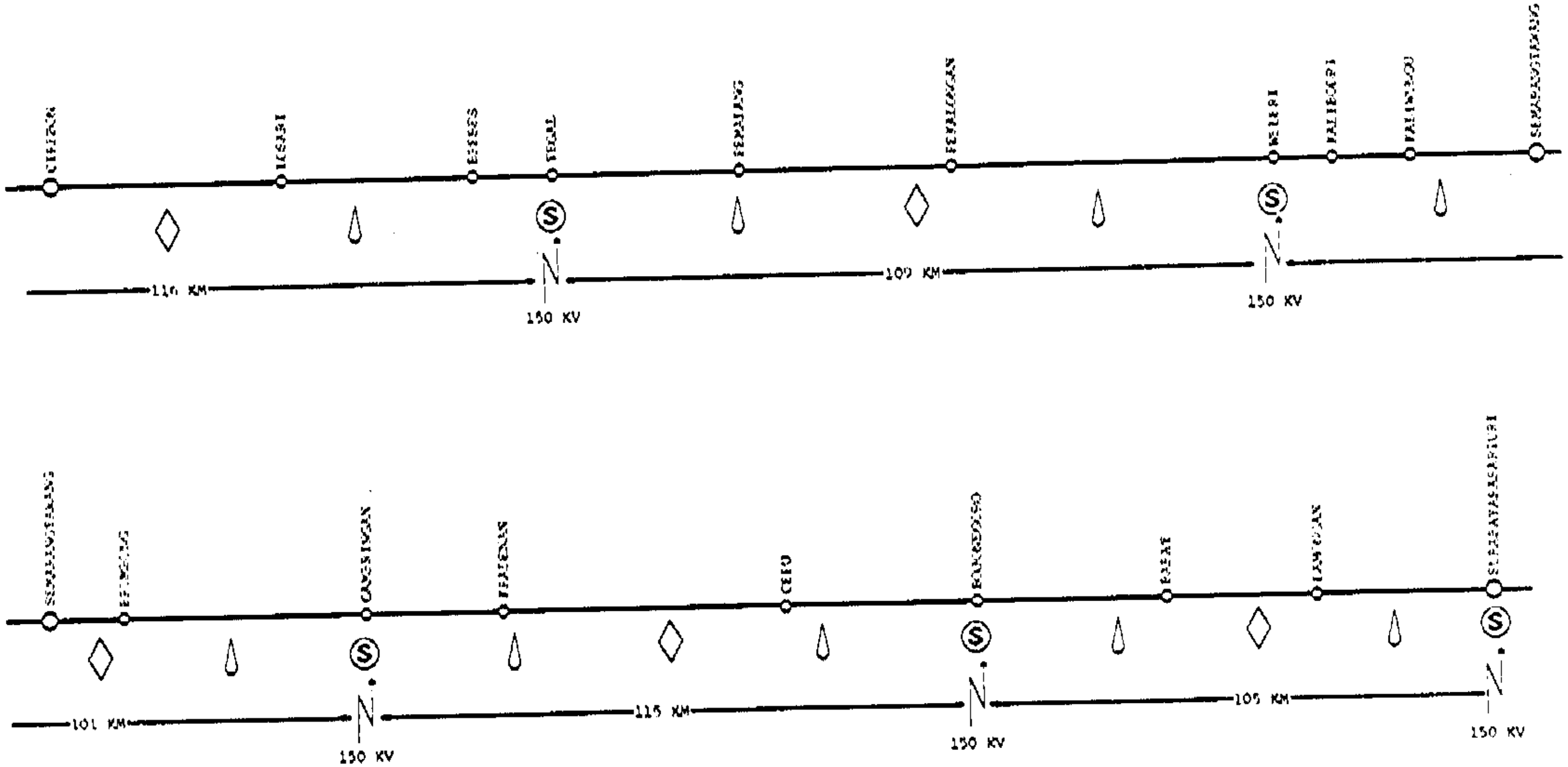


Fig. 4.3.4-6

THE THIRD STAGE ELECTRIFICATION PLAN

SEMARANGTAWANG ∿ SOLOBALAPAN (2,003)

KIARACONDONG ∿ KROYA (2,003)

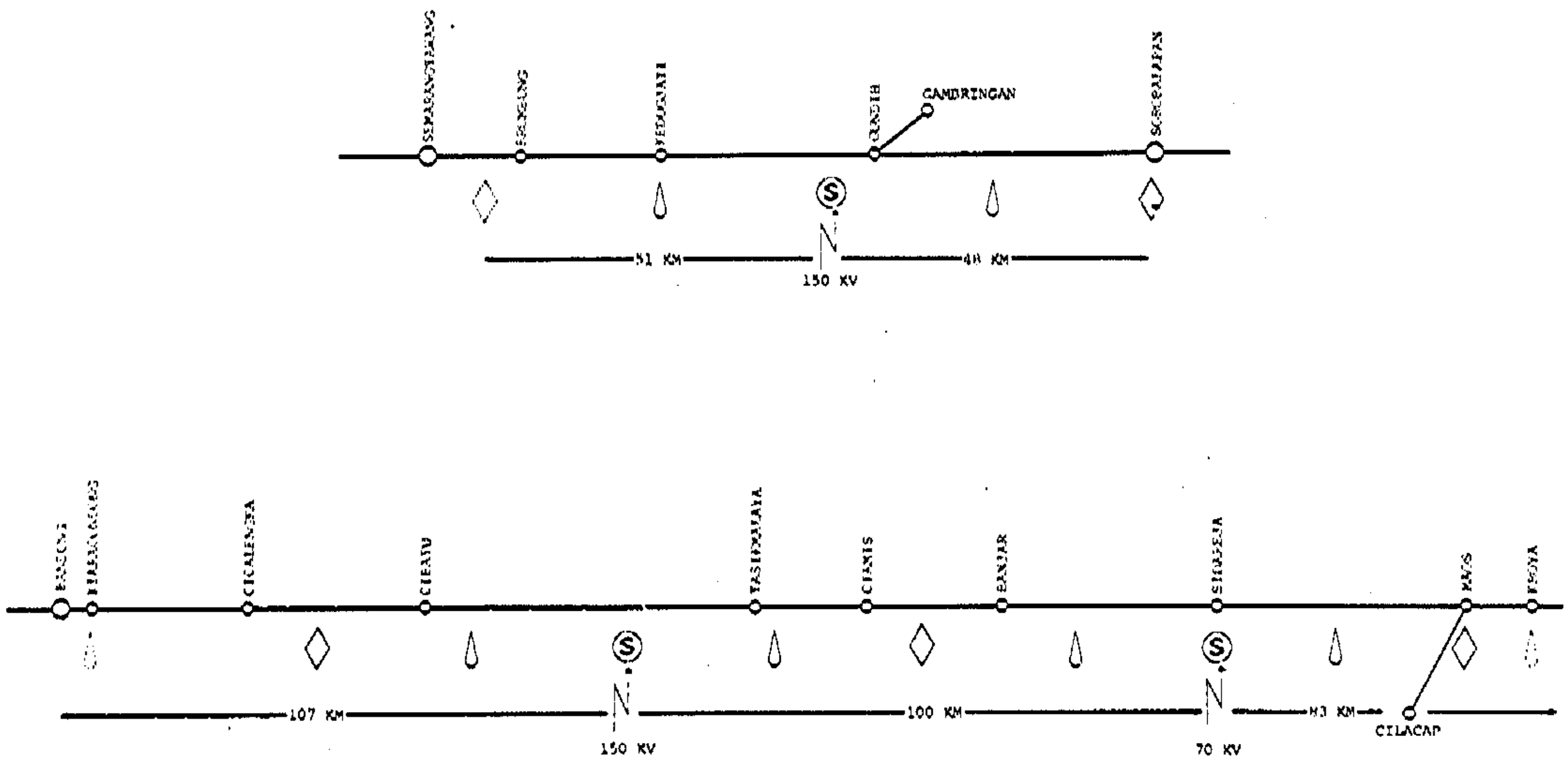


Fig. 4.3.4-7

THE THIRD STAGE ELECTRIFICATION PLAN

BOGOR ∿ SUKABUMI (2,003)

PROBOLINGGO ∿ JEMBER (2,003)

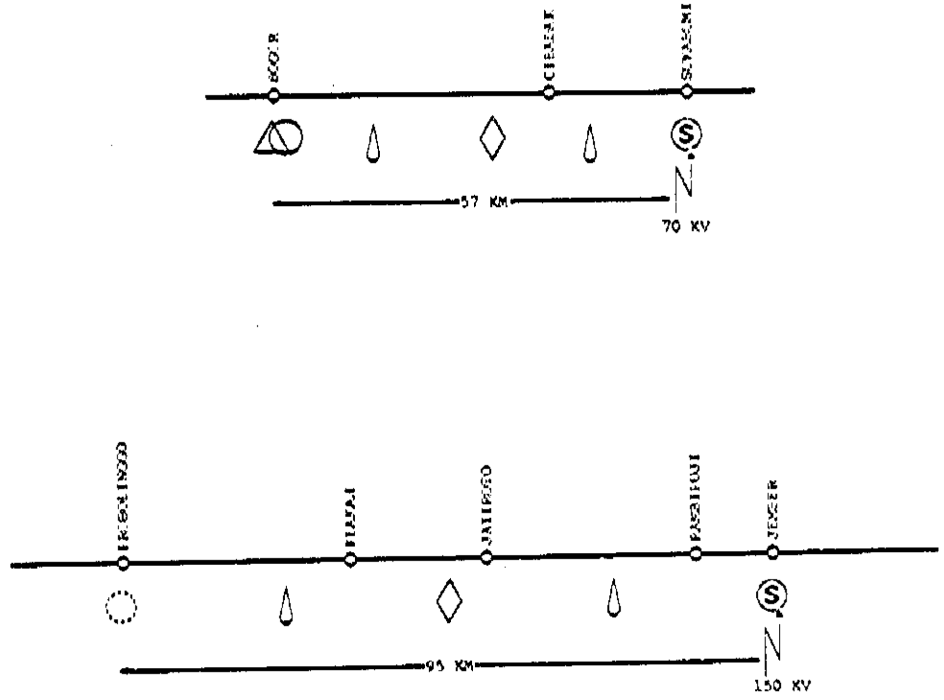


Fig. 4.3.4-8

THE THIRD STAGE ELECTRIFICATION PLAN

SUKABUMI ∿ PADALARANG (2,008)
JEMBER ∿ BANYUWANGI (2,008)
KERTOSONO ∿ BANGIL (2,008)

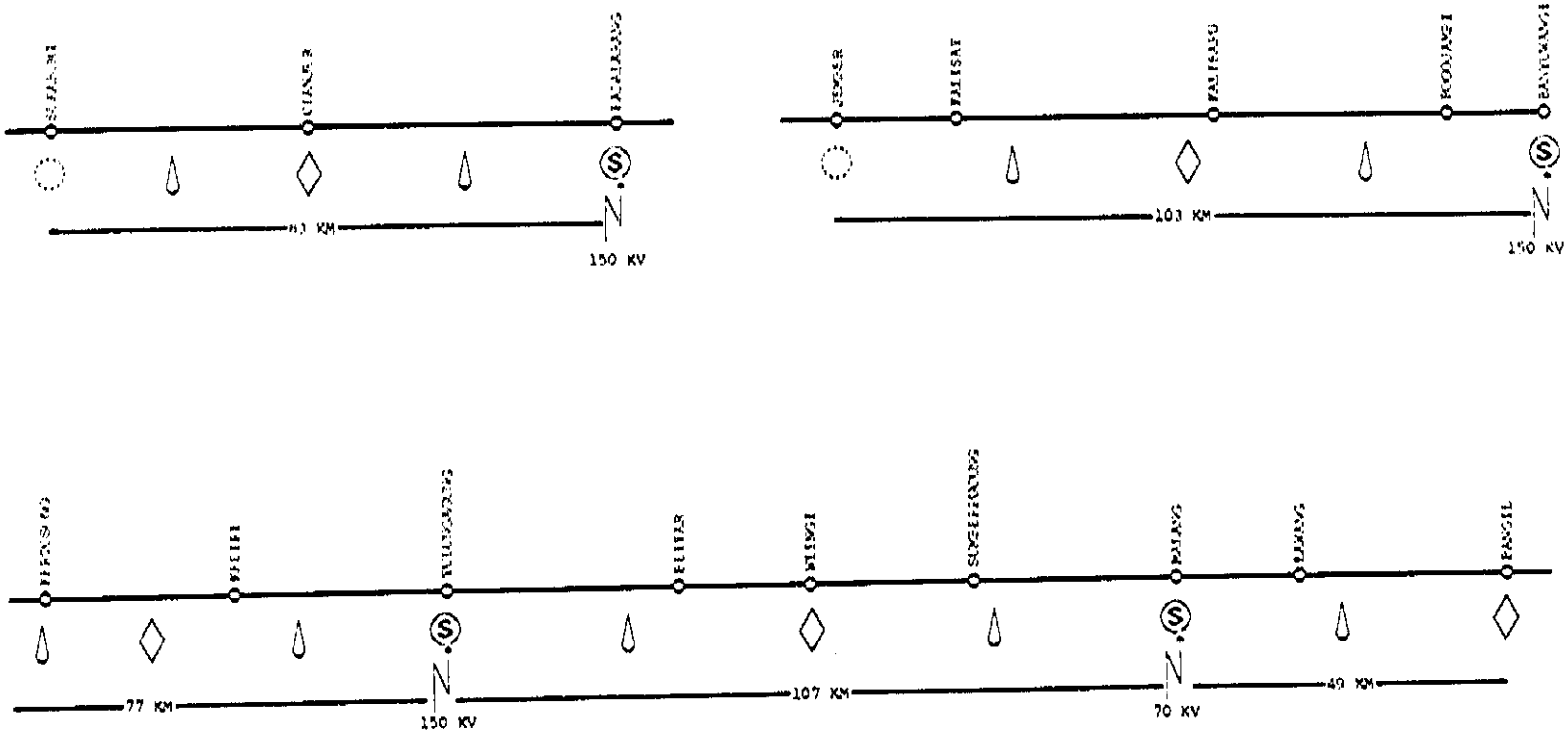


Fig. 4.3.4-9

4.4 Selection of Overhead Contact System and Structure

4.4.1 Basic Matters

Since overhead contact system supplies power through pantographs to electric motor vehicles, there must be mechanically and electrically sufficient harmony among them.

Furthermore, such meteorological conditions as air temperature and wind, too, must be considered as preconditions for designing.

The following basic matters are only proposed at this stage, and some of them will have to be clarified in more detail through discussion with the Indonesian side.

(1) Speed and hauling capacity

At the time of electrification, the following speeds and hauling capacity will be attained.

Passengers	100 km/h, 400 tons
Freight	85 km/h, 1,000 tons

but the facilities prepared should be able to allow 120 km/h to be attained in future when the track have been completed.

(2) Heights of vehicles and contact wire

Height of vehicles:	3,800 mm
Min. height of contact wire:	4,250 mm (tunnel)
	4,900 mm (railway crossing)
Standard height of contact wire:	5,300 mm (according to Jakarta West Line)

(3) Insulation distance

The insulation distance between the voltage applied portion and the earthed portion determines the scale of the improvement to be performed for existing bridges and tunnels, and also affects the maintenance of installations after electrification.

For the insulation distance, the UIC gives standard values (minimum insulation distance 220 mm, momentary proximity insulation distance 170 mm), but in various countries, they try to lessen the values, for more economical electrification. Also for the electrification of the main railway lines in Java, this conception is adopted, to adopt the following values.

Minimum insulation distance	200 mm
Momentary proximity insulation distance	150 mm

(4) Meteorological conditions

The meteorological conditions in Java are approximately as follows:

Air temperature	+22°C ∿ +35°C	Average +27°C
Wind velocity	20 m/sec., max.	
Rainfall	1,500 ∿ 2,500 mm/year on flatland	
	3,000 ∿ 5,000 mm/year in mountains	
IKL	Jakarta	85
	Bandung	115
	Tasikmalaya	73
	Tegal	46
	Semarang	100
	Yogyakarta	114
	Solo	72
	Surabaya	115

4.4.2 Selection of Catenary System

The catenary systems now adopted in the respective countries of the world for electrification can be classified into the following four basic systems.

Simple catenary system

Stitched catenary system

Compound catenary system

Contact wire system

These systems are also combined, to make twin simple catenary system, etc. for example. Due to the differences in the kind of wire used, tension, etc., they can be further classified into many kinds.

These various systems are adopted respectively in the various histories of railways and in different conditions of train operation of speed and load, in the respective countries.

Fig. 4.4.1 shows examples of catenary systems.

(1) Simple catenary system

In the catenary type, this is the simplest system. In ordinary simple catenary system, the upper limit of speed is usually about 100 km/h, but the heavy simple catenary system with a total tension of 3 tons (contact wire = 1 ton, messenger wire = 2 tons) by adopting a thick catenary wire can sufficiently meet upto 120 km/h.

For the main railway lines in Java, as mentioned before, operation at 120 km/h is considered for future, and furthermore, considering to introduce multiple unit electric cars with 3 to 5 pantographs per train, the adoption of heavy simple catenary system is surmised to be best.

(2) Stitched catenary system

The speed adaptability is higher than that of simple catenary system. In this system, since a stitched wire (generally a wire smaller than the catenary wire in sectional area is used) is provided under each support point, the composition of catenary is complicated compared with simple catenary system. Especially in construction and maintenance, the adjustment of the stiched wire is difficult.

Furthermore, the stitched wire may break due to any mechanical or electrical cause, drooping below the contact wire, as a trouble.

Therefore, this system is not recommended for the main railway lines in Java.

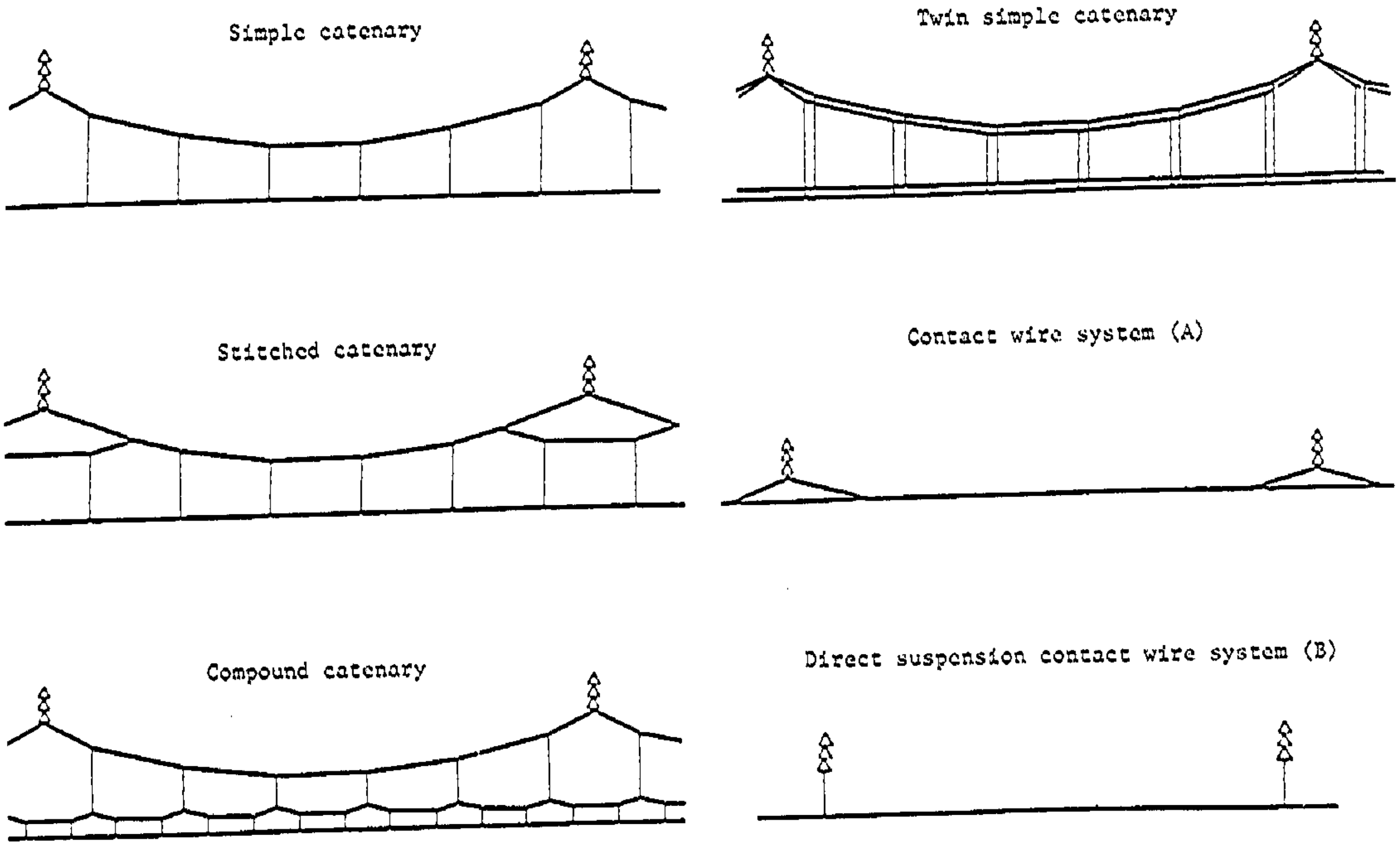


Fig. 4.4.1 Kind of Catenary System

(3) Compound catenary system

This system is large in collected current and excellent in speed adaptability, being used for sections of high speed operation or heavy load. On the other hand, the construction costs are high.

In view of the speeds and loads of the main railway lines in Java, this system is surmised to be too much.

(4) Contact wire system

This system is simple compared with catenary type, and low in construction costs.

However, also to maintain a good current collecting characteristic of the contact wire for pantographs, the tension of the contact wire must be kept high, and the utilization of the contact wire is lowered by that.

The adjustment of the tension of the short and thin suspension wire near each support point and the adjustment of the height of the contact wire are difficult, compared with simple catenary. Especially in a district with a high train frequency and a large load current, the problems of voltage drop and contact wire wear arise.

For the main railway lines in Java, this may be properly adopted in places where the load of siding line, etc. is small with a less train frequency.

Table 4.4.1 shows the respective systems in comparison.

Table 4.4.2 shows the construction costs of simple catenary system and stitched catenary system in comparison. Fig. 4.4.2 shows their structural views.

They are different not only in system, but also in the material of messenger wire, that is, there is a difference between iron material (St 135 mm^2) and copper material (CdCu 60 mm^2). They are shown in Table 4.4.3 for comparison.

Since iron (St 135 mm^2) messenger wire is economical for the electrification of the main railway lines in Java and can be produced domestically in Indonesia, its adoption is desirable.

Table 4.4.1 Catenary Systems and Performance

Kind of system	Standard Wire (sq.mm.)			Tension of ires(t)	Speed (km/h) (about)	Duty	Other features
	Messenger wire	Aux. Mess. wire	Contact wire				
Simple catenary system	St 90		Tr 110	M:1 T:1	100	Medium load	Basic type of simple catenary
Heavy simple catenary system	St 135		Tr 110	M:2 T:1	140	Medium load	Uplift small. For high speed.
Stitched simple catenary system	CdCu 60		Tr 110	M:1 T:1	120	Medium load	As compared with simple catenary, uplift somewhat larger.
Compound catenary system	St 135	Cu 100	Tr 110	M:1 Aux.M:1 T:1	160	Heavy load	Basic type of compound catenary High construction cost
Direct suspension system			Tr 110		50~80	Light load	Low safety. Low construction cost

Abbreviations St: Galvanized stranded wire
Cu: Copper stranded wire
Tr: Grooved hard-drawn copper wire

Table 4.4.2 Construction Costs by Catenary Systems in Comparison

		Heavy Simple Catenary System	Stitched catenary system
Supports		44	44
Feeder		12	12
Contact wire		39	51
Common equipment		5	5
Total		100	112
Kind of wire	Messenger wire	St 135 mm^2	CdCu 60 mm^2
	Contact wire	Tr 110 mm^2	Tr 110 mm^2
	Feeder	Al 200 mm^2	Al 200 mm^2
	Protective wire	ACSR 40 mm^2	ACSR 40 mm^2

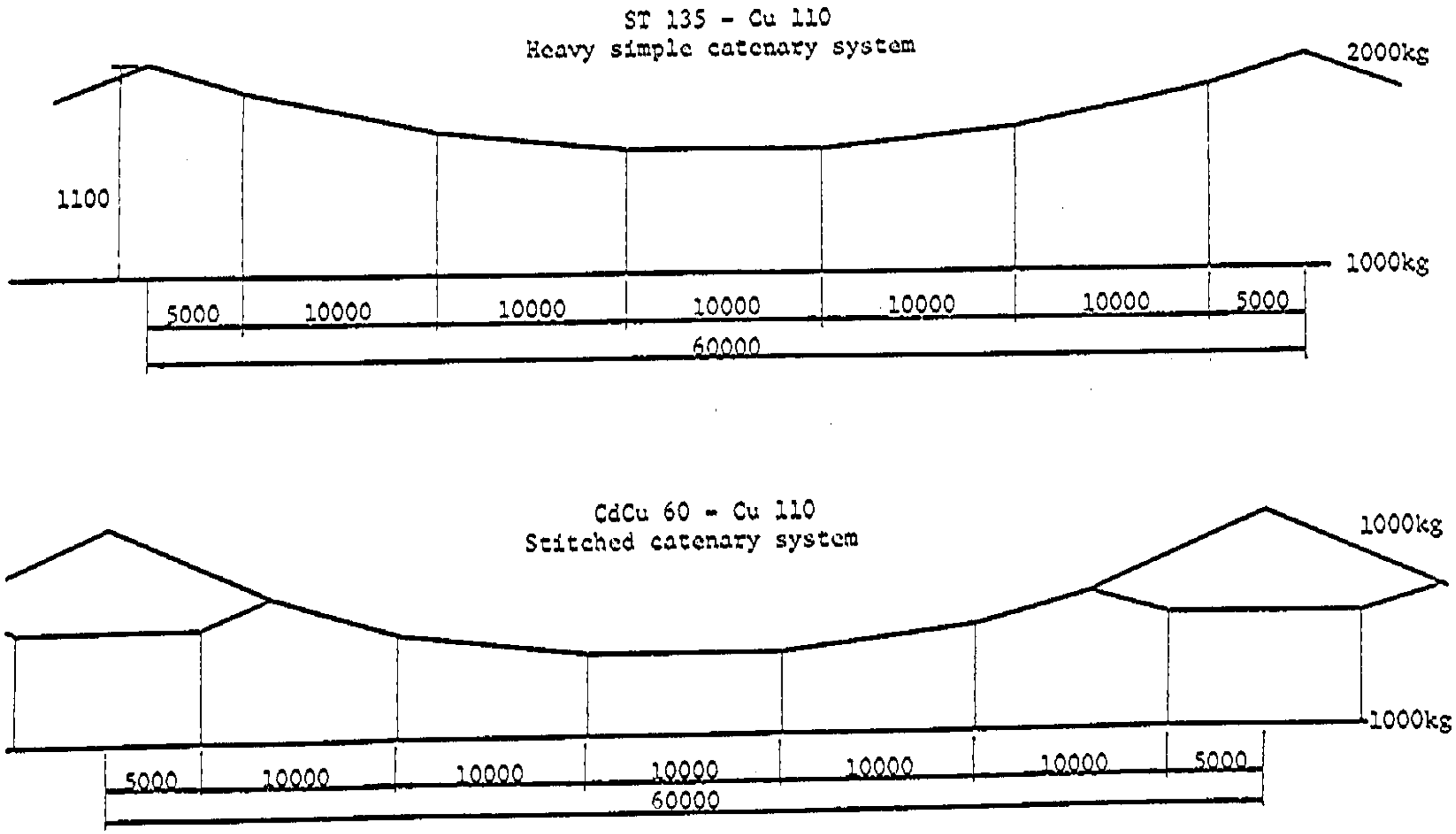


Fig. 4.4.2 Profile of Catenary System

Table 4.4.3 Iron and Copper Messenger Wires in Comparison

Item	Iron messenger wire	Copper messenger wire
Properties of vibration resistance, fatigue and wear resistance	◎	O
Current capacity as catenary system	O	◎
Mechanical properties as catenary system	◎	O
Corrosion	O	◎
Product cost	◎ (Low)	Δ (High)
Production	O	Δ

Note: ◎ Superior
O Ordinary
Δ Inferior

4.4.3 Selection of Structures

Structures for overhead contact system include poles and beams basically, and in addition, stays, drop arms, cross-arms, etc. as accessories. They support a contact wire and a feeder, and have various markers attached, being an important element of electric operation installations.

(1) Types of supports

Various types are considered, and standard types are shown in Fig. 4.4.3. These are selectively used according to respective installation conditions.

(2) Selection of poles

1) Concrete poles

Concrete poles produced by the prestressed centrifugal method are little cracked or deflected and have sufficient strength, having semi-permanent life. They are low-priced and are not required to be plated or painted unlike steel masts, not being required to be maintained.

The PLN already uses concrete poles, and the setup for domestically producing them in Indonesia is being completed.

Therefore, for the electrification of the main railway lines in Java, it is surmised to be good to adopt mainly concrete poles.

2) Steel masts

Steel masts include built-up steel masts, H-section steel masts, steel pipe masts, etc., and the steel masts properly designed are simple both in structure and appearance, having long life if effective corrosion preventive treatment is applied.

Also for the main railway lines in Java, steel masts may be adopted in places where concrete poles are not sufficient due to load conditions, as in station yards.

3) Wooden poles

Wooden poles can be used for about 30 years, if properly treated by preservatives, except places of severe environmental conditions such as marshland or exposed to damage by birds. Therefore, they can be practically used though not so good in appearance as concrete pole.

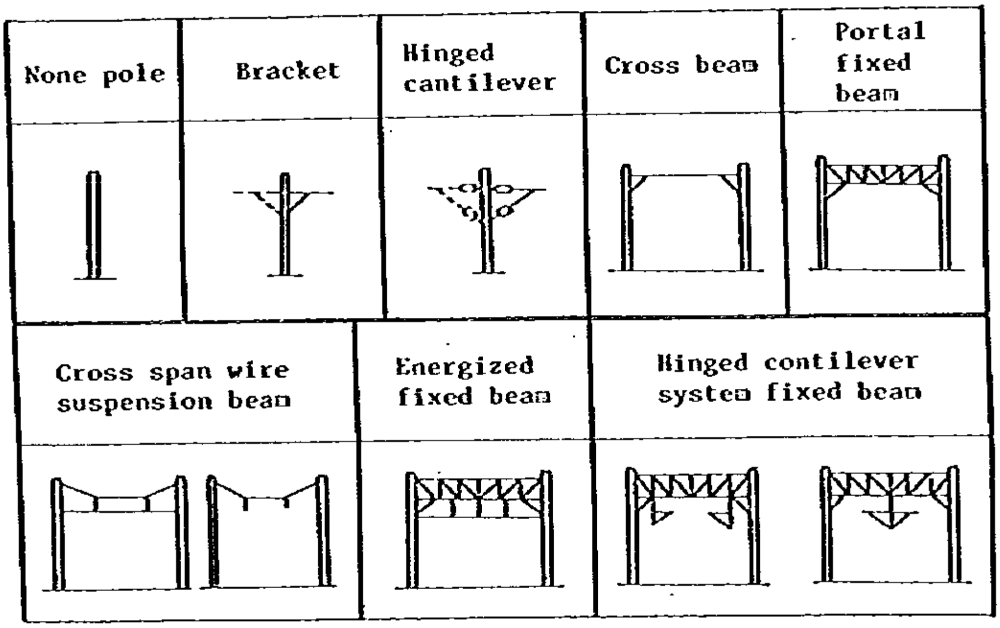


Fig. 4.4.3 Types of Support

(3) Selection of beams

Beams can be roughly classified into rigid type, headspan type and hinged type, and used selectively according to installation conditions.

1) Rigid beam

Rigid beams are made by combining steel materials, and include portal beams such as cage beams, V truss beams, flat truss beams and cross beams, and rigid cantilever beams.

Employment of these beams is considered when the domestic production system is improved and if the steel is not expensive.

2) Headspan beam

Headspan wire are suspended across the track, to support the contact wire, and this type is widely used in the existing direct current electrified sections in Jakarta.

The adoption of this type must be considered when the erection of posts cannot be made due to narrow track intervals in a station yard, etc. and when the span is long.

This beam is not good in following up the movement of the contact wire, and where the movement of the contact wire is considerable, its use should be avoided.

3) Hinged beam

A hinged cantilever is hinged at the joint between the beam and the post as shown in Fig. 4.4.4, and the beam can rotate freely in the track direction.

Thus, since it can follow the movement of messenger wire and contact wire, the adjustment of tension is easy, allowing good catenary characteristics to be maintained.

Furthermore, the entire beam is insulated against the ground. Since the insulation distance from the earth is large, working with live line can be made safely. Furthermore, since insulators are provided aside, they are less soiled by the exhaust gases of diesel and steam locomotives, compared with those provided right above the track.

Therefore, the adoption of hinged cantilever is mainly recommended for an intermediate portion of each station.

4) Energized beam

These are improved rigid beam as shown in Fig. 4.4.5, allowing the number of insulators to be remarkably reduced and facilitating working with live line.

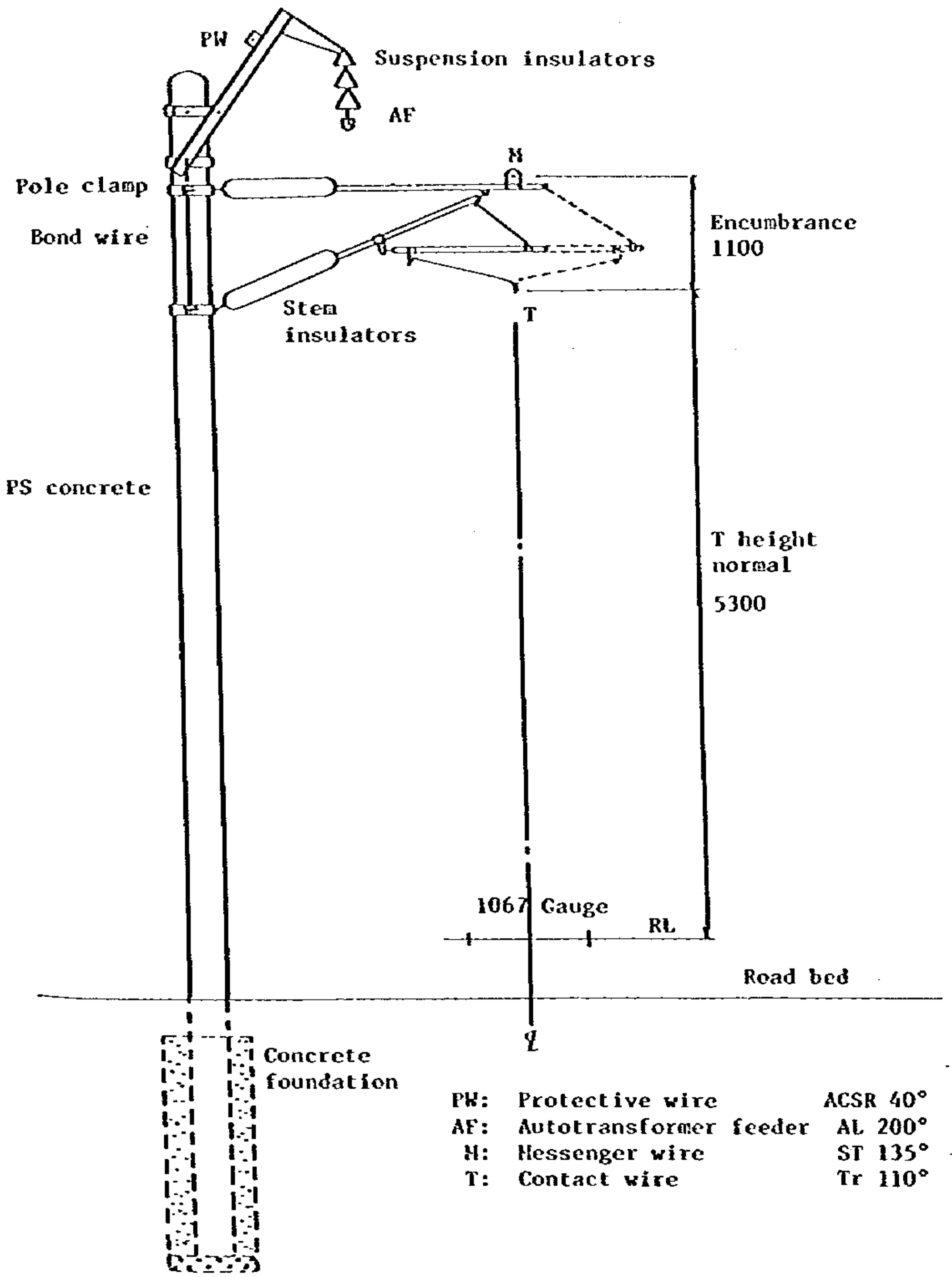


Fig. 4.4.4 Standard Assembling View

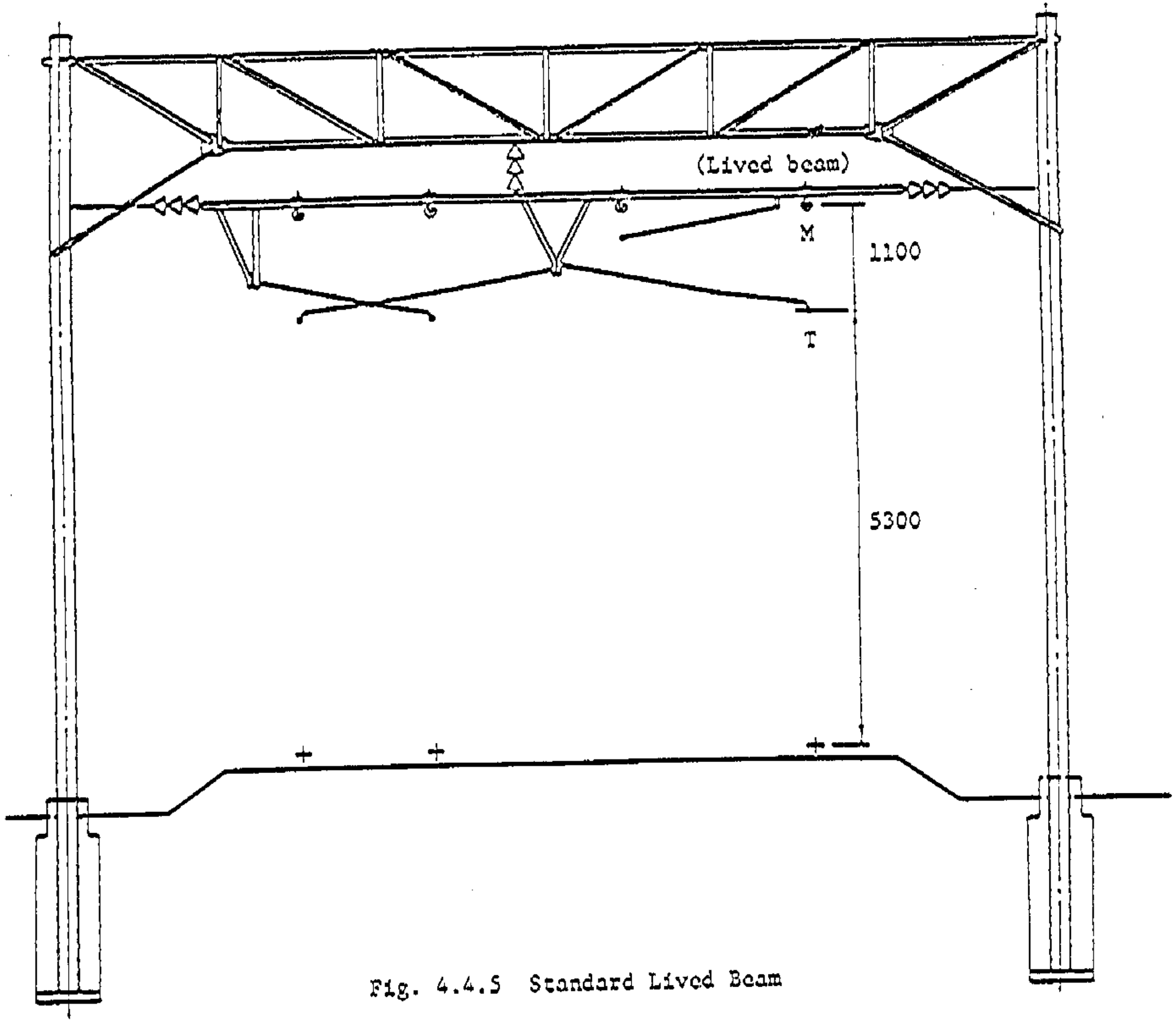


Fig. 4.4.5 Standard Lived Beam

CHAPTER 5 SIGNALLING AND TELECOMMUNICATION PLAN

5.1 Present Status

5.1.1 Present Status of Signalling and Telecommunication Installations

(1) Block system and dispatch system

The operation of trains on all zones of the main railway lines in Java is carried out safely by means of a manual block system which operates blocking as agreed upon by the operators of both stations.

The operation of trains in all zones is controlled by dividing the whole island into 10 areas. In each area dispatchers in the dispatch office collect information from each station by phones and prepare actual schedules. Table 5.1.1 shows the location and control areas of the train dispatching offices.

Table 5.1.1 Operation Dispatch System

No.	Dispatch office	Control areas
1	Jakarta	Merak ∿ Jakarta ∿ Cikampek, Jakarta ∿ Sukabumi
2	Cirebon	Cikampek ∿ Cirebon ∿ Tegal, Cirebon ∿ Prupuk
3	Bandung	Cikampek ∿ Bandung, Bandung ∿ Banjar
4	Purwokerto	Purpuk ∿ Purwokerto, Purwokerto ∿ Kroya ∿ Kutoarjo
5	Semarang	Tegal ∿ Semarang ∿ Bojonegoro, Semarang ∿ Kedungjati
6	Yogyakarta	Kutoarjo ∿ Yogyakarta ∿ Solo
7	Madiun	Solo ∿ Madiun ∿ Mojokerto
8	Surabaya	Bojonegoro ∿ Surabaya ∿ Mojokerto, Surabaya ∿ Bangil
9	Malang	Kertosono ∿ Malang ∿ Bangil ∿ Probolinggo
10	Jember	Probolinggo ∿ Jember

(2) Signal device

The signal device in Java is comprised of mechanical signal equipment of mostly the double wire type semaphore signals in each area.

Since many years have passed since its construction, it not only takes much work to operate the devices but also the coordination of the field equipment is poor and the reliability of the equipment is lowered due to obsolescence.

Table 5.1.2 gives the number of the signal devices according to branch office.

Table 5.1.2 Number of Signal Devices

	Signal device			Level crossing safety device	
	Mechanical type	Electro-mechanical type	Relay type	Electric type	Mechanical type
West Region Office	86	86	1	9	479
Central Region Office	149	54	1	5	426
East Region Office	141	35	-	5	429
Total	376	175	2	19	1,334

1) Block system

The Morse telegraph plays an important role as a block device for the manual block system. On important routes, the electro-mechanical block devices are operated at both terminal stations and blocking is carried out by mutual confirmation. Since there is a possibility of a traffic accident occurring through misoperation of the equipment on both sides, the improvement of block system is urgently desired for advancing safety irrespective of the electrification project.

2) Signal device

Various signal safety devices are used for the main railway lines in Java including simple mechanical signal safety devices and relay interlocking devices.

a) Simple safety device

Representative simple safety devices include Krian lever frames, wooden lever frames and iron lever frames. With these systems, the point is locally operated and a signal device is operated with an outdoor signal lever. Each signal device has mechanical locking relationship but they are obsolete and not very safe.

b) Alkmaar type safety device

With the Alkmaar type safety device, the point is also operated locally but the signal device levers are concentrated. The signal devices and the points are locked mechanically by wires and since safety is low, the grading up to S & H type safety devices is being promoted.

c) S & H type safety device

The S & H type safety device is the safest system among the mechanical signal systems in PJKA. The signal levers and point levers are concentrated and the locking between signals and points is mechanically carried out with a locking device consisted with "dog" etc. A double wire type mechanical signal is used for the signal system.

Because the mechanical signal used in a), b) and c) above have poor visibility at night requiring trains to slow-down, color light signals are desired to improve the trávelling speed and to advance safety.

d) N. X. type safety device

The N. X. type safety device, a relay interlocking device, is the safest one in PJKA, but is only installed at Bandung and Solobalapan stations.

The type is a selective route type manufactured by Siemens Co.

For signal devices, multi-color light signal is used and trailable electric point machines are used for point machines and single-rail track DC track circuit is used for the track circuit.

3) Level Crossing Safety System

There are about 820 level crossings with safety devices on the main railway lines in Java, of which about 70% are less than 6m wide and about 25% are from 6m to 12m wide.

Various level crossing safety devices are installed at these level crossings.

Electric level crossing safety devices are only installed in large cities such as Bandung, Semarang and Surabaya.

At most level crossings, mechanical safety devices using arms and sliding fences are installed.

(3) Telecommunication system

Although a radio communication network is being developed, the telecommunication system in Java is comprised mostly of Morse telegraph and telephones with a communication network mostly of open-wire used as a means of communication.

The number of telecommunication systems by regional offices is given in Table 5.1.3.

Table 5.1.3 The Number of Telecommunication Systems

System		West Region Office	Central Region Office	East Region Office	Total
Physical system	Telegraph	360	270	301	931
	Local battery telephone	325	281	152	758
	Train dispatching telephone	50	88	74	212
	Automatic private telephone	1,028	369	518	1,915
	Teleprinter	30	16	16	62
Radio system	HF-SSB	4	-	4	8
	VHF-radio train dispatching telephone	84	42	14	140
	UHF-radio communication	36	34	15	85
	VFT-radio	5	8	2	15

1) Communication circuit network

The present situation of the communication circuit network comprises 300MHz UHF radio links for the main trunk lines of the long distance circuit generally having safficient capacity.

While the short distance and branch lines use an aerial open-wire system mostly of steel wire (partly copper-weld wire is used), it is very difficult to construct a good circuit network.

For this reason, although there are some sections where circuits of more than 50km are constructed, 100km distances are covered by Morse telegraph and communications between adjacent stations, are carried out by telephone and communication between stations far apart is almost impossible.

2) Dispatching System

The circuit network of train dispatching telephone is comprised of aerial open-wires and radio communication network.

A dispatch network by aerial open-wires covers the South Line route between Cirebon-Purwokerto - Yogyakarta-Surabaya. There are many types of dispatching systems such as ATA-70, W.11, B10 and Alkmaar type, etc.

These systems have difficulty in constructing a dispatching system due to obsoleteness and lack of parts for maintenance. The North Line route between Jakarta-Bandung-Cirebon and Cirebon-Semarang -Surabaya comprises a dispatching system, as a monitoring system, with radio network which connects dispatching offices with each railway satation using VHF (160MHz band)

3) Radio System

There is the BASA radio system which can use telephone exchange network of PJKA through operators of each communication center together with the dispatching system given in above section 2).

For long distance communication, a 300 MHz UHF link of 72 CH capacity is installed in major districts and used for long distance telephone and telex communications among the headquarters and regional offices, the offices and the major railway stations.

While HF band SSB radio telephones are located at the headquarters and regional offices, for communication in Sumatra and Java, their communication quality is unstable due to atmospheric conditions.

4) Exchange system

At the main stations in Java, a Philips UH-200 automatic telephone exchange is installed and subscriber telephone is installed at stations where the exchange is installed, and with PJKA business organizations nearby.

Some exchanges are used as private branch exchanges because trunk circuits cannot be constructed.

Also, Philips UT-11 are installed as relay exchanges at Jakarta, Bandung, Semarang and Surabaya and carry out relay connection of long distance telephone circuits. Siemens Telex automatic telegraph exchanges are installed in Jakarta, Bandung, Cirebon, Semarang, Yogyakarta, Surabaya and Bangil and form a telex network for the reporting and collection of data with regard to railway operations.

5) Telephone

Automatic telephone is installed with business organizations around locations, as shown in section 4) above, where the automatic exchange is installed so that subscribers can be called by toll dialling where trunk circuit is constructed. Where automatic telephone equipment is not installed, magneto telephones with earth return system, are installed for blocking communication and business communication. Also in some districts, inter-call telephones are installed but since it is a selective relay type and the circuit comprises aerial open-wires, long distance calling is difficult.

6) Telegraph

Morse telegraph is installed at each station as blocking system for train operation and is still a very important system. The morse telegraph is also used for long distance calls within districts but there are mounting problems of securing trained Morse personnel, the tedious work of record control and lack of maintenance parts due to obsolete equipment.

7) Others

For other communication systems, there are passenger information service announcing devices at major stations and electric clocks at major stations and business organizations.

5.1.2 Present Status of Control and Maintenance

(1) Control and Maintenance Organization

The signalling and telecommunication department belongs to the fix installation bureau as well as that of tracks and bridges within the composition of PJKA.

The number of the staff at the headquarters and in the district of Java is about 1100.

1) Headquarters

The headquarters is staffed with 31 persons and carries out technical control, business control and audit business for the whole PJKA railways network area.

Directly under the headquarters, a workshop is located at Bandung and a staff of 38 persons carries out equipment repair work which cannot be attained at the regional maintenance section and assembly work of mechanical interlocking devices etc.

2) Regional Offices

Three regional offices in the Java district carry out business control and maintenance work for each district. Each regional office is allocated maintenance offices according to the size of its control area and the Java district comprises 11 maintenance divisions and 1017 maintenance workers.

(2) Education

The staff in charge of signalling and telecommunication work is acquiring knowledge regarding control and management at DIKLAT I (Training Center Building I) and regarding general technology and maintenance at DIKLAT II (Training Center Building II), the educational facilities of PJKA at Bandung.

As educational material regarding signalling and telecommunication, there is nothing but only mechanical machine interlocking device with electro-mechanical block system and Morse telegraphs at DIKLAT II. There is SATKA (Railway Technical College) available as a commissioned education organ in cooperation with ITB (Bandung Technology Institute).

(3) Correlation of Train Operation Accidents and Signalling and Telecommunication Systems

Table 5.1.4 shows an aggregate of train operation accidents which are considered to have been related to signal and communication systems, taken from the statistics of train operation accidents in the central district for 8 years from 1974 through 1981.

Table 5.1.4 Statistics of Train Operation Accidents

Type of accidents	Number of train operation accidents (times/year)								Average
	1974	1975	1976	1977	1978	1979	1980	1981	
Train collisions (between stations)	1	1	0	1	0	0	1	1	0.6
Collision of rolling stock during shunting	3	2	1	1	2	1	0	0	1.3
Train collisions (mostly at level crossing)	13	21	30	29	38	34	26	16	26
Failure of signal systems	1	1	0	0	0	0	0	0	0.3
Ignoring of signals	3	6	7	5	7	3	4	5	5
Landslide, flood, etc.	23	11	5	7	49	0	10	10	14.4
Others	780	609	723	733	588	533	566	439	621
Total	824	651	766	776	684	571	607	471	669

According to Table 5.1.4, 95% of operation accidents are not related to signalling and telecommunication systems. Most of these accidents were due to breakdowns of the rolling stock, etc.

Since recent operation of trains is relatively infrequent, collisions of trains between stations apparently due to blocking misoperations average 0.6 times a year and collisions of rolling stock during shunting occur 1.3 times and signal system failures 0.3 times. Although they are very few compared with other causes of accidents, advancement of safety is desired since these accidents are liable to lead to more serious accidents.

While train collisions on level crossings average 26 a year and ignoring of signals 5 times, there is a higher rate accidents related with signal system. Therefore, improvement of the level crossing safety system and the introduction of an automatic train stop system are desirable.

Also there are train operation accidents due to landslides and floods averaging 14 a year, so the installation of a monitoring system for falling rocks and landslides along the railway routes is considered to be of use.

5.1.3 Future Improvement Plan for Signalling and Telecommunication Systems at PJKA

The improvement of signalling and telecommunication systems is being promoted largely for the PELITA Plan (Five Year Development Plan) and the basic ideas on the development of the railway sector toward year 2000 has been developed.

(1) The 4th PELITA Plan

The signal system improvement program under the 4th PELITA Plan to be started in 1984/1985 mostly involves the installation of automatic block signals between Cikampek and Cirebon and relay interlocking device of 11 major stations (Cikampek station, Cirebon district, Semarang district, Yogyakarta district and Wonokromo district).

The telecommunication system improvement program is largely involved with the expansion of the UHF radio network.

(2) Basic development idea for year 2000

The following is studied for the development of the signal system in order to improve the safety of railway transportation and to increase the track capacity.

- Extended application of Siemens & Halske system with block device to trunk lines.
- Introduction of relay interlocking systems to main stations
- Introduction of automatic block system and ATS's to congested lines.
- Automatization and grade separation of city level crossings.

The development of telecommunication systems is studied concentrating on the expansion of radio communication system for the railway operation and control as follows:

- Train dispatching system with the possibility of expansion to CTC.
- Computerization of ticketing and seat reservation.
- Use of solar energy technology
- Multiplex cable carrier system and optical fiber communication system

5.1.4 Outside Organization Installations along the Railway Line

(1) PERUMTEL

Communication circuit network of PERUMTEL, Telegraph and Telephone Corporation, covers almost all the areas along the main railway lines in Java.

These trunk circuits of PERUMTEL comprise open-wire of Fe, Cu and Cw and supports are erected 4 ∿ 5m away from the tracks.

In some sections with many circuits, they are installed on both sides of the track.

PJKA's communication lines use these PERUMTEL support posts and are installed together underneath PERUMTEL's trunk circuits.

Also coaxial carrier cables are used in some sections. These communication circuits are subject to inductive interference when railway lines are converted to AC electrification. Inductive interference and its countermeasures will be given in 5.3.

(2) PLN

The power transmission network of PLN, Electric Power Corporation, is largely located some distance from the railway. Although in some sections the network is located close to the railway and since the distance parallel to the communication lines is comparatively short, there seems little problem of inductive interference between the PLN power line and the telecommunication lines.

5.2 Improvement Plan Following Electrification

5.2.1 Basic Study Items in the Improvement of Signalling and Telecommunication Systems

(1) Outer environmental conditions

Signalling and telecommunication systems cannot only not function fully due to outer environmental conditions such as the track and bridges, etc. but in the worst case, the composition of the system becomes impossible.

Especially in signal systems, the composition of the track circuit which is the basis of train operation safety is greatly restricted by environmental conditions.

With regard to the improvement of the signal systems of the main railway lines in Java, improvements for the block system may be carried out according to increasing transportation demand in the following order.

i) Tokenless block system

ii) Single-track automatic block system

iii) Double-track automatic block system

For these improvements, there are many districts which do not have adaptability of automatization of signal devices as given in ii) and iii) above due to the present outer environmental conditions shown in Table 5.2.1.

Therefore, it is desirable for the renewal of rail tracks in the future to carry out in advance the replacement of iron sleepers with wood or concrete sleepers and insulation measures for trough girders, gauge ties and railway level crossing.

Table 5.2.1 Outer Environmental Conditions

Classification / Section	Iron Sleeper (km)	Trough Girder (m)	Gauge Tie Bar (Place)	Railway Level Crossing (Place)	Highway Level Crossing (Place)
Bekasi ∿ Cirebon	0	77	2	0	170
Cikampek ∿ Kiarakondong	0	17	5	0	59
Cirebon ∿ Yogyakarta	149	133	0	3	213
Yogyakarta ∿ Solo	59	4	0	1	60
Jakarta Kota ∿ Krawang	0	0	0	0	300
Solo ∿ Surabaya	15	110	4	5	82
Wonokuromo ∿ Probolinggo	0	80	9	1	156
Merak ∿ Serpong	141	28	12	0	91
Bogor ∿ Sukabumi	56	6	11	0	39
Kiarakondong ∿ Kroya	41	110	5	5	99
Cirebon ∿ Semarang	0	30	2	3	93
Semarang ∿ Surabaya	165	227	9	0	143
Brumbung ∿ Solo	0	12	0	0	61
Probolinggo ∿ Jember	0	42	0	0	-
Sukabumi ∿ Padalarang	39	0	3	0	57
Bangil ∿ Kertosono	0	126	28	0	104
Jember ∿ Banyuwangi	9	18	0	0	-

(2) Signalling system

1) Disturbance current due to AC electrification and adaption of the track circuit

Generally in AC electrified section, the traction current runs irregularly in a electric circuit and causes disturbance currents giving various effects upon the signalling system.

Disturbance current is comprised of harmonic currents caused by AC substation, AC electric locomotive and AC electric cars; rush current generated when air-blast circuit breakers are closed with these cars; and AC stray current from AC electrified sections into DC electrified sections and DC stray current from DC electrified sections to AC electrified sections generated around the connection of AC and DC.

Therefore, it will be necessary to adopt a track circuit which can sufficiently withstand these disturbance currents in order to carry out the stable detection of trains in AC electrified sections. The type of track circuit applicable to the AC electrified sections is generally classified into DC track circuits, low frequency track circuits, pulsating track curcuits and AF track circuits.

These conventional track circuits have their respective peculiarities in function and character as shown in Table 5.2.2.

The following track circuits have recently been put into practical application by improving these shortcomings of the track circuits after considering the safety and economy of the whole system.

A study of these track circuits as well as the conventional track circuits for the main railway line in Java will be required.

Table 5.2.2 Comparison of Track Circuits for the AC Electrified Section

Item \ Name of Track Circuit	D C	DC Code	Halved-and-doubled frequency	Pulse	Audio Frequency
Length of track circuit (km)	0.75	2.0	2.0	2.0	1.0
Capacity of power source (KVA/Track)	0.05	0.15	1.0	0.05	0.15
Signal high voltage power line	Not necessary	Not necessary	Necessary	Not necessary	Not necessary
Power source on receiving side	Not necessary	Necessary	Necessary	Not necessary	Necessary
Track relay	DC relay	DC relay	AC Double Element Type	Pulse relay	DC relay
Maintainability	B	A	A	B	A
Price of equipment	A	A × 3	A × 4	A × 3	A × 4
Remarks	Short track circuit Susceptible to DC disturbance current Not possible to detect rail breakage	Susceptible to DC disturbance current Needs more than 2 modulation code frequencies	Large power source capacity	Difficult to adjust Susceptible to disturbance	More than 2 modulation code frequencies required.

a) High Power DC Track Circuit (hereafter called HDC)

HDC is produced to reduce the effects of misoperation due to inferior train shunt sensitivity, DC stray current, rush current and polarization in conventional DC track circuits.

The main cause of inferior train shunt sensitivity is the increase of the contact resistance between the rail track face and wheels caused by rusted rail track faces. HDC prevents misoperation by increasing short circuit current.

For misoperation due to stray current from the DC electrified sections, a rush current from AC electric motor vehicle and polarization by PC ties and submersion of sea water, HDC increases the normal current of the track circuit and improves S/N and the stability against outer disturbance.

Fig. 5.2.1 shows the basic configuration of HDC in an AC electrified section

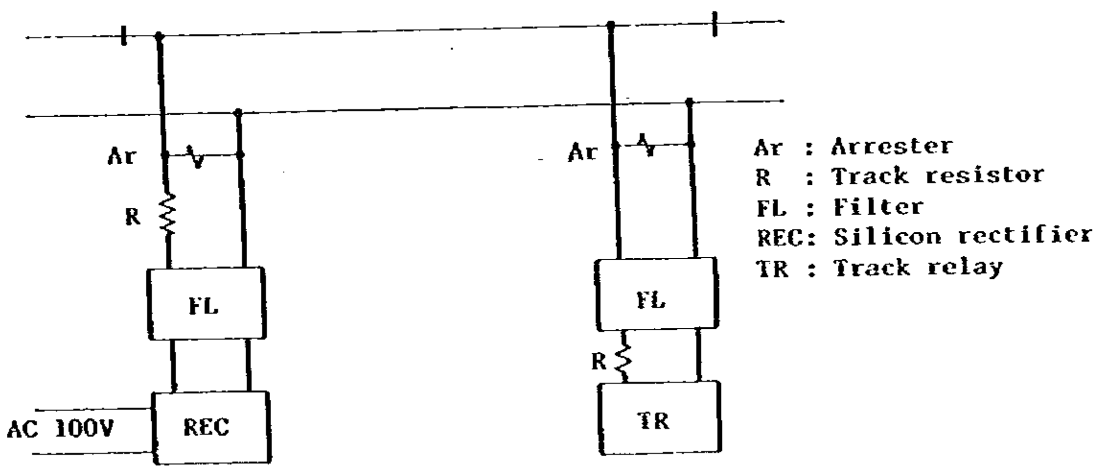


Fig. 5.2.1 HDC Track Circuit Configuration

b) 80Hz AC code track circuit (hereafter called HAC)

HAC uses 80Hz as carrier frequency and performs low-frequency modulation to enhance the safety.

It has the following characteristics.

- It has enough interference-resistivity to operate stably against disturbance currents into 50Hz fundamental wave and 80Hz signal band.
- Long control distance
- Can detect rail-breakage
- High reliability

Fig. 5.2.2 shows the basic configuration of HAC.

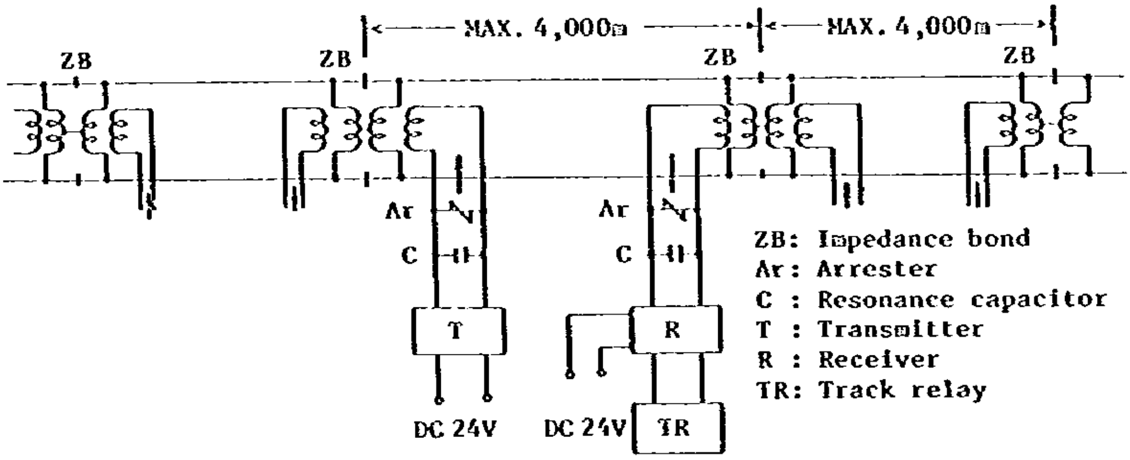


Fig. 5.2.2 HAC Track Circuit Configuration

2) Inductive interference with signalling facilities

50Hz high voltage is used for the contact wire in the AC electrification section.

Therefore, induced voltage and induced current by electrostatic induction or electromagnetic induction are generated on block circuits, signal control cables, signal wires and switch levers and such other signal apparatus which parallel adjacently to contact wires.

Also, the railway track circuit running in parallel close-by is impeded by electromagnetic induction. Table 5.2.3 shows the effects on these signalling systems in AC electrified sections and their respective countermeasures.

Table 5.2.3 Inductive Interference with the Signalling Systems in the AC Electrified Section and Their Countermeasures

Type of induction	Induced objects	Reasons of troubles	Countermeasures
Electrostatic induction Electro-magnetic induction	°Cable °Open-wire °Signal wire °Switch lever, etc.	Danger of electric shocks on a man (dangerous voltage)	°Shifting of cables and open-wires Shielding, in cables °Inserting insulated section and grounding of signal wires, etc.
Electro-magnetic induction	Track circuit	The track relay is liable to mis-operate.	°Inserting resistor in the receiving end of the track circuit °Changing the track circuit system

3) Protection from surge voltage

To protect signalling equipment from abnormal voltages due to lightning surges entering from overhead cable, etc. and grounding fault of the contact wire, countermeasures requiring insulated transformers, arrester and other safety equipment must be studied.

4) ATS system

a) Prevention from accidents by ATS

ATS (Automatic Train Stop Device) is the control system to indicate warning to the engine driver by interlocking to the "stop" aspect condition signals and stop the train if necessary. ATS can prevent from accidents caused by the following factors:

- Ignoring of signals
- Exceeding the speed-limit of turnouts
- Exceeding the speed-limit of curvatures
- Exceeding the maximum-speed of train running speed

In main railway lines in Java, there are now some accidents caused by ignoring of signals. With the advance of high speed and high density operations due to electrifications, it is required that ATS will be installed for the improvement of safety to prevent these accidents.

b) System classifications

The ATS systems are largely divided into the intermittent control system which transmits control data interlocked with the indicating conditions of the signals into the train at a fixed place; and the continuous control system which continuously transmits the changing conditions of signal indications into the train through the track circuit.

The intermittent control system is superior in maintainability, economic viewpoints and expansibility of the system because of the simplified constitution of its components.

The intermittent control system, therefore, is summarized below.

The intermittent control system are classified into the system A without a speed checking function, the system B with the function done on the ground and the system C with the function done on the train.

i) System A

The system A gives warning only at the location of the wayside coil in no relation to the running condition of a train. This is the simplest and most economical system to prevent ignoring of signals. This system, however, is unable to prevent from exceeding the speed-limit on turnouts and curvatures.

ii) System B

The system B makes speed check from the running time between the two control points of the wayside coil installed on ground by comparing the preset reference-time. This system cannot only prevent ignoring of signals, but also detect the speed-limit on turnouts and curvatures. This system, however, has such drawback that no precise speed check can be made because of the fixed reference-time.

iii) System C

The system C has the speed checking function on the train and is divided into the system (reference-speed type) in which the information received from the fixed point is put into the memory device and the speed is continuously checked separately for each type of trains and the same system (reference-time type) mentioned above ii).

In the employment of ATS system, the train operation conditions such as traffic density and types of train and economic viewpoints should be considered, because ATS systems have respective peculiarity mentioned above.

c) Introduction of ATS system

ATS systems comprises the cab device and wayside device. In the introduction of ATS system, the train to be installed with cab devices is required to have a place for devices and a continuous brake system. Meanwhile, the wayside device as an information transmission medium has to be fixed on a suitable place of track conditions.

In main railway lines in Java, various types of trains and trains without the continuous brake system will be operated for some time in future.

The study in the introduction of ATS is required as follows:

i) Cab device

Existing trains will be provided with only a warning device following no improvements on their brake system, so the driver will operate manually to stop trains.

The ATS system for trains to be procured in future will be adapted to the system C.

In the selection of the reference-time check and the reference-speed, moreover, the latter is desirable for the adaptability on the system expansion of wayside devices. It is required to study with due consideration to the train operational pattern, train operation density and investment effect.

ii) Wayside device

At the beginning the system A, which has a adaptability to the cab device of system C, will be provided for the wayside device in order to prevent from ignoring of signals.

In future, however, the expansion to the system C is required following changes of train operational pattern.

(3) Telecommunication system

1) Composition of communication circuit

Since telecommunication system are an important data transmission means for the safe and efficient operation of trains, and the composition of telecommunication systems, due consideration must be given to maintain systematic coordination of each business organ in the communication circuit project as well as for the reserve system of the equipment, composition of the reserve communication system and the switching system. For the composition of telecommunication systems, the following studies will be required.

a. Long distance communication circuit of over 100km between main local cities as operation bases and the center will use radio or coaxial cable long distance carrier system.

b. Medium distance communication circuits of about 50 ∿ 100km are installed between main local points and their auxiliary points will use cable carrier system.

c. Short distance communication circuits of several km installed between stations will use telecommunication cable.

The composition of communication circuits must take into consideration the establishment of dispatch systems such as power dispatch, signal and telecommunication dispatch and fix-installation dispatch, etc. upon the electrification of the railway.

Also the study of communication circuit as given in Table 5.2.4 will be required in consideration of the future operation of the circuit lines so as to fully use telecommunication systems for train operation, business and maintenance of facilities, etc.

Table 5.2.4 Construction of Telecommunication Circuit

System	Name of circuit	Description
Operation	Operation dispatch	Dispatch office ——Stations
	CIC	CIC center ——Stations
	Power dispatch	Dispatch office ——Substation or maintenance offices
	Substation control	Dispatch office ——Substation
	Signal and telecommunication dispatch	Dispatch office —— Maintenance offices, equipment room
	Fix-installation dispatch	Dispatch office —— Maintenance offices
	Direct telephone for operation	Dispatch office ——Along the track
	Exchange telephone	Exchange ——Subscribers (Station, maintenance offices, etc.)
	Facsimile	Dispatch office ——Stations
	Information along the track	Stations ——Along the track
	Train radio	Dispatch office —— Crew
Passenger	Exchange telephone	Exchange —— Subscribers
	Facsimile	Dispatch, stations ——Stations
	Electric clock	Stations ——Stations
Freight	Freight car service dispatch	Dispatch office ——Stations, yard
	Exchange telephone	Exchange —— Subscribers
	Facsimile	Dispatch office, yard ——Yard, stations

Note: For the utilization of circuits in the future, the possibility of using data transmission circuits to transmit the following data is considered.

- Train control data
- Freight and passenger control service data
- Management control data

2) Inductive Interference with Telecommunication System

Detailed discussions are made in 5.3 with regard to inductive interference of telecommunication systems. Existing bare communication wire must be improved to cable with larger shielding effect, because induced voltage and induced noise increase by electromagnetic induction in the AC electrification.

Even after shielded cable conversion, however, the induced voltage and the induced noise on the sectional circuit line may sometimes exceed the allowable values depending on its length, which will be thus restricted. Therefore, cable core must use well balanced type and the method of installation must also be studied.

As a countermeasure for inductive interference in the AC electrified section, it is also necessary to study the introduction of optical fiber cable which has made remarkable advances in technology lately.

This will be discussed in Appendix 5-1.

5.2.2 Basic Policy for Improvement of Signalling and Telecommunication Systems

Improvement of signalling and communication systems following electrification shall be carried out to the minimum extent necessary.

Modernization of signalling and telecommunication systems shall be carried out under a separate project in coordination with the improvement project of the railway infrastructure such as tracks and bridges, etc.

Concept of promotion of signalling and telecommunication system modernization is given in Appendix 5.2.

(1) Signalling system

Improvement of signalling systems is carried out to secure safer transportation and to carry out protection measures against induced currents and return currents in AC electrification.

Available signalling system is indispensable to secure safety of transportation but the present system is not always satisfactory.

Therefore, the following points are considered in the improvement utilizing the present system with the least investment.

a. Advancement of safety to secure safer transportation.
b. Advancement of maintenance performance and reliability.
c. Saving of manpower in signal handling and prevention of mis-operation.
d. Ease of improvements against the future increase of transportation volume.

Since transportation demand is heavy in Jakarta-Cikampek, adjacent to the JABOTABEK Area and countermeasures using the present signalling system are not sufficinet, overall improvement will be carried out.

(2) Telecommunication system

For the telecommunication system, an expansion plan for the radio, telegraph and telephone exchange networks of the whole island of Java is being carried out.

Since the telecommunication system comprises a network, the improvement of the telecommunication system must be coordinated with these plans.

The communication circuit system is largely divided into short distance circuits, medium distance circuits and long distance circuits.

The present plan involves medium distance with radio circuit networks.

While the improvement of telecommunication systems following electrification generally involves turning them into cables as countermeasures against inductive interference. The circuit lines should contain not only the currently used circuit lines but also power dispatch circuits power remote control circuit lines, other dispatch circuits following the electrification and also spare circuits for the utilization of the circuit in the future.

Therefore, following the extension of the electrified lines, more lines are turned into cable and short distance and medium distance circiut networks with communication cables will develop accordingly.

In other words, the train operation dispatch circuits, telephone and telegraph trunk circuits using the present radio system will be contained in the telecommunication cable and stable data exchange will become possible.

In this case, the present radio system can be made into a part of the train radio, maintenance radio and reserve systems.

For long distance circuit networks, the composition of an SHF system, etc. will become necessary due to the extension of the electrified lines, expanded area of data exchange and larger volume of data exchange.

Between Jakarta and Cikampek, the modernization of telecommunication system following the electrification is considered since data exchange will be congested in this section.

5.2.3 Improvement Plan for Signalling and Telecommunication Systems

The following gives an outline of the signalling and telecommunication improvement plan based on the aforementioned basic policy.

(1) Signalling system

1) Block device

Since the manual block system the presently used Morse telegraph and electro-mechanical block devices is liable to cause accidents such as collisions and clashes from behind due to misoperation, an automatic block device is installed between Jakarta and Cikampek and a tokenless block device is method in other districts to enhance safety.

Tokenless block devices as shown in Fig. 5.2.3 detect the advance and entering of trains into the block section through the short track circuits installed near home signals. At both terminal stations of the block section, a pair of block levers with an electric locking relationship is provided on a control panel and blocking of stations is secured by operating block levers under mutual agreement and joint operation at both terminal stations. After blocking between stations is complete, "Proceed" aspect is displayed by reversing the starting signal. When trains depart and a short track circuit is short-circuited, the starting signal automatically displays the "Stop" aspect.

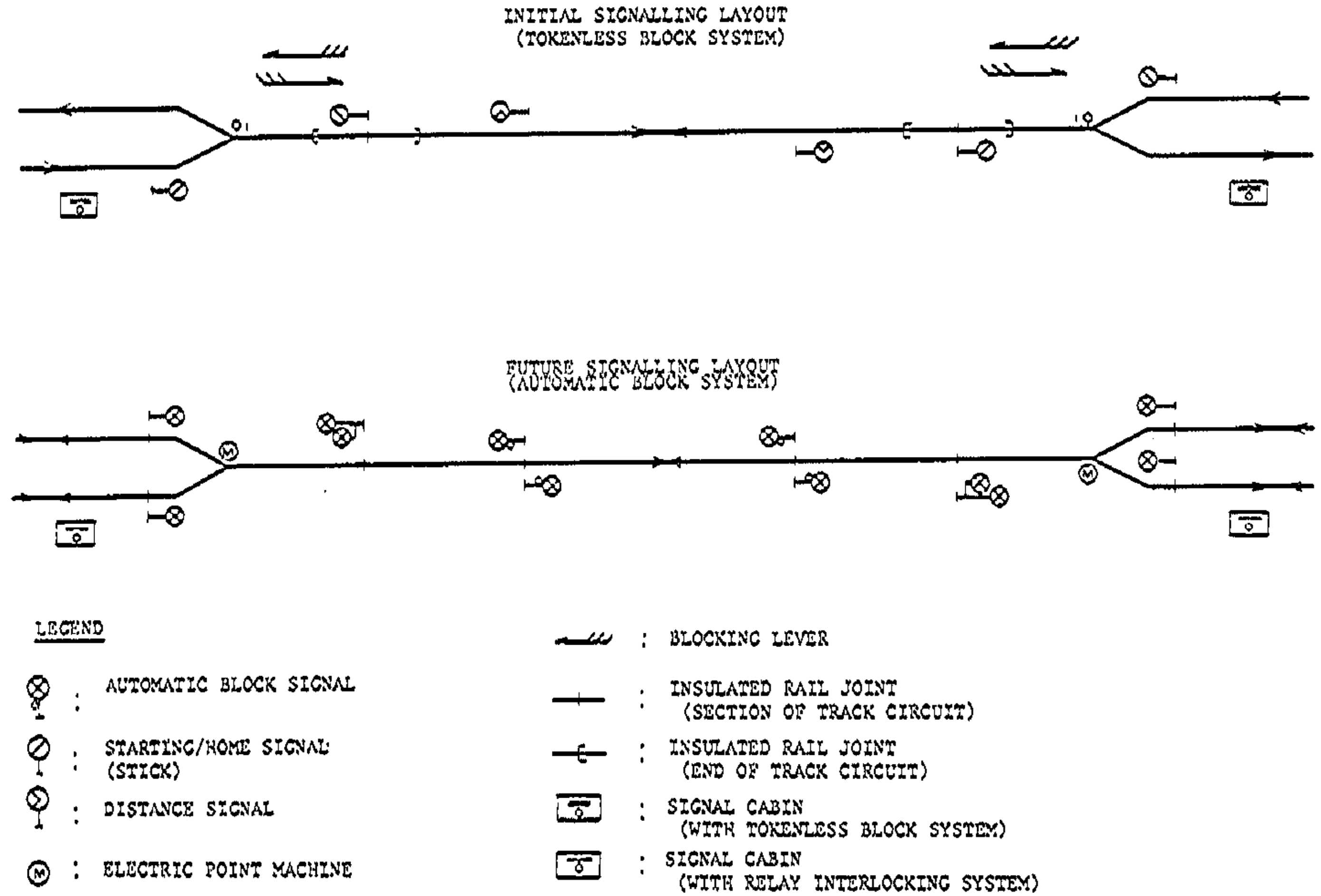


Fig. 5.2.3 BLOCK SYSTEM

While trains are in the block section, safety of the trains is secured by the stick indication of "Stop" aspect. In other words, the tokenless block device is a system to control the interlocking relationship between block devices (block levers) and signal devices by short track circuits.

Although the tokenless block system is a popular system for single track sections, the employment of an automatic block system is effective for the area near major terminal stations in big cities where comparative high density train operation is expected for continuous train operation to one direction and so on.

When outer environmental conditions such as tracks and bridges, etc. are improved, this tokenless block system can be easily turned into single line automatic block system and can not only increase the track capacity for future traffic demands but also advance safety.

2) Signal device

The present mechanical semaphore signals is difficult to maintain and has poor night visibility. These semaphore signals will be changed to color light signals because semaphore signals would be obscured in sometimes by the contact wire support structures and train operation would be hindered.

Fig. 5.2.4 shows the layout of color light signal and the relative position of signal and contact wire support structures.

Block signals are only installed between Jakarta and Cikampek and not in any other districts.

3) Track circuit

There are various track circuits used in the AC electrified section as given in 5.2.1 (2) 1), and it must be decided in consideration of reliability, maintainability and economic viewpoint.

The track circuits between Jakarta-Cikampek stations and that of the main track in the station yards are preferably to be of the double-rail track type, however, in the station yards the single-rail track type must also be studied for economic reasons.

In other districts, no track circuit is installed between

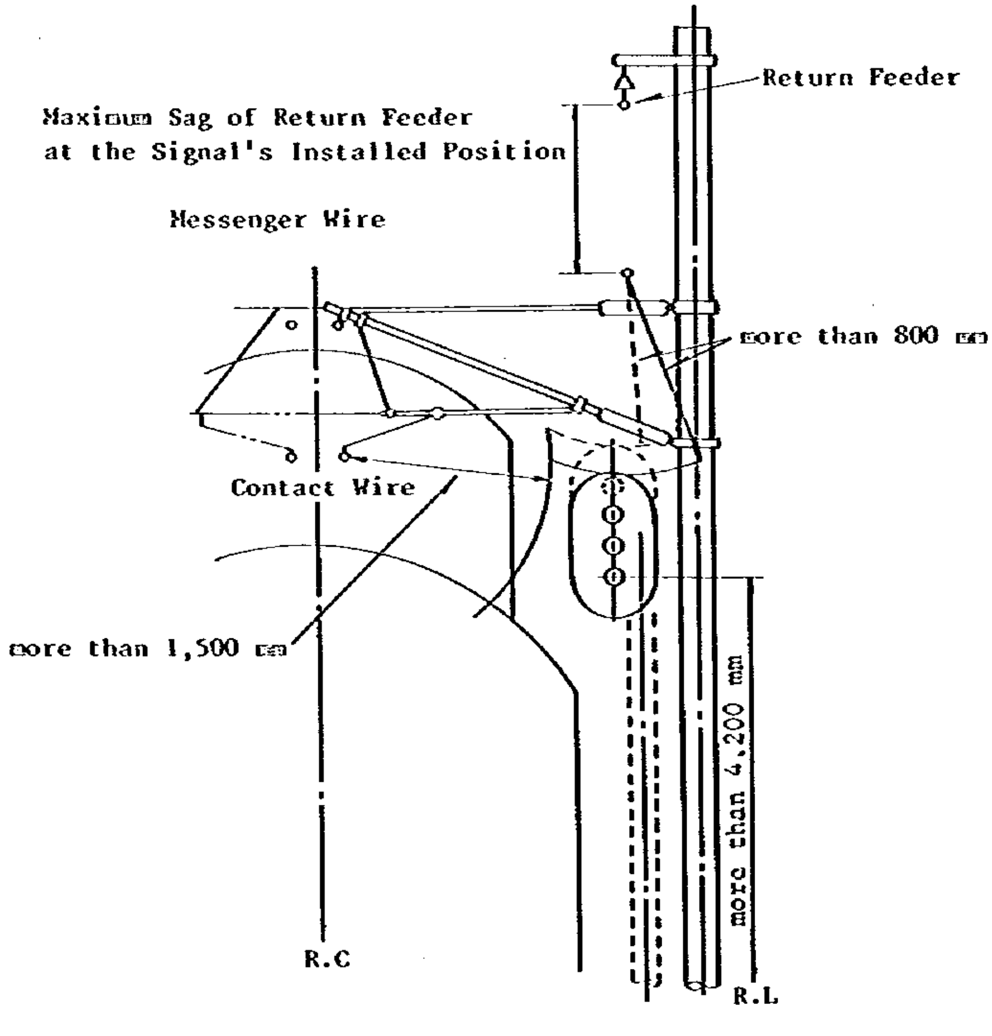


Fig. 5.2.4 Layout of Signalling Devices in the AC Electrified Section

stations and a single-rail short track circuit will be installed around the home signal.

4) Switch Machine

The switch machine must withstand the high speed travel of trains. Trailable type electric switch machines will be required within the station yards on the automatic block section between Jakarta -Cikampek in consideration of its maintainability. Switch machines within station yards on the tokenless block section will be improved to keep locking relationship of turnouts with external locking device or switch levers with electric locking devices.

5) Interlocking Device

Improvement and installation of relay interlocking devices is carried out between stations on the automatic block section between Jakarta-Cikampek.

A relay interlocking system is carried out separately for large stations among the tokenless block section. For interlocking devices of middle stations, electric locking relationship will be given between signals and switch machines and block levers.

6) Level Crossing Safety System

All level crossings in the automatic block section between Bekasi and Cikampek are automatically controlled with level crossing signals and barriers.

Automatization of level crossings in the tokenless block section must be carried out separately in consideration of the rail track renewal program etc., since this is outside the subject of the electrification project.

(2) Telecommunication System

Improvement of the telecommunication system, as discussed in 5.2.2 (2), except Jakarta-Cikampek, basically involves only changing into cable as countermeasure against inductive interference. An concept of improvements of telecommunication systems of the main railway in Java is given below.

1) Communication circuit network

The present telecommunication line uses the earth return system, etc. using aerial open-wires which has a very weak circuit against inductive interference.

Therefore, in adopting AC electrification, the system of alminum sheathed underground cable having a high shielding capacity and paired cable system will be adopted. With the cabling system for the entire line, middle stations can subscribe to exchange and transmission loss will be reduced by the use of carrier circuit and indemnification of loss. Since the T circuit connecting presently used portable telephone can no longer be used due to changes in the cabling system, terminal boxes for portable telephone are installed between stations.

The new installation of SHF link and UHF link and addition of channels; and carrier systems for alternative composition are carried out as countermeasures for long distance circuit composition.

2) Dispatch system

The present train dispatching system using open-wires has become obsolete and is gradually being shifted to a radio system.

However, since a dispatch system using radio system is liable to be affected by weather conditions and by municipal structure, etc., the change to a cabling system will be considered necessary when the whole system is turned into cable system and the present radio system will be used as a reserve system to improve the system's reliability.

Also, along with the electrification, dispatch telephones related to power, fix-installation, signal and telecommunications will be installed and coordination with train dispatch will be carried out.

3) Radio system

Following the increasing demand for rail transport, and the higher speed and wider area of transport, SHF links and UHF links will be newly installed to cope with the increase traffic of long distance information along with the addition of channels.

4) Exchange equipment

With electrification, there will be installed newly or additionally such facilities as control stations, traction substations, electric maintenance depots, car depot and workshops. For these facilities and the intermediate stations subscribing in the telephone system, subscribers' telephones will be installed newly, while the switches and trunks of the automatic telephone switchboards will be installed additionally and newly, and so the switches of the automatic switchboards for telex additionally.

5) Telephone

Following the new and additional installation of business organs accompanying electrification, automatic telephone, magneto telephone, inter-call telephone and dispatching telephone will have to be newly installed.

Talk-back equipment will be installed as telecommunication equipment for shunting and maintenance works in the station yards for shunting and car depots.

By turning the whole line into a cable system, automatic telephone can be installed at intermediate stations.

6) Telegraph

Following the new installation of the car depot and installation and addition of business organs, terminal equipment for telex subscribers will be installed for sending making-up and classification lists for freight cars and general telegrams.

Also at main stations, facsimile equipment will be installed for the transmission of dispatching data, general telegrams and documents requiring recopy.

7) Passenger guide facilities, etc.

At main stations, electric clocks and public address equipment to make announcements for passenger guidance will be installed to improve passenger services.

8) Monitoring equipment for the rail track

In order to avoid accidents due to local heavy rains, etc., monitoring equipment is installed as required at hazardous places to provide information about falling rocks, landslides and rising river water levels, etc.

Fig. 5.2.5 shows the configuration of telecommunication system between Bekasi and Cikampek, the automatic block section to be projected under the Phase I.

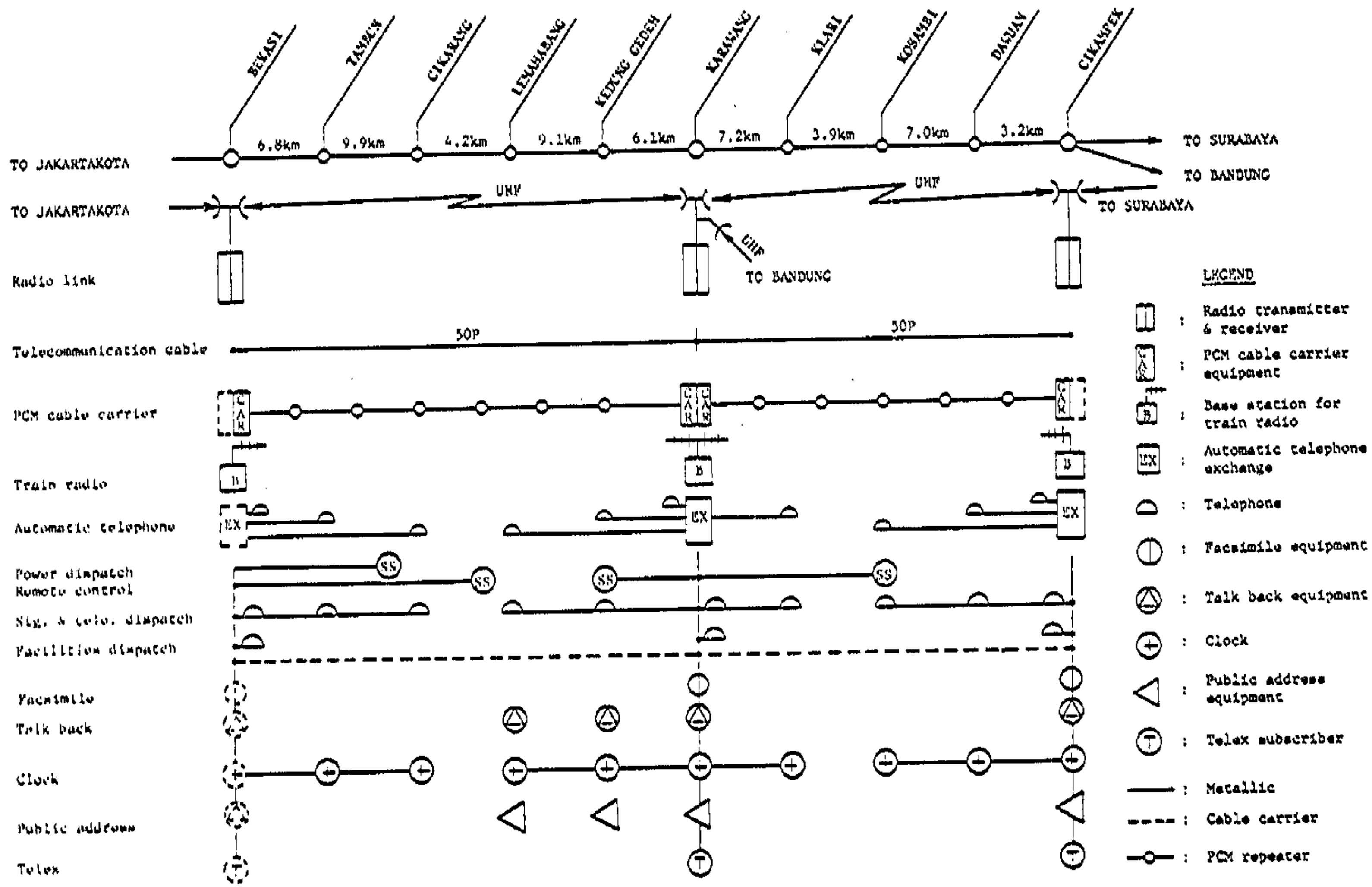


Fig. 5.2.5 Telecommunication System Configuration

5.3 Inductive Interference and Its Countermeasure

The inductive interference in electrified railway systems is shown as Appendix 5.3.

Where the AT feeder system is employed as a feeder system for AC electrification, the inductive interferences on the railway and public telecommunication lines running close and parallel to the feeding circuit are generally induced.

The prediction of inductive interference and its countermeasure are summarized below.

5.3.1 Estimate of Earth Conductivity Along the Railway Track

Earth conductivity along the railway track is an element required to calculate the electromagnetic induction voltage and must be calculated from actual measurements for accuracy. A rough estimate of the earth conductivity obtained from the geological map shows about 0.01 ∿ 0.1 s/m on alluvium of the central and eastern districts and about 0.001 ∿ 0.01 s/m on the limestone facies and volcanic facies along the North Line in the western districs and mountainous zone between Cikampek and Padalarang.

Therefore, a rough calculation of electromagnetic induction voltage assumes an earth conductivity σ of 0.01 s/m.

5.3.2 Inductive Interference against Existing Telecommunication Lines

In making estimate calculation, conditions on the induction side and conditions of telecommunication line are roughly given as follows:

a. In single-track AT feeding system, the length of feeder is 50km at feeding voltage of 50kV and frequency of 50Hz.

b. AT spacing distance is 10km and leakage impedance from AT is 0.1 + j0.45Ω at 50Hz.

c. Fig. 5.3.1 shows the feeder assembly of feeding circuit and type of lines.

d. Earth leakage resistance of the rail will be 1Ω·km. (Where earth leakage resistance is small in the section of iron sleepers, they must be replaced with wood or concrete sleepers to reduce earth leakage current.)

e. Train load current I_p is assumed to be 200A, and equivalent disturbing current J_p by harmonic current at 7A and the number of trains which run with simultaneous load is assumed at 3 trains with saturated operation diagram and train travel is spaced average 20km.

f. Fig. 5.3.1 shows the position of installation posts assuming metallic circuit lines using open-wire and unshielded cable for telecommunication lines.

T :	Contact Wire	$110mm^2$ Cu
M :	Messenger Wire	$135mm^2$ St
AF:	Feeder	$95mm^2$ Aℓ
Pw:	Protection Wire	$40mm^2$ ACSR
R :	Rail	50kg/m Rail
C_1:	Communication Line (open-wire)	
C_2:	Communication Line (unshielded cable)	

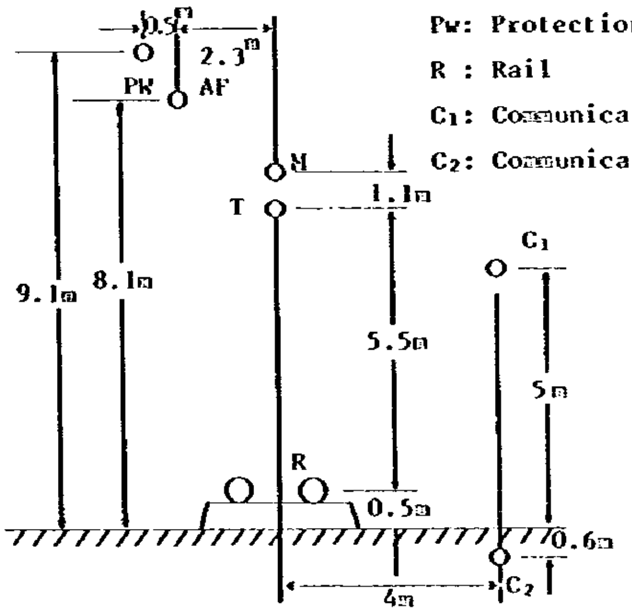


Fig. 5.3.1 Clearance between Feeder Assembly of AT Feeding Circuit and Communication Line

(1) Induced Dangerous Voltage

When the induction current of an AT feeding circuit and the induced voltage of a communication line are obtained on the length of communication line according to the foregoing conditions, they show different values according to the position of the communication line as given in Table 5.3.1.

Table 5.3.1 Induced Voltage of Telecommunication Line by AT Feeding Circuit

I_p = 200A

Length of communication line (km)	Train load in case of 1 train		Train load in case of 3 trains	
	C_1 (V)	C_2 (V)	C_1 (V)	C_2 (V)
30	125~160	85~105	150~264	95~170
24	130~140	82~91	161~233	75~148
15	73~110	54~73	91~202	46~129
10	57~90	42~52	77~153	48~95
4	38~60	28~31	38~80	24~49
2	20~33	13~21	23~41	17~27

(2) Induced Noise Voltage

Noise voltage depends on the balance degree of communication line.

In the case of open-wire, the balance degree is assumed to be 46dB and the same value is assumed when exchange, etc. are connected.

The noise voltage obtained in this case is given in Table 5.3.2

Table 5.3.2 Noise Voltage of Telecommunication Line by AT Feeding Circuit

J_p = 7A

Length of communication line (km)	Train load in case of 1 train		Train load in case of 3 trains	
	C_1 (mV)	C_2* (mV)	C_1 (mV)	C_2* (mV)
30	310~380	33~42	325~405	35~43 mV
24	320~355	36~39	320~410	36~45
15	185~250	20~28	190~305	21~33
10	130~210	14~25	160~250	17~28
4	105~155	12~18	100~155	12~18
2	60~105	7~12	60~105	7~12

Note: * C_2 is unshielded telecommunication cable and the balance degree is 60dB.

According to the results of this calculation, noise voltage in case of open-wire becomes very large and shielded cables are required.

5.3.3 Countermeasures against Inductive Interference for the Existing Communication Lines

In the case of overhead bare communication lines, induction voltage should not exceed the allowable value of 60V up to line lengths 4km when one train is travelling. However, in case of 3 trains running, even at lengths of 4km, the allowable value will be exceeded depending on the position of the communication line against feeding circuit.

Therefore, as countermeasures for induced voltage of open-wires, when open-wire is turned into cable with a shielding coefficient of 0.45 and buried 0.6m underground the limit value will not be exceeded until 30km for 1 train and in the case of 3 trains, all communication circuit of 15km long will be less than the allowable value.

With regard to noise voltage (voltage between lines), when aerial open-wires are turned into shielded cables and buried 0.6m underground, using a shielding coefficient of 0.03 at 800Hz against noise voltage and making the cable balance degree 60dB, the allowable value of 1mV will not be exceeded up to 15km of the length of communication line for 1 train load and 3 train load operation.

Also in the case of noise voltage as a product of the balance degree and the shielding coefficient, when the balance degree is elevated 6dB, the shielding coefficient can stay at 0.06.

As given above, countermeasures to make induced voltage and noise voltage below the allowable value are to make the physical circuit (metallic circuit) less than 15km long and to turn existing open-wires (PJKA, PERUMTEL) into shielded cables with the shielding coefficient 0.45 at 50Hz and 0.03 (when the balance degree is 60dB) at 800Hz.

For long distance circuit of more than 15km, countermeasures by carrier system may be undertaken. In concrete terms, the composition of communication circuit will be as given in Fig. 5.3.2.

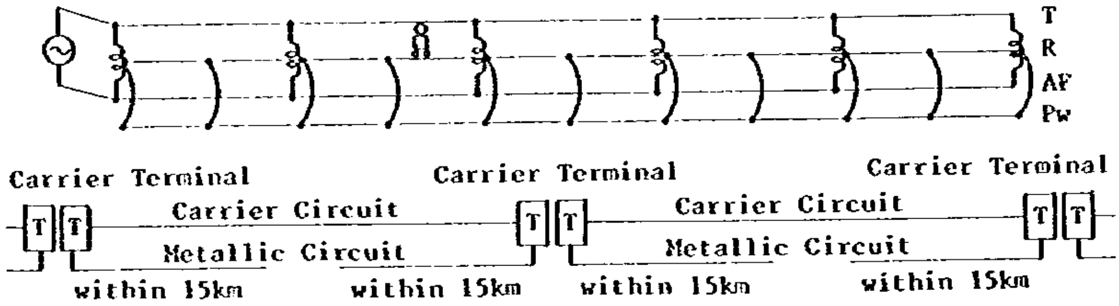


Fig. 5.3.2 Composition of Communication Circuit Line

Also, the critical voltage when the feeder circuit grounding faults can be coped with by shielded cable but arresters are used on the side of the equipment.

In long bridges, these cables are inserted in ducts to support the bridge legs.

In tunnels, cables are hung on the side wall of the tunnels.

In this case, the induction voltage becomes a little larger in comparison with the buried position of the communication cable but it is not greatly affected unless the length of the tunnels is long.

In the case of coaxial cables of public communication line, when the induction voltage is large, a large voltage is generated between the inside and outside conductors and the equipment will be overloaded, so caution must be paid.

In such a case, it is necessary to install filters to prevent induction voltage from entering into the equipment. Also, communication line can be separated from the feeding circuit to reduce induction, voltage and noise voltage.

In the case of communication circuits with open-wire, when the line length is 30km and separation is 300m, electromagnetic induction voltage becomes less than the allowable limit value (electrostatic induction voltage less than 1V). However, for noise voltage, the required separation would be about 800m or over.

If the earth conductivity σ is 0.1 s/m, the required separation to ensure that the noise voltage value would not exceed its allowable limit would be about 300m or over, but about 2,500m in the case of 0.001 s/m.

In the case of subscriber circuits in automatic and common battery exchange systems, it is desirable to connect repeating coils to its circuits to improve the balance degree.

CHAPTER 6 STRUCTURAL PLAN

CHAPTER 6 STRUCTURAL PLAN

6.1 Present Status

The subject of the structure plan in this project are related to mainly tracks, bridges and tunnels. The purpose of the survey was to determine how to utilize the current facilities to the maximum extent after completion of electrification and collection of the information for the improvment plan which is being presently executed.

6.1.1 Track

The track length of the planning section is 2,550 km and most of its portion consist of single track. The double line sections are located between Jatinegara ~ Chikampek, Padalarang ~ Kiarakondong, Surabaya ~ Konokromo and total length is about 100 km.

(1) Standard of earth work

The track spacing is 1,067 mm and is classified as narrow gage in the Indonesian State Railway system. The track structure, according to the construction standards, is based on train running speed (120, 100, 59, 45/30 km/h) and the shapes of the standard of earth work are different from each other depending on the speed. The track structure of the survey section is 100 km/h except for a small portion. Fig. 6.1.1 shows the standard of earth work for the currently planned structure at 120 km/h.

(2) Construction gage

Fig. 6.1.2 shows the construction gage of the aerial line according to the Indonesian State Railways Construction Standards. Conventionally, the clearance in the non-electrified section was 3,850 mm, but the container transportation plan section is enlarged this to 4,300 mm.

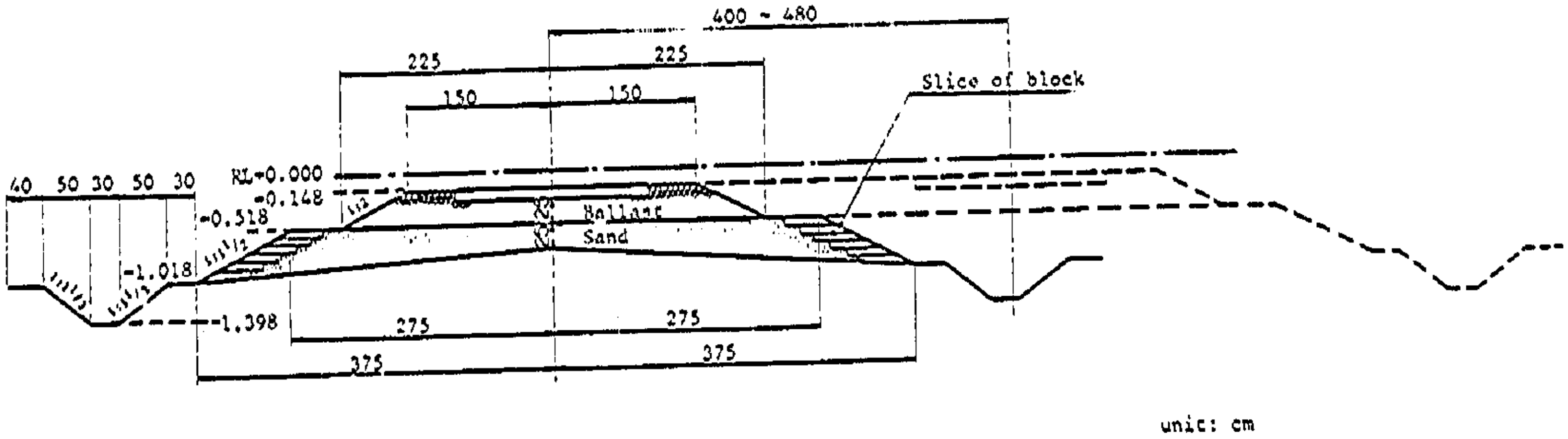
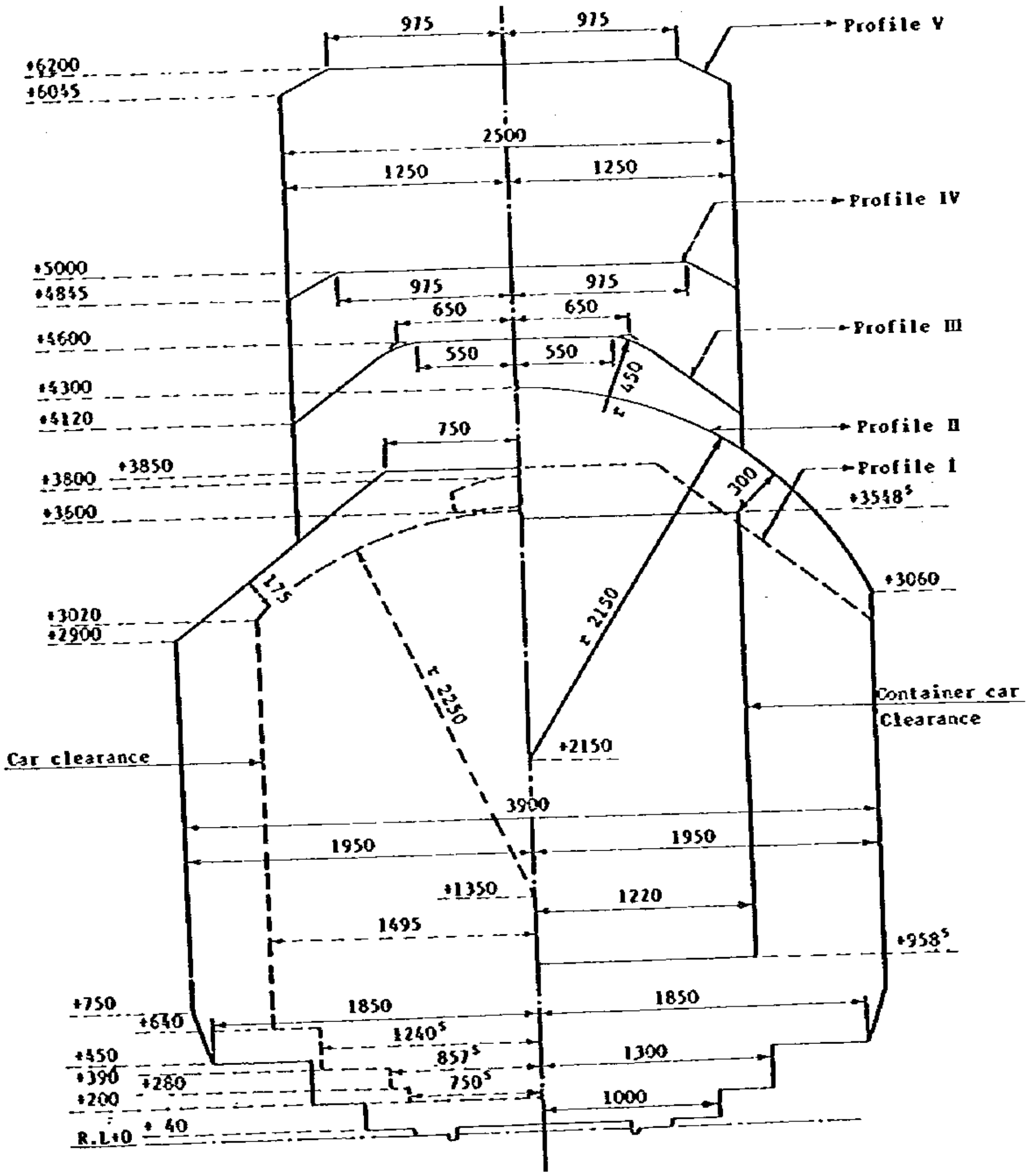


Fig. 6.1.1 Standard of earth work



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

Profile II : Minimum profile for TUNNEL and VIADUCT with speed restriction 60km/hour and for BRIDGE no restriction

Profile III : Minimum profile for New VIADUCTS and new Constructions, except TUNNELS and BRIDGES

Profile IV : Normal profile for Electric Car.

Profile V : Normal profile for New VIADUCT

Fig. 6.1.2 Construction gage

(3) Conditions of track

1) Track structure

The track consists of the rail, the fastening device, the sleeper and the ballast, and they disperse the load of the train to the roadbed.

The track structure for each type in the survey section is shown in Table 6.1.1. As shown in Fig. 6.1.3, R14/R14A (41.52/42.18 kg/m) rails occupy almost 50% of the entire section, and other types less than 40 kg/m.

In the fastening device, 88% is the elastic fastening. As for sleepers, 75% are wood sleepers, but since their serviceable life is about 8 years, therefor the introduction of concrete sleepers with longer life is promoted.

2) Track maintenance

The yearly plan of track maintenance for main lines is determined by the result measured by the inspection car.

The track inspection result of 1981 is shown in Fig. 6.1.4, and the majority is in good condition (N>100) or in normal condition (100>N>85).

However, this is not considered the result of good track maintenance but due to the current speed limit of 80 km/h and slow running speeds in the sections of speed restriction.

Table 6.1.1 Track structure

Section	Length of Section (km)	Track length (km)	Rails (km)				Fastening device (km)		Sleepers (km)	
			R14/14A	R3	15P	R2	Rigid	Elastic	Steel	Wood
Jatinegara ~Cirebon	207.5	279.8	279.8	-	-	-	-	279.8	-	279.8
Cikampek ~Kiarakondong	94.8	114.5	103.1	11.4	-	-	-	114.5	-	114.5
Cirebon ~Yogyakarta	297.7	297.7	220.2	77.5	-	-	167.2	130.5	149.3	148.4
Yogyakarta ~Solo	59.2	59.2	51.3	7.9	-	-	-	59.2	59.2	-
Solo ~Sulabaya	262.4	270.0	239.8	15.0	15.2	-	2.5	267.5	15.0	255.0
Wonokuromo ~Probolinggo	93.6	93.6	39.2	54.4	-	-	-	93.6	-	93.6
Merak ~Tanahabang	141.4	141.4	17.3	124.1	-	-	141.4	-	141.4	-
Bogor ~Sukabumi	57.2	57.2	-	57.2	-	-	-	57.2	56.2	1.0
Kiarakondong~Kroya	242.6	242.6	74.5	168.1	-	-	-	242.7	40.5	202.1
Cirebon ~Semarang	225.5	225.5	223.8	-	1.7	-	-	225.5	-	225.5
Brumbung ~Solo	94.8	94.8	-	-	94.8	-	-	94.8	-	94.8
Semarang ~Surabaya	280.0	280.0	-	-	280.0	-	-	280.0	164.8	115.2
Probolinggo ~Jember	95.8	95.8	-	95.8	-	-	-	95.8	-	95.8
Sukabumi ~Padalarang	83.3	83.3	1.4	81.9	-	-	-	83.3	38.8	44.5
Kertosono ~Bangil	215.4	215.4	49.2	-	-	166.2	-	215.4	-	215.4
Jember ~Banyuwangi	103.1	103.1	-	20.8	-	82.3	-	103.1	9.2	93.9
Total	2554.3	2653.9	1299.6	714.1	391.7	248.5	311.1	2342.8	674.4	1979.5

(4) Speed restrictions

There are 446 sections where speed is restricted in this survey section, averaging one per 6 km. This causes train operation delays. The causes for the slow speed include track renewal or repair work, but the majority are due to the breakdown of the present facility. Table 6.1.2 shows the status of slow speed sections according to elements.

Table 6.1.2 Slow speed section

Elements	Number of points (%)	Most frequent section	Number of points	Number of points per 1 km
Sinking of roadbed in the rainy season	101 (23)	Semarang ~ Bojonegoro	30	0.17
Breaking of the pier or abutment	89 (20)	Kroya ~ Yogyakarta	11	0.08
Breaking of sleepers and shortage of ballast	68 (15)	Bojonegoro ~ Surabaya	6	0.06
Aging of turnouts	31 (7)	Cikampek ~ Croya	5	0.04
Sub-total	289 (65)	-	-	-
Others	157 (35)	-	-	-
Total	446 (100)	-	-	-

(5) Improvement plan of PJKA

Track renewal was conducted from 1960 to 1962 in the section between Jatinegara and Cikampek. Since then, the work has been conducted according to the five-year plan which started in 1964.

By the end of 1981, track renewal was completed over 1,700 km, or 64% of the total length of the main line. By the end of 1984 when the third five-year plan expires, the 2,200 km should be completed which is 83% of the total length.

In the future improvement plan, R14/R14A or 50N/UIC 54 rail laying with under planning of the concrete sleepers are scheduled to be executed in the following fourth five-year plan.

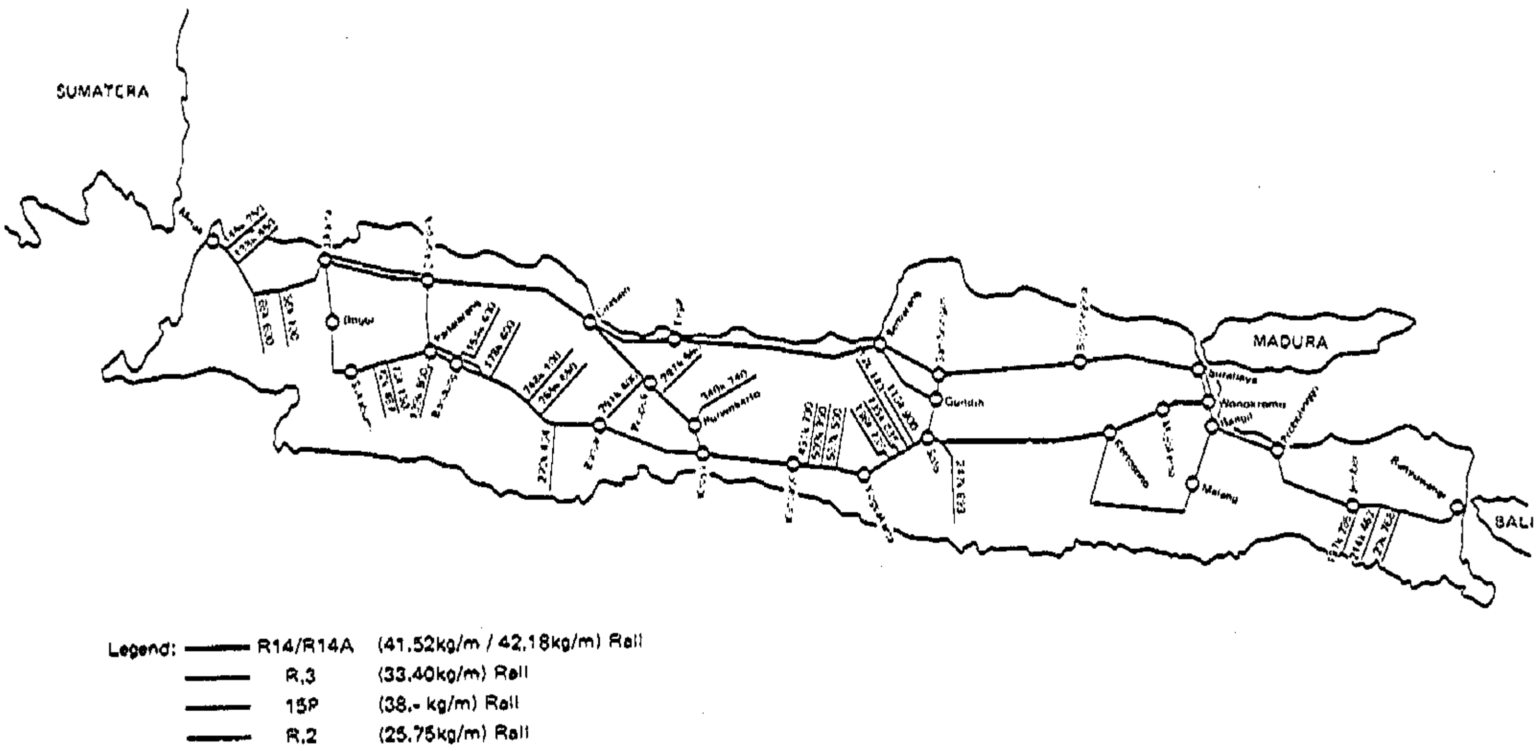


Fig. 6.1.3 Present type of rail

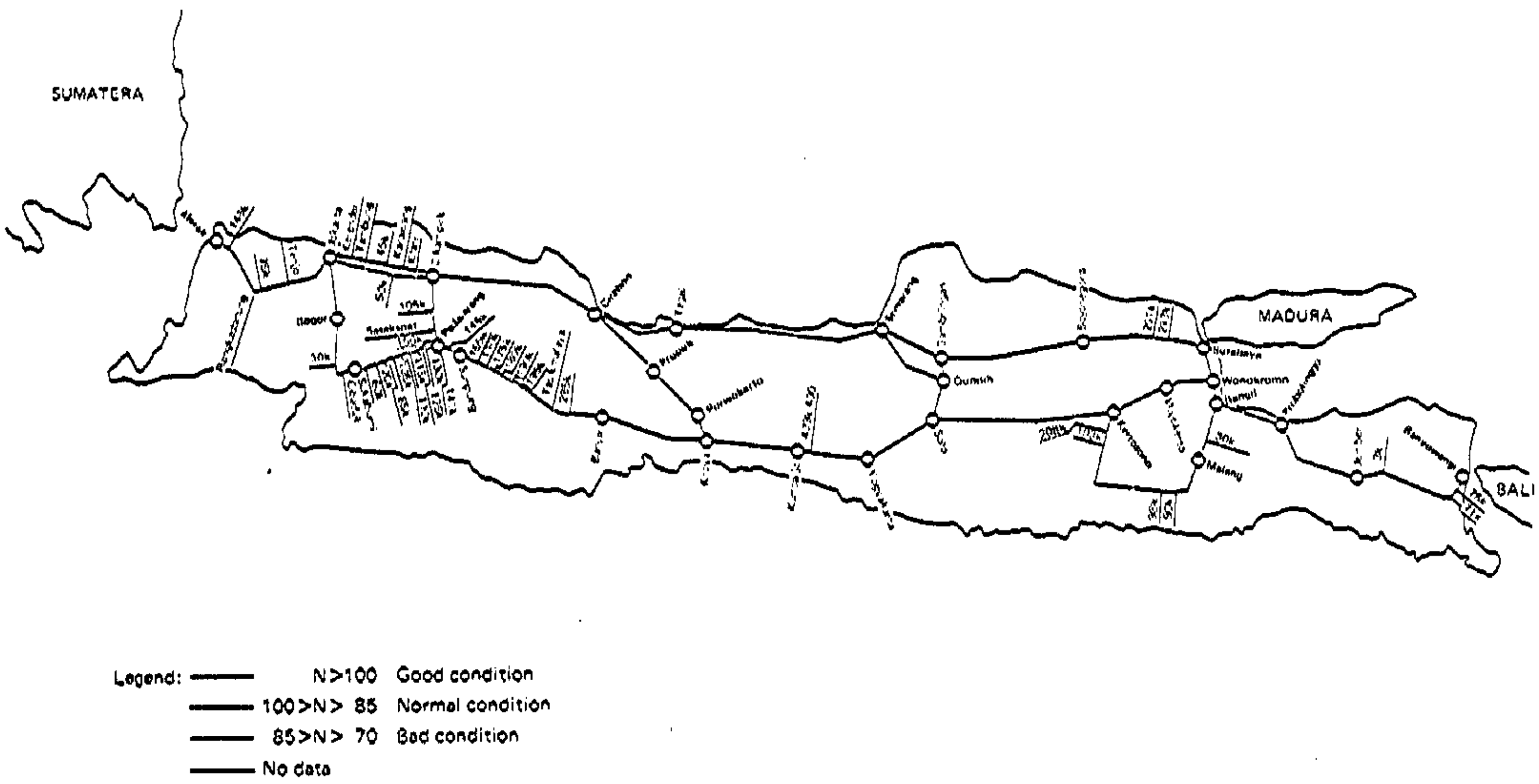


Fig. 6.1.4 Result of Track Inspection Car

6.1.2 Bridges

The points to which special attention was given while the master plan was drawn-up were confirming the strength of the structure, clearances for electric locomotives and measures against aging.

(1) Strength of the structure

The structural strength of bridges in the main line is designed to bear axle loads ranging from 9 ~ 20 tons for both superstructure and substructure as shown in Fig. 6.1.5~6.

Many bridges are breaking on piers or abutments because of unsuitable shore protection facilities, and in some areas the speeds as low as 10 km/h are seen. Further, according to the bridge soundness survey conducted in between Semarang and Panunggalan in 1982, approximately half of the bridges require repair work.

(2) Clearance

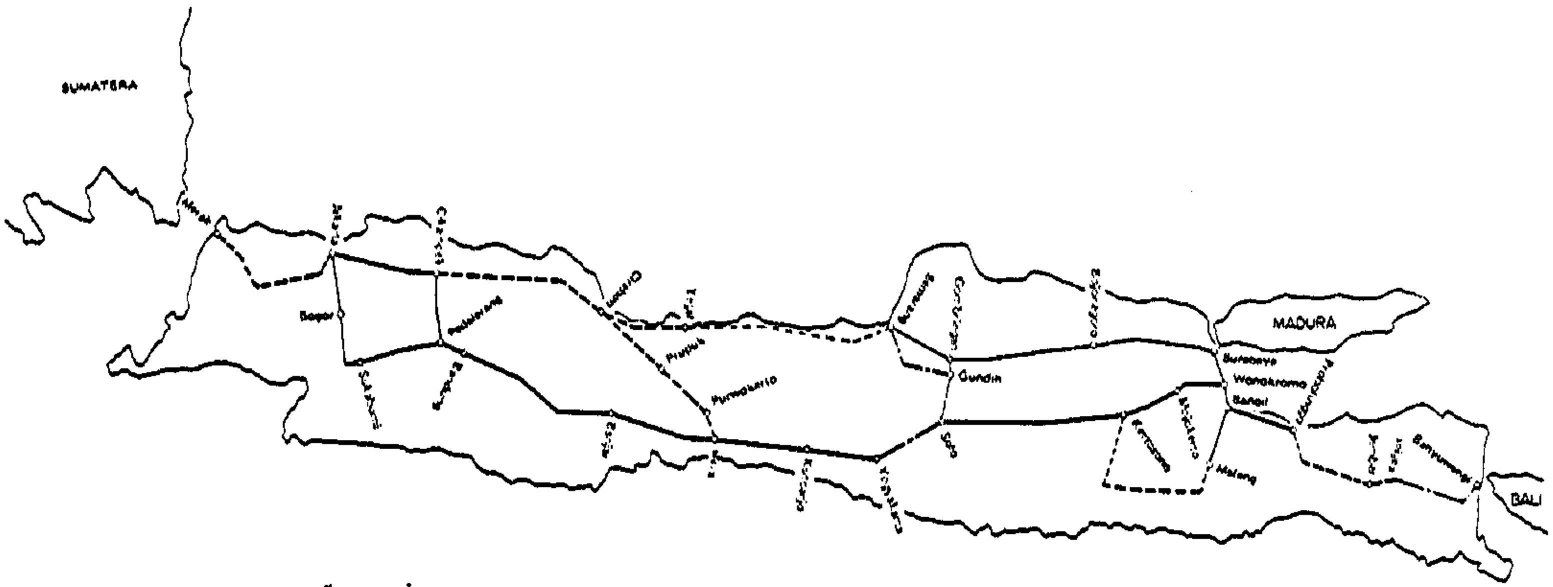
In the present construction gage, the distance from R.L. (rail level) to the top of the bridge is 3.85 m or 4.30 m. However, the construction gage will become larger as car clearances expand with electrification.

The objects that may cause problems in terms of securing the clearance are the railway truss bridge, the aqueduct and the roadway overbridge.

(3) Improvement plan of PJKA

The improvement plan for railway bridges mainly consists of reinforcement work. All the bridges will be strengthened for axle loads of 15 ~ 20 tons during the third and the fourth five-year plans.

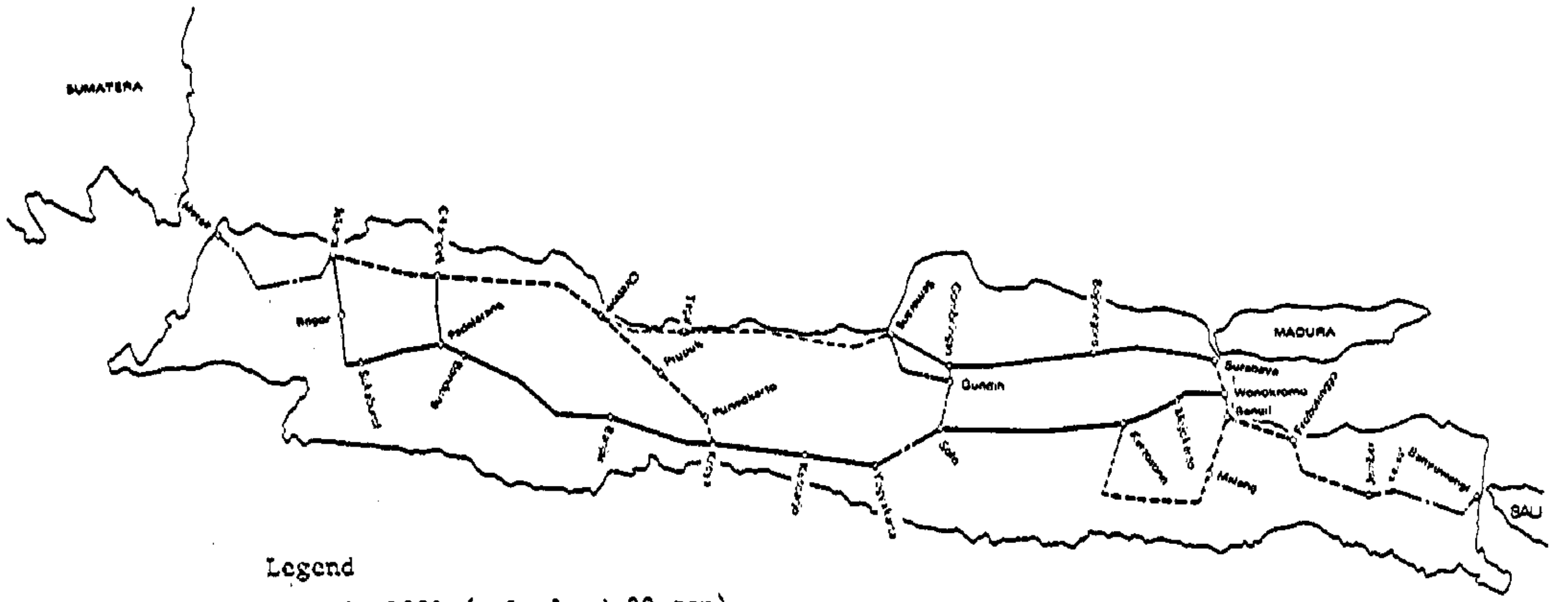
Furthermore, for older bridges, about 2,000 tons of bridge renewal is planned for each year.



Legend

———	Loading scheme	RM 1921 (axle load 20 ton)
– – – –	"	RM 75% 1921 (axle load 15 ton)
—·—	"	RM NIS 1A 11T (axle load 18 ton)
———	"	RM NIS GS (axle load 13 ton)
·----	"	RM SCS (axle load 12 ton)
—·—	"	RM 1907 Second stage (axle load 9 ton)

Fig. 6.1.5 Construction Load for Superstructure



Legend

	Loading scheme
Loading scheme	RM 1921 (axle load 20 ton)
//	RM 75% 1921 (axle load 15 ton)
//	RM NIS SV (axle load 16 ton)
//	RM NIS GS (axle load 13 ton)
//	RM SCS (axle load 12 ton)
//	RM 1907 Second stage (axle load 9 ton)

Fig. 6.1.6 Construction Load for Substructure

6.1.3 Tunnels

As for the tunnel survey, the clearance measurement of the tunnel, and the inspection of the degree of deterioration of the lining, deformation due to the earth pressure and fatigue were conducted because of the construction gage enlargement due to the electrification.

(1) Present condition

The Indonesian State Railways has 19 tunnels and 9 are located in the survey section as shown in the Fig. 6.1.7.

Most of them were constructed during 1880s to 1900s and they are brick or wet masonry as indicated in Fig. 6.1.8. The two tunnels between Malang and Blitar are concrete construction and relatively new because this detour line was built due to the construction of Karang Kates power plant in 1970.

The result of the tunnel site survey is shown in Table 6.1.3, and deformation due to the earth pressure was considered to be none, because there is no record of repair-work done on track irregularity.

The two tunnels between Surabaya and Banyuwangi has cracks at the entrance. The reason for this is considered to be partially caused by the collapse of the tunnel entrance due to irregular heavy rainfalls. In the future, a full investigation of the cause and countermeasures are expected.

Water leakage causes the deterioration of the tunnel lining. In the rainy season, water leakage is reported to be seen in all tunnels. However, since this survey was conducted in the dry season, there was no water leakage in the two tunnels between Purworkerto and Kroya and in the tunnels between Kroya and Kutarjo.

The water leaking points in the tunnel between Cikampek and Bandung had solidified accumulated substance. This is considered to be the solidified alkaline substance containing calcium contents that flows out from the ground.

(2) Improvement plan of PJKA

The Indonesian State Railway plans to conduct a survey for the repair work for four tunnels showing considerable deterioration.

The tunnels for which the survey is planned are as follows;

Sukabumi ~ Padalarang	km 72+464 ~ km 73+150
Bandung ~ Cikampek	km 142+939 ~ km 143+888
Kroya ~ Kutarjo	km 425+125 ~ km 425+705
Surabaya ~ Banyuwangi	km 25+493 ~ km 25+606

Section	Location	Length (m)
Surabaya ~ Banyuwangi	km 25+493 ~ km 25+606	113
- " -	km 30+417 ~ km 31+107	690
Maland ~ Blitar	km 83+087 ~ km 83+527	440
- " -	km 84+239 ~ km 84+836	597
Purwokerto~Kroya	km359+412 ~ km359+672	260
- " -	km363+259 ~ km363+338	79
Kroya ~ Kutarjo	km425+125 ~ km425+705	580
Bandung ~ Cikampek	km142+939 ~ km143+888	949
Sukabumi ~ Padularang	km 72+464 ~ km 73+150	686

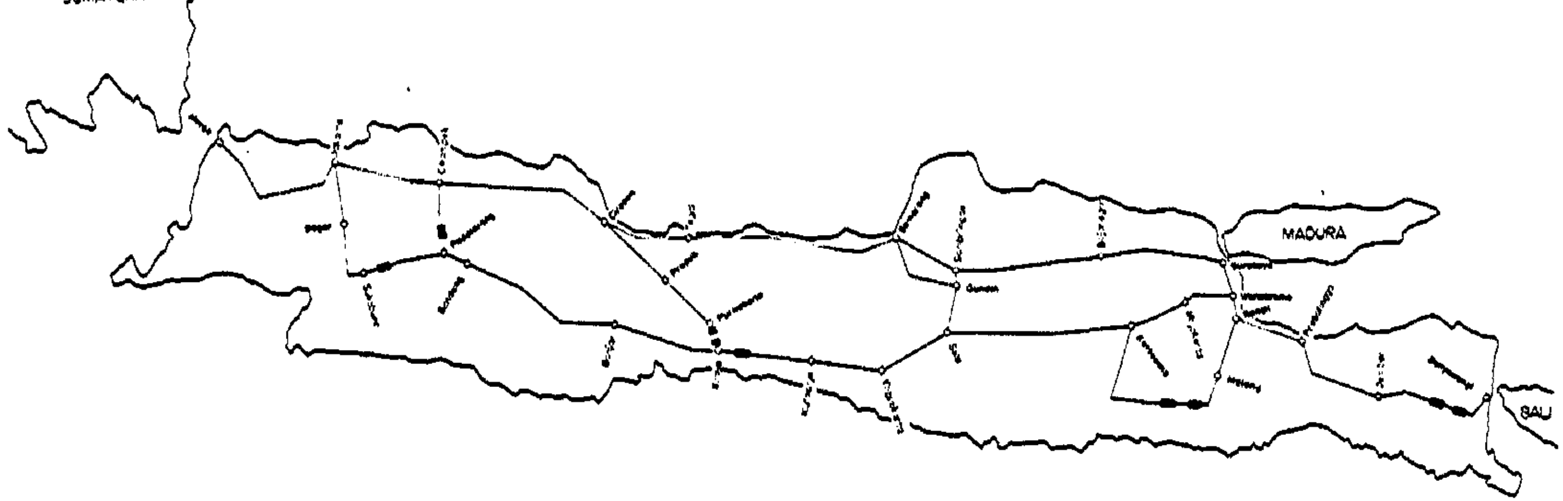


Fig. 6.1.7 Location of Tunnels

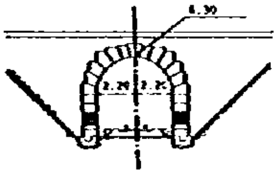
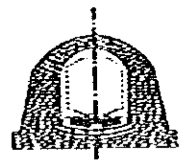
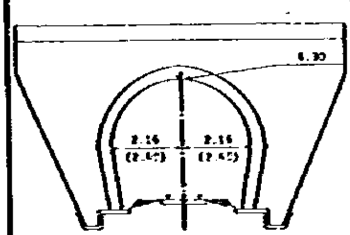
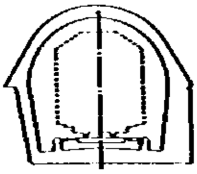
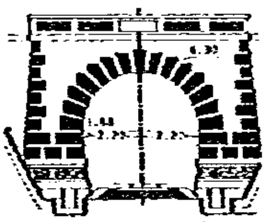
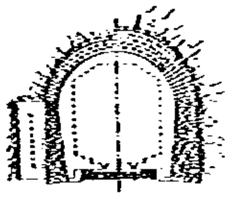
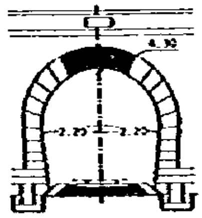
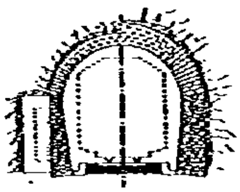
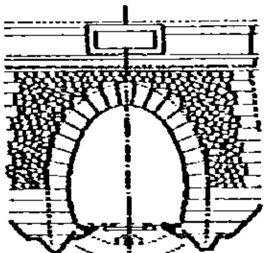
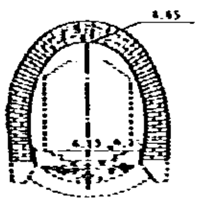
		°Surabaya ~ Banyuwangi Km 25+493 ~ Km 25+606 Km 30+417 ~ Km 31+107
		°Malang ~ Blitar Km 83+087 ~ Km 83+527 Km 84+239 ~ Km 84+836
		°Purwokerto ~ Kroya Km359+412 ~ Km359+672 Km363+259 ~ Km363+338 °Bandung ~ Cikampek Km142+939 ~ Km143+888
		°Kroya ~ Kutarjo Km425+125 ~ Km425+705
		°Sukabumi ~ Padalarang Km 72+464 ~ Km 73+150

Fig. 6.1.8 Rough cross section of tunnels

Table 6.1.3 Result of Tunnel Survey

	Section / Item / Location	Surabaya-Banyuwangi		Malang-Blitar		Purwokerto-Kroya		Kroya - Kutarjo	Bandung - Cikampek	Sukabumi - Padalarang
	Location	km 25 + 493 - km 25 + 606	km 30 + 417 - km 31 + 107	km 83 + 087 - km 83 + 527	km 84 + 239 - km 84 + 836	km 359 + 412 - km359 + 672	km 363+ 259 - km363 + 338	km 425 + 125 - km425 + 705	km 142 + 939 - km143 + 888	km 72 + 464 - km 73 + 150
1	Year in construct	1902	1901 1910	1970	1970	1886	1886	1886	1903	1882
2	Dimension (m)	H = 4.30 W = 4.40	H = 4.30 W = 4.40	H = 4.30 W = 4.32	H = 4.30 W = 4.32	H = 4.30 W = 4.40	H = 4.30 W = 4.40	H = 4.23 W = 4.40	H = 4.30 W = 4.40	H = 4.65 W = 4.10
3	Length (m)	113	690	440	597	260	79	580	949	686
4	Line Alignment	R = 200	R = 300 R = 300	R = 300	R = 300	R = 300	R = 300	-	-	-
5	Accident	'81 - '82 No	'81 - '82 No	'81 - '82 No	'81 - '82 No	'78 Derailment	'81 - '82 No	'81 - '82 No	'81 - '82 No	'81 - '82 No
6	Speed restriction	10km/h (Clearance)	10km/h (Clearance)	45km/h	45km/h	20km/h (Rail corrugation)	40km/h	75km/h	50km/h	30km/h
7	Nature of Soil	*Sedimentary facies *Loose rock	←	←	←	←	←	←	←	←
8	Water leak	Yes & a spring water	Yes (118 points)	Partly from joint between in bert	←	Yes in rainy season	←	←	Yes	Yes
9	Repair record	No	←	←	←	←	←	←	←	Expansion of clearance
10	Deformation (Crack, etc)	No	←	←	←	←	←	←	←	←
11	Displacement of track	No	←	←	←	←	←	←	←	←
12	Area condition	Partly farm (coffee)	←	Partly farm	←	←	←	←	←	←

6.2 Improvement Plan for Electrification

The track, the bridge and the tunnel will have to be improved for electrification.

The improvement plan in the master plan for the structure only includes elements that may cause problems after electrification, because the PELITA Program has the priority in execution.

6.2.1 Tracks

(1) Basic policies for the improvement plan

The designed maximum speed after electrification was set at 100 km/h assuming that current track renewal plans are carried out.

According to the Indonesian State Railways Construction Standards, the track structure of R3, R14/R14A rails and 20cm thick ballast currently used in the track renewal can cope with speeds of 100 km/h. Therefore, no additional costs will be required for track renewal. In some sections, there is a track reinforcing plan for 50N/UIC 54 rails and concrete sleepers. In these sections, the locomotive speed capacity is designed to be 120 km/h, therefore, it is possible to operate at 120 km/h if the track maintenance is fully conducted in these sections.

Making the track serviceable for speeds of 120 km/h requires a great amount of investment. Thus, it was decided to finalize the timing for the entire set of main line improvements after seeing the future trends of vehicular transportation.

(2) Drawing up the improvement plan

To increase train speeds, the track structure can make a contribution in the area of track reinforcement and the improvement of curves.

Track reinforcement and renewal are currently being executed in the PELITA Program, and no allowance have will be made for these in order to avoid duplicate investment.

Curve improvement will be examined at the stage of the later cautious study.

In addition, when the signal and telecommunication system is automated, steel sleepers have to be changed to wood ones in order to avoid the rail clamp shunt. However, for the time being, since automation for the entire section will not be discussed, sleeper changes will not included in this project.

Therefore, the investment work included in this project are;

- Track laying and road crossing construction, due to the double track addition work between Manggarai and Krawang station.

- Track lowering work of the South line at the Surabaya Kota station area where the South and the North lines cross, due to the clearance shortage after electrification.

(3) Improvements to be made before electrification

The track is constantly damaged by the weight of trains and natural forces. As the result of survey shows, the slow speed section of the entire survey section average one in every 6 km. This causes problems for the safety and punctual train operations.

Currently, the improvement of the slow speed section has been executed in the third five-year plan, and in order to cope with mass and high speed transportation in the future, the following improvements should be executed as soon as possible.

1) Reinforcement of the track structure

As the train frequency increases, time that can be used for track maintenance work decreases. Therefore, it becomes necessary the countermeasures for decrease track deterioration and for facilitate the maintenance work by means of the reinforcement of the track structure.

2) Execution of mechanized construction

Mechanized construction allows for briefer maintenance work time and improves the quality of the work. Therefore, the introduction of mechanized system should be established as soon as possible. Especially in the section where no track reinforcement will be made, it is necessary in order to maintain good track conditions.

3) Disaster prevention

The breaking of the track is considered to be largely caused by the roadbed conditions. In unsuitable roadbeds, phenomena such as mud pumping, land slides or the subsidence of the roadbed appear.

As countermeasure for these, it is necessary to form a suitable plan after sufficient site survey, because various conditions influence the situation in a complex matter General causes and their countermeasures are stated in Appendix 6.1.

As the development of Java Island proper proceeds, the excessive tree cutting is occurring along the wayside. In mountain areas, this may cause erosion. Erosion was observed at the points km25 + 400 and km 30 + 400 near Banyuwangi and km 194 + 400 near Cicalengka, and the track structure is damaged. It is necessary to control this disordered development in the future.

6.2.2 Bridges

(1) Basic policies for the improvement plan

Bridges are classified as superstructural or substructural. In the fourth five-year plan, starting from 1984, both structures will be made serviceable to bear axle loads of 15 to 20 tons.

The results of using the locomotive designated in this master plan on the current structure will be considered.

When the load moves on the beam, the value of the shearing stress and the bending moment in each section of the beam vary according to the shifting of the load.

Maximum shearing stress (Sa) and bending moment (Me) against Indonesian State Railway design load and locomotive load planned in this master plan (axle load of 11.5 ton and wheel base of 16.0 m for the coaches currently used) are calculated by span. The result calculated is shown in the Table 6.2.1.

Table 6.2.1 Comparison of (Sa) and (Me) for each train load

Span (m)	RM 1921		RM 75% 1921		Master Plan E.L	
	Sa(ton)	Me(ton·m)	Sa(ton)	Me(ton·m)	Sa(ton)	Me(ton·m)
2.5	28.88	13.72	21.66	10.29	13.13	9.38
5.0	44.20	45.24	33.15	34.07	18.45	20.54
10.0	64.60	151.30	48.45	113.48	26.12	64.64
20.0	100.08	460.93	75.06	345.70	41.73	226.86
30.0	144.00	979.45	108.00	748.09	52.03	434.32

Judging from this result, the designed strength of the present bridge was found to be sufficient to bear the load of the locomotive of the master plan. Therefore, as for the railway bridges, both super- and sub-structure shall be kept as they are and work to secure the clearance of aqueduct and roadway bridges will be executed.

(2) Drawing up the improvement plan

The present improvement plan of the railway, roads and the aqueduct includes work to secure clearance only when the car clearance of the designated electric locomotive is great.

When the signal and telecommunication system is fully automated, the trough girder should be improved to avoid rail clamp shunt. However, since automation of the entire section cannot be considered for the time being, the improvement of the trough girder is not be included in this project.

Fig. 6.2.1 shows the relationship between the car clearance and the construction gage. In continuous elements such as tunnels, the distance is 4,650 mm between R.L. (rail level) and the roof. If the obstacle element is not continuous, a distance up to 4,500 mm is allowed. However, detailed site measurements should be done at the stage of the actual construction and, based on that, judgement given.

1) Railway bridge

This project only deals with truss bridges. The majority of the truss bridges are Warren truss structures. If the overhead clearance is too small, the following method will be used for remodeling.

- Warren truss : Extending the vertical element and providing a new top chord member. The present top chord member will be removed and the new clearance secured.
- Portal bracing : Remodelling to the panel type portable bracing (Refer to Appendix 6.2)
- Curved chord warren truss : Providing the entire new super-structure. (The bridges in the surveyed section had a sufficient clearance for electrification.)

2) Roadway bridge

The roadway bridge is supervised by BINAMARGA, which must be consulted beforehand. In this master plan, the lifting of the girders for the roadway girder, bridges and the new construction for brick masonry arch bridges are tentatively provided.

3) Aqueduct

The aqueduct are supervised by Public Works, and seem to require pre-discussion in the same way as the roadway bridge. They will be improved as siphon type channels.

(3) Improvements to be made before electrification

Many bridge piers or abutments are damaged due to the unserviceable condition of the river banks, and in some areas train speeds are restricted. If this condition is left as it is, conditions will deteriorate rapidly. Therefore, urgent repairwork is necessary.

At present, substructure reinforcement work is being excecuted in the PELITA Program, and river improvement from a long range view will be necessary in the future.

In addition, approximately 2000 tons of bridge renewal is planned for each year for old bridges. It is desirable to take the clearance for electrification into consideration in future work.

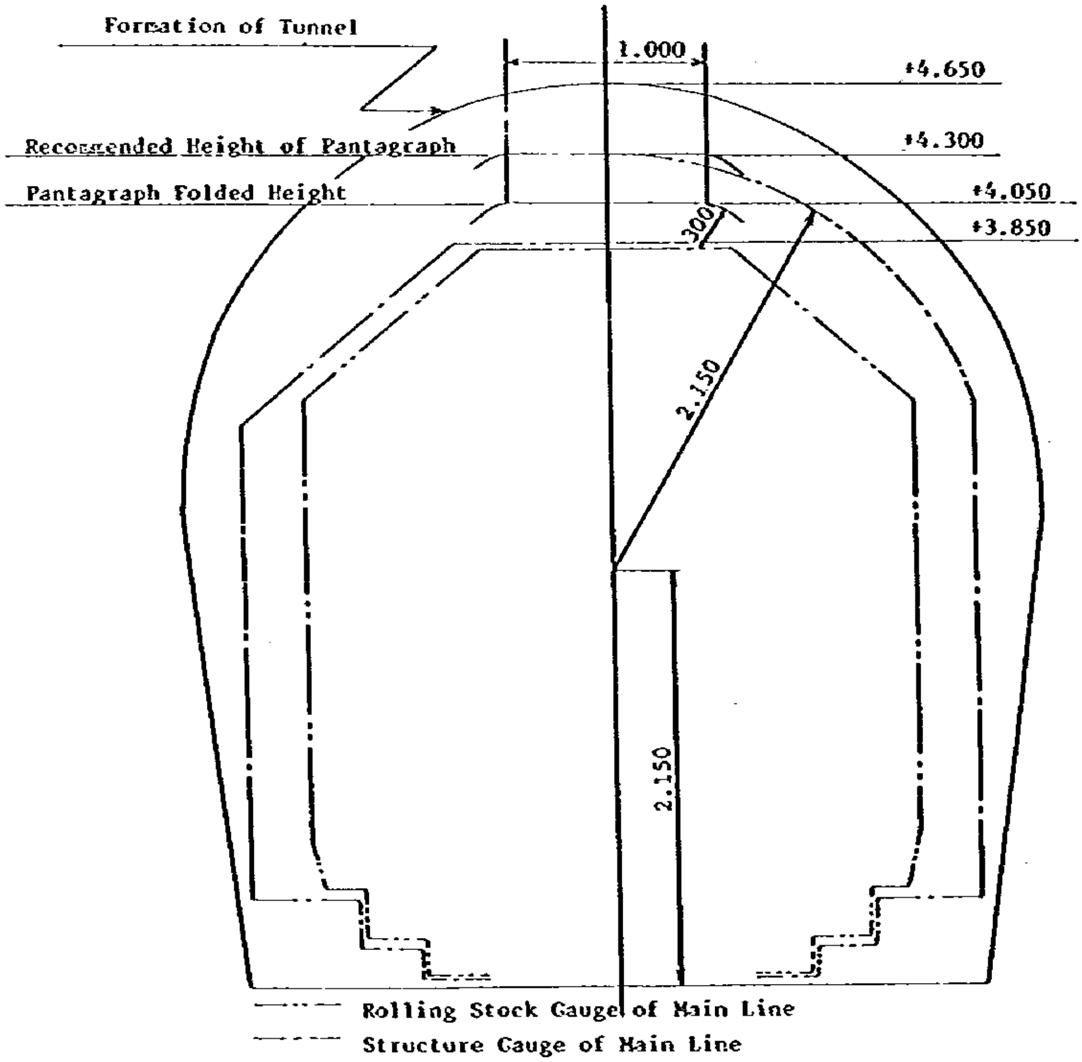


Fig. 6.2.1 Enlarged construction gage in alternating current electrification.

Table 6.2.2 Improvement object bridges

Electrified section \ Type	Siphon type aqueduct	Roadway bridge: Rebuilding	Roadway bridge: Girder lifting	Railway bridge: Upper chord member extension	Railway bridge: Portal bracing improvement
	(Locations)	(Locations)	(Locations)	(m)	(Bridges)
Bekasi - Cirebon	0	0	0	40	1
Cikampek - Kiara Kondong	11	0	2	30	0
Cirebon - Yogyakarta	4	0	9	300	0
Yogyakarta - Solo	0	0	0	50	0
Manggarai - Kravang	Note 1. No. of improvements due to track addition to double track line				
Solo - Surabaya	2	0	1	65	0
Wonokromo - Probolinggo	1	0	0	72	0
Merak - Serpong	1	3	1	105	0
Bogor - Sukabumi	7	2	3	0	0
Kiarakondong - Kroya	10	0	2	0	0
Cirebon - Semarang	0	0	0	450	11
Semarang - Surabaya	0	0	0	291	0
Brumbung - Solo	0	0	1	164	0
Probolinggo - Jember	1	0	1	0	0
Sukabumi - Padalarang	5	0	0	0	0
Bangil - Kertosono	3	1	5	0	0
Jember - Banyuwangi	0	0	1	0	0

Note 1

Section \ Type	Truss bridge	Girder bridge	Reinforced concrete bridge	Abutment	Pier
	(m)	(m)	(m)	(Locations)	(Locations)
Manggarai - Kravang	277	176	128	26	86

6.2.3 Tunnel

(1) Basic policy of the improvement plan

Out of 9 tunnels in the survey object section, 6 tunnels have small radius curve between R = 200 and R = 300. These sections are all limited speed zones.

In this project, since improvement of line alinement speed increase was not considered, work is limited to overhead clearance expansion. At the actual construction stage, it is desirable to examine the possibility of new tunnel construction depending on the degree of deterioration of the tunnel.

(2) Drawing up the improvement plan

There are many ways to enlarge the overhead clearance of the tunnel. The following are the typical methods:

- Securing the required overhead by lowering tracks
- Remodeling of the upper section

When selecting the remodeling method, various conditions such as economic aspects, safety, difficulty of construction and provision of the track grade, should be considered. In this master plan, the method of track lowering was tentatively adopted because that has lower costs and higher safety compared with other methods.

As for the actual execution of the improvement work, the following three alternatives were examined:

- Remodeling by dead line work
- Remodeling by live line work
- New line construction

Taking into consideration that the line in the tunnel is presently a single track line, and it is impossible to provide alternative transportation by bus because of mountainous conditions, live line remodeling work is adopted. The general construction procedure is shown in Appendix 6.3.

(3) Improvements to be made before electrification

The tunnels in the survey section are 80 ~ 100 years old except for the two between Malang and Blitar.

Deterioration is considered to be significant.

According to the survey result, no deformation was observed, but the deterioration of the lining due to the water leakage was considered to be rather serious.

At present Indonesian State Railways plans to repair 4 severely deteriorated tunnels, and it is desirable to do the work with most suitable method.

The tunnel remodeling method was adopted by visual inspection, and at the actual execution stage, it will be necessary to examine the most suitable remodeling method with the full understanding of the surrounding soil conditions, environment and the degree of deterioration of the tunnel structures.

CHAPTER 7 STATION PLAN

CHAPTER 7 STATION PLAN

7.1 Results of Field Survey

7.1.1 Passenger Equipment

(1) Number of stations under survey

The total number of stations on the lines to be electrified is 374: including, 5 terminal stations, 40 junction stations between trunk lines and branch lines and 329 intermediate stations. See Table 7.1.1.

(2) Persons boarding or alighting

The number of people boarding or alighting in the 25 blocks having lines which are to be electrified is shown in Fig. 7.1.1. According to this, the greatest number is the Jakarta block (53,800 a day) and in the Surabaya block (13,500 a day), followed by Bandung (8,200 a day). The number is less than 7,000 a day for the other blocks.

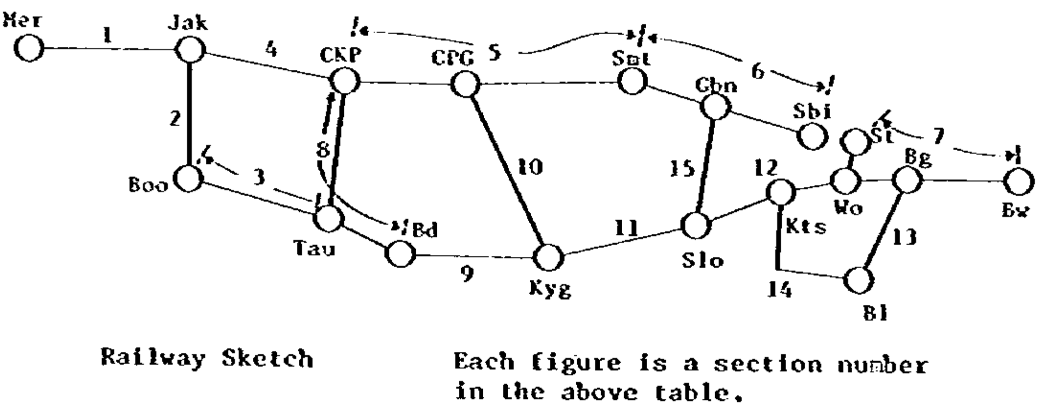
As for the passenger rush period, passenger concentration is greatest in the holiday month after Ramadan. In 1981, the number of passengers in August, which is the rush period of the year, was 122% of the annual average, as indicated in Table 7.1.2.

Stations with many people boarding or alighting include Jakarta (67,000 a day), Bogor (30,000 a day), Gresik (11,000 a day), Bandung (10,000 a day) and Serang (9,000 a day), as indicated in Table 7.1.3.

Table 7.1.1 Number of Stations on Lines Under Survey

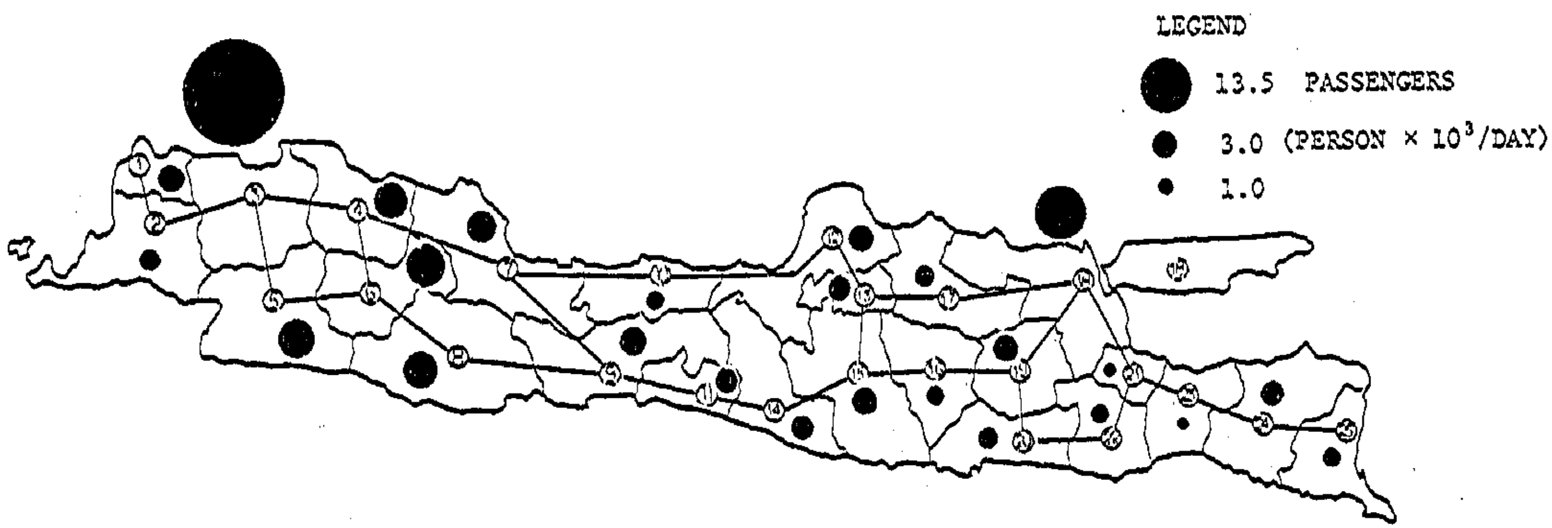
No.	Section	Terminal Station	Junction Station	Inter-mediate Station	Total	Remarks
1	KOMP BADAN - MEREK	1	3	18	22	
2	JAKARTAKOTA - BOGOR	1	-	11	12	
3	BOGOR - TAOOGAPU	-	-	21	21	
4	JAKARTAKOTA - CIREBON	-	2	31	33	(Except for JAKARTAKOTA)
5	CIREBON - SEMARANG-TAWANG	-	5	23	28	(Except for CIREBON)
6	SEMARAG-GUDANG - SURABAYA PASARTURI	1	7	31	39	
7	SURABAYA KOTA - BANYUWANGI	2	7	34	43	
8	CIKAMPEK - BANDUNG	-	1	16	17	(Except for BANDUNG CIKAMPEK)
9	BANDUNG - KROYA	-	4	30	34	(Except for KROYA)
10	CIREBON - KROYA	-	2	19	21	(Except for CIREBON KROYA)
11	KROYA - SOLO BALAPAN	-	2	33	35	(Except for SOLO BALAPAN)
12	SOLO BALAPAN - WONOKROMO	-	5	29	34	(Except for WONOKROMO)
13	BOGIL - BLITOR	-	1	16	17	(Except for BOGIL)
14	BLITOR - KERTOSONO	-	-	13	13	(Except for BLITOR KERTOSONO)
15	GAMBRINGAN - SOLO BALAPAN	-	1	4	5	(Except for GAMBRINGAN SOLO BALAPAN
	Total	5	49	329	374	

PJKA: Calculated from railway map.



Railway Sketch

Each figure is a section number in the above table.



No.	Block	Passengers (×10³)	No.	Block	Passengers (×10³)	No.	Block	Passengers (×10³)
1	Merak	3.4	10	Pekalongan	1.5	19	Kertosono	3.0
2	Rankaspitung	2.1	11	Kebumen	2.6	20	Tulungagung	1.9
3	Jakarta	53.8	12	Semarang	3.3	21	Bangil	0.7
4	Cikampek	5.6	13	Purwodadi	2.7	22	Malang	1.7
5	Sukabumi	6.7	14	Yogyakarta	2.8	23	Probolinggo	0.6
6	Bandung	8.2	15	Solo	3.0	24	Jember	2.3
7	Cirebon	4.7	16	Madiun	1.7	25	Banyuwangi	1.7
8	Tasikmalaya	6.4	17	Bojonegoro	1.9			
9	Kroya	4.1	18	Surabaya	13.5		Total	139.8

Data is based on the PJKA statistic.

Fig. 7.1.1 Number of Passengers for Each Block 1981 (Person/day)

Table 7.1.2 Number of Passengers, Java Island, and Rush Rates

Unit: 1,000 persons

Month	First	Second	Third	Total	Days	Daily average	Rush rate
1	20	232	2,742	2,994	31	96.6	0.948
2	16	215	2,615	2,846	28	101.6	0.997
3	17	217	2,782	3,016	31	97.3	0.955
4	20	225	2,753	2,998	30	99.9	0.981
5	20	243	2,913	3,176	31	102.5	1.005
6	27	293	3,111	3,431	30	114.4	1.122
7	24	257	2,918	3,199	31	103.2	1.013
8	23	265	3,572	3,860	31	124.5	1.222
9	19	207	2,574	2,800	30	93.3	0.916
10	22	230	2,873	3,125	31	100.8	0.989
11	19	200	2,557	2,776	30	92.5	0.908
12	16	215	2,744	2,975	31	96.0	0.942
Total	243	2,797	34,154	37,196	365	101.9	1.000

1981 PJKA: Calculated from statistical data.

Chart of Rush Rates

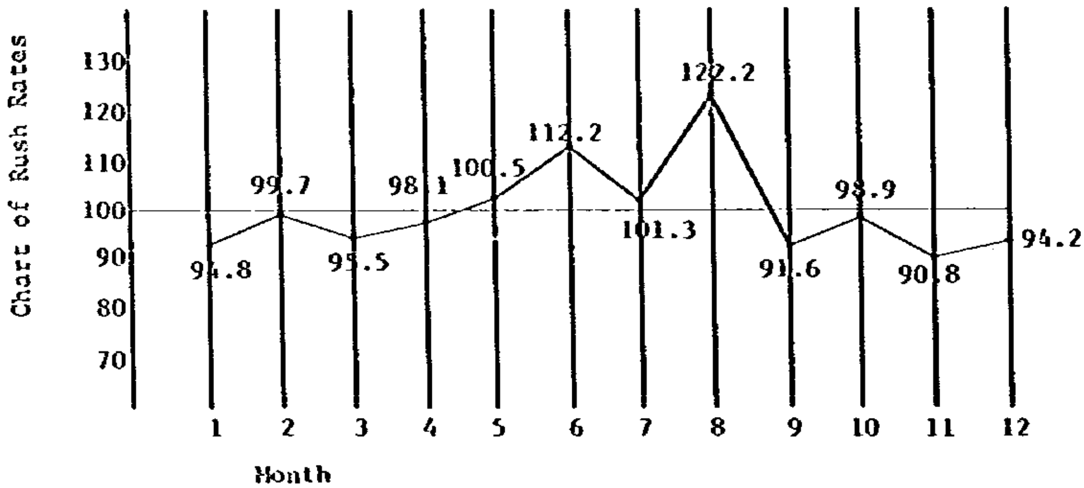


Table 7.1.3 Survey on Number of Passengers by Station (Per day)

Part 1

1,000 persons

Month/year Kabupaten	August	1981	Rush rate (%)
JAKARTA	75.8	66.6	113.8
BEKASI	5.0	4.9	102.0
KARAWANG	5.6	4.9	114.3
TANGGERANG	2.5	2.5	100.0
BOGOR	33.8	30.2	111.9
LEBAK	3.8	3.4	111.8
PANDEGLANG	-	-	-
SERANG	12.5	9.4	133.0
CIREBON	2.7	2.4	112.5
SUBANG	0.5	0.6	83.3
INDRAMAYU	1.6	1.6	100.0
BANDUNG	11.8	10.2	115.7
PURWAKARTA	2.0	1.6	125.0
CIANJUR	3.2	2.3	139.1
SUKABUMI	5.5	4.3	127.9
GARUT	4.2	2.9	144.8
TASIKMALAYA	1.9	1.2	158.3
CIAMIS	3.3	2.0	165.0
BANYUMAS	1.4	0.9	155.6
BREBES	1.0	0.7	142.9
KEBUMEN	2.8	1.6	175.0

Part 2

1,000 persons

Kabupaten \ Month/year	August	1981	Rush rate (%)
PURWOREJO	2.1	1.5	140.0
CILACAP	5.5	3.2	171.9
PEMALANG	0.2	0.1	200.0
TEGAL	0.8	0.5	160.0
PEKALONGAN	0.7	0.5	140.0
BATANG	0.2	0.1	200.0
KENDAL	-	-	-
DEMAK	0.4	0.2	200.0
PURWODADI	3.5	2.6	134.6
BLORA	1.3	0.9	144.4
BOJONEGORO	0.9	0.5	180.0
REMBANG	0.4	0.3	133.3
TUBAN	1.4	1.2	116.7
KULONPROGO	0.3	0.2	150.0
SLEMAN	5.0	4.5	111.1
KLATEN	0.4	0.3	133.3
SRAGEN	0.3	0.3	100.0
KARANGANYAR	0.1	0.1	100.0
BOYOLALI	0.4	0.3	133.3
SEMARANG	5.6	4.2	133.3
SURAKARTA	2.6	1.8	144.4
BANTUL	-	-	-
NGAWI	0.6	0.4	150.0

Part 3

1,000 persons

Month/year / Kabupaten	August	1981	Rush rate (%)
MAGETAN	-	-	-
MADIUN	1.4	1.0	140.0
NGANJUK	0.9	0.6	150.0
JOMBANG	2.0	1.3	153.8
PONOROGO	0.1	0.1	100.0
KEDIRI	0.9	0.7	128.6
TULUNGAGUNG	0.7	0.4	175.0
BLITAR	2.2	1.6	137.5
MALANG	2.8	1.9	147.4
PASURUAN	0.9	0.6	150.0
SIDOARJO	1.4	1.1	127.3
MOJOKERTO	0.8	0.6	133.3
GRESIK	14.1	11.1	127.0
LAMONGAN	0.6	0.6	100.0
BANGKALAN	0.2	0.1	200.0
SAMPANG	-	-	-
PROBOLINGGO	0.1	0.1	100.0
LUMAJANG	0.7	0.3	233.3
JEMBER	1.8	1.3	138.5
BONDOWOSO	0.8	0.5	160.0
SITUBONDO	0.4	0.3	133.3
BANYUWANGI	2.2	1.4	157.1
JEMBRANA	0.2	0.1	200.0

(3) Effective length

Table 7.1.4 shows the effective length of main stations determined from station plans. According to this, the shortest effective length is 180 m for Jakarta and Surabaya Pasarturi Stations. The other stations have 200 m or more and can cope with eight-car passenger train formations and 300-m freight trains.

(4) Distance between track centres

At least 4 m is ensured between the primary main line and the secondary main line. The distance is at least 4.5 m if there is a platform between the tracks.

(5) Passenger platforms

As indicated in Fig. 7.1.2 platforms are only about 100 mm ∿ 200 mm above the rail level at many stations other than at Jakarta Kota Station which has elevated platforms. At some of these stations, portable stairs are used for the convenience of passengers. But most stations lack these stairs — to the great inconvenience of women and children.

(6) Yard drainage facilities

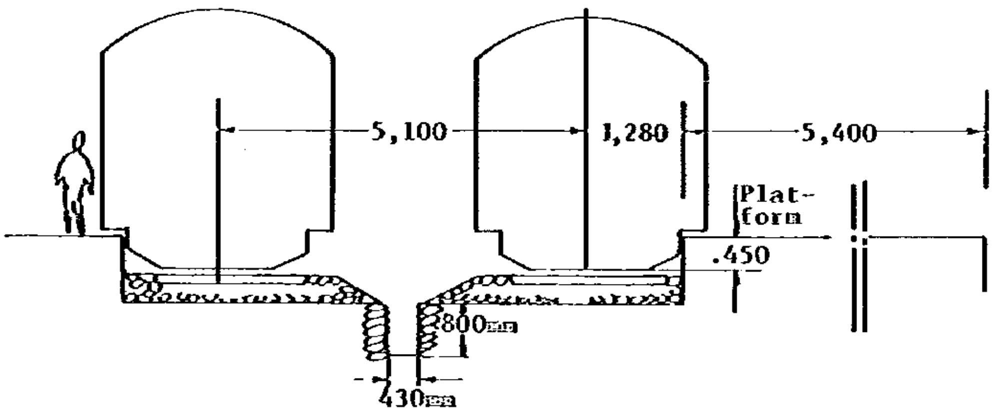
Inter-track broken stone drainage ditches of about 800 mm depth are provided near the platforms of Jakarta Station, as indicated in Fig. 7.1.2, thus making it possible to cope with rainfall. But no drainage facilities are found at other stations and it is feared that, at many points, rails may be submerged during the rainy season.

Table 7.1.4 Survey on Effective Length and Track Intervals at Main Stations

Station \ Name of main line	I	II	III	IV	V ∿	Minimum track interval
1 JAKARTA KOTA	180^m	180^m	180^m	180^m	180 m for V ∿ XII	5.1^m
2 MANGGARAI	320	320	320	320	110 m for both V and VI	4.0
3 JATINEGARA	280	230	200	200	V 190 VI 130	4.0
4 KRAWANG	190	190	140	140		6.0
5 CIKAMPEK	300	300	290	290	$^{V}80$ $^{VI}80$	5.0
6 JATIBARANG	460	460	380	380	V 290 VI 290	5.0
7 CIREBON	360	360	300	200		5.3
8 SEMARANG TAWAG	460	230	230	310	$^{V}310$	4.5
9 BANJUWANG	480	390	390	390	$^{V}370$	4.3
10 GAMBRINGAN	470	360	290	290		4.3
11 CEPU	200	200	340			4.0
12 BOJONEGORO	300	300	470			4.0
13 BABAT	440	380	340	250		8.4
14 SURABAYA PASARTURI	180	180	210			4.0
15 SURABAYA KOTA	240	240	350	350		5.3
16 SURABAYA GUBENG	380	380	380			4.15
17 WONKROMO	290	290	330	330	$^{V}330$	5.0
18 BANGIL	260	260	330	330	$^{V}330$	3.9
19 KLAKAH	330	330	360			4.0
20 RAMBPUJI	330	330	310	310		4.5
21 KALISAT	310	230	230			3.8

Name of main line / Station	I	II	III	IV	V ∿	Minimum track interval
22 BANYUWANGI	260m	260m				4.0m
23 PADALARANG	510	460	210	210		5.3
24 BANDUNG	330	300	300	300	V 250 VI 250	4.0
25 CIBATU	260	260	260	160		5.0
26 TASIKMALAYA	260	250	220			4.1
27 BANJAR	480	480	400	80		4.4
28 KASOEGIHAN	320	260				4.0
29 KROYA	600	600	620	460		8.0
30 YOGYAKARTA	330	330	240			6.0
31 SOLOBALAPAN	390	330	330	300		4.0
32 MADIUN	390	370	300			4.4
33 KERTOSONO	310	260	240	290		4.1
34 JOMBANG	130	350	260			4.7
35 MOJOKERTO	380	470	370			4.4
36 TARIK	500	500	500	440		4.3
37 KRIAN	590	590				7.0
38 PRUPUK	390	400	360	240		4.4
39 PURWOKERTO	320	300	320	280		5.9
40 KEDUNGJATI	470	510	350	300		5.1
41 MALANG	280	230	200	160		4.5
42 MERAK	380	370				4.4

Sketch of Platform at Jakarta Station



Platform at Cirebon Station

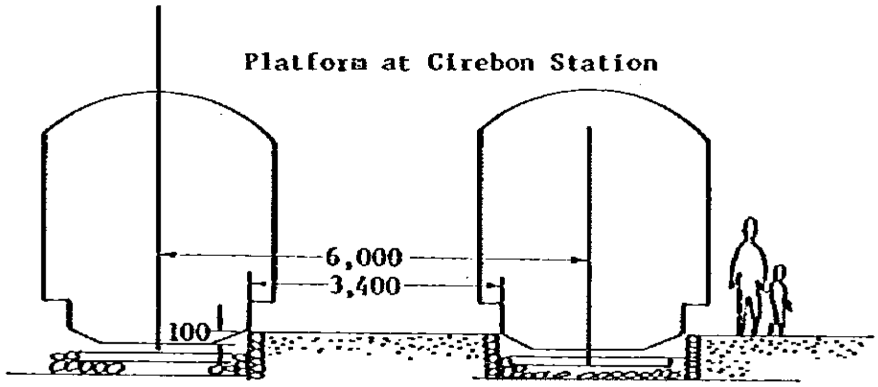


Fig. 7.1.2

7.1.2 Freight Facilities

(1) Freight handling stations

All general stations are provided with freight loading/unloading tracks. Besides, there are the following stations exclusive for freight handling:

(1) JAKARTA GUDANG
(2) TANDJUNG PRIUK GUDANG
(3) SEMARANG GUANG
(4) BENTENG
(5) KALMAS
(6) SOLOJEBRES

(2) Volume of freight handled

According to 1981 PJKA statistics, the volume of freight handled was 2,542,000 tons. By item, petroleum products represented 33% of all, followed by fertilizer, cement, sand and molasses (see Table 7.1.5). The volume of transportation decreased yearly and slumped to 85% in 1981, compared with the previous year (2,990,000 tons in 1980).

Table 7.1.5 1981 Volume of Freight Handled, by Item

Unit: $\times 10^3$ tons

Item	Quantity	%	Item	Quantity	%
Rubber	0.1	0	Steel	9.3	0.4
Latex	4.4	0.2	Fertilizer	471.4	19.2
Rice	32.6	1.3	Paper	1.0	0
Maize	82.2	3.4	Bagasse	0.2	0
Tea	13.3	0.5	Sugar	15.6	0.6
Teak logs	21.7	0.9	Molasses	62.6	2.5
Coal	2.3	0.1	Salt	19.8	0.8
Petroleum products	799.3	32.6	Asphalt	24.1	1.0
Cement	316.5	12.9	Wheat	3.7	0.2
Sand	112.0	4.6	Others	455.7	18.6
Gravel	4.1	0.2	Total	2452.0	100.0

PJKA: Calculated from statistics.

(3) Volume of freight, by station

The volume of freight handled by main freight stations is indicated in Table 7.1.6. The volume handled in 1981 was large with Gresik (922,000 ton/year), Jakarta (387,000 ton/year) and Cilacap (381,000 ton/year). The volume handled by each of the other stations was less than 300,000 ton/year.

The above stations refer to general areas of which the details are as follows:

Table 7.1.6 Survey on Volume of Freight Handled in Different Areas of Java Island

1981 ton/year

Name of area	Outgoing	Incoming	Total	Name of area	Outgoing	Incoming	Total
JAKARTA	171,936	215,507	387,443	REMBANG	4,121	758	4,879
BEKASI	11,172	3,298	14,470	TUBAN	3,320	6	3,326
KARAWANG	134,075	1,880	135,955	KULONPROGO	-	3,419	3,419
TANGGERANG	99,504	231	99,735	SLEMAN	4,032	81,563	85,595
BOGOR	472	14,493	14,965	KLATEN	11,174	8,105	19,279
LEBAK	359	2,516	2,875	MASARAN	9,243	12,123	21,366
PANDEGLANG	-	450	450	WONOGIRI	120	3,602	3,722
SERANG	1,924	24,499	26,423	KARANGANYAR	12,894	5,790	18,684
CIREBON	8,456	56,397	64,853	SUKOHARJO	-	14,011	14,011
SUBANG	11	21,909	21,920	MAGELANG	-	120	120
INDRAMAYU	2,817	26,020	28,837	BOYOLALI	293	120	413
MAJALENGKA	-	12	12	SEMARANG	158,939	104,544	263,483
BANDUNG	13,444	94,064	107,508	SURAKARTA	9,504	138,310	147,814
PURWAKARTA	35	79,929	79,964	SALATIGA	10	48	58
CIANJUR	32	1,103	1,135	NGAWI	2,348	12,143	14,491
SUKABUMI	10	2,145	2,155	MAGETAN	-	10,937	10,937
GARUT	-	21,744	21,744	MADIUN	12,050	150,190	162,240
TASIKMALAYA	18,209	12,174	30,383	NGANJUK	7,531	12,112	19,643
CIAMIS	1,930	5,888	7,818	JOMBANG	1,823	-	1,823
BANYUMAS	3,144	11,494	14,640	PONOROGO	120	1,286	1,406
BREBES	462	2,514	2,976	KEDIRI	5,768	136,357	142,125
PURBALINGGA	-	40	40	TULUNGAGUNG	2,282	9,072	11,354
BANJARNEGARA	-	1,276	1,276	BLITAR	1,449	7,522	8,971
WONOSOBO	-	2,207	2,207	MALANG	5,025	136,562	141,587
KEBUMEN	228	12,643	12,871	PASURUAN	1,133	13,668	14,801
PURWOREJO	-	2,530	2,530	SIDOARJO	1,771	2,593	4,364
CILACAP	349,813	31,317	381,130	MOJOKERTO	5,339	-	5,339
PEMALANG	-	2,402	2,402	JALANMEREDI	30	-	30
TEGAL	5,298	138,330	143,628	GRESIK	821,645	100,608	922,253
PEKALONGAN	2,800	702	3,502	LAMONGAN	8,418	4,725	13,143
KENDAL	3,520	86	3,606	PROBOLINGGO	13,591	18,284	31,875
DEMAK	30	9,783	9,813	LUMAJANG	21,458	24,911	46,369
PURWODADI	3,343	22,868	26,211	JEMBER	9,467	55,075	64,542
BLORA	35,757	11,874	47,631	BONDOWOSO	946	5,617	6,563
BOJONEGORO	4,148	10,129	14,277	SITUBONDO	1,446	9,623	11,069
KUDUS	800	1,536	2,336	BANYUWANGI	5,833	41,184	47,017
PATI	3,303	1,479	4,782	JEMBRANA	-	6	6
Grand Total							3,992,620

1) Gresik area

There are six freight handling stations as indicated in Fig. 7.1.3. Those with large volumes of freight handled are Benteng (420,000 ton/year), Kalimas (292,000 ton/year) and Indro (160,000 ton/year) (see Table 7.1.7 and Fig. 7.1.4). By items handled, petroleum products represented 47%, fertilizer 24%, cement 18% and molasses 7% (see Table 7.1.8).

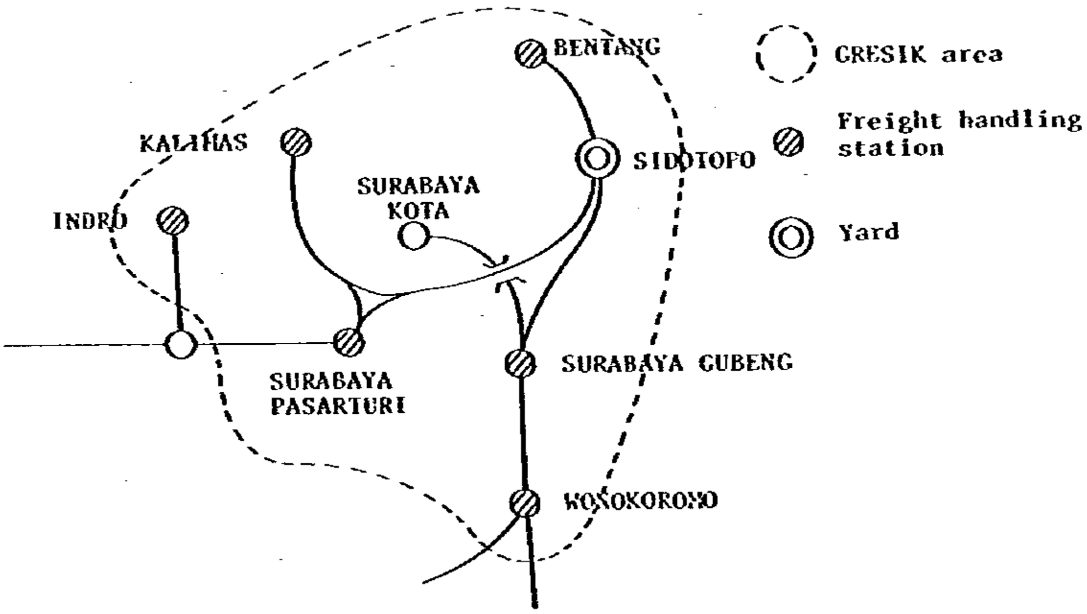


Fig. 7.1.3 Sketch Map of the Gresik Area

Table 7.1.7 Volume of Freight Handled in Gresik Area, by Stations

Unit: 1,000 tons

	Outgoing	Incoming	Total
BENTENG	420	-	420
INDRO	159	1	160
KALIMAS	217	75	292
SURABAYA PASARUTORI	22	9	31
SURABAYA GUBENG	2	14	16
WANOKROMO	2	2	4
Total	822	101	923
Ratio	89%	11%	100%

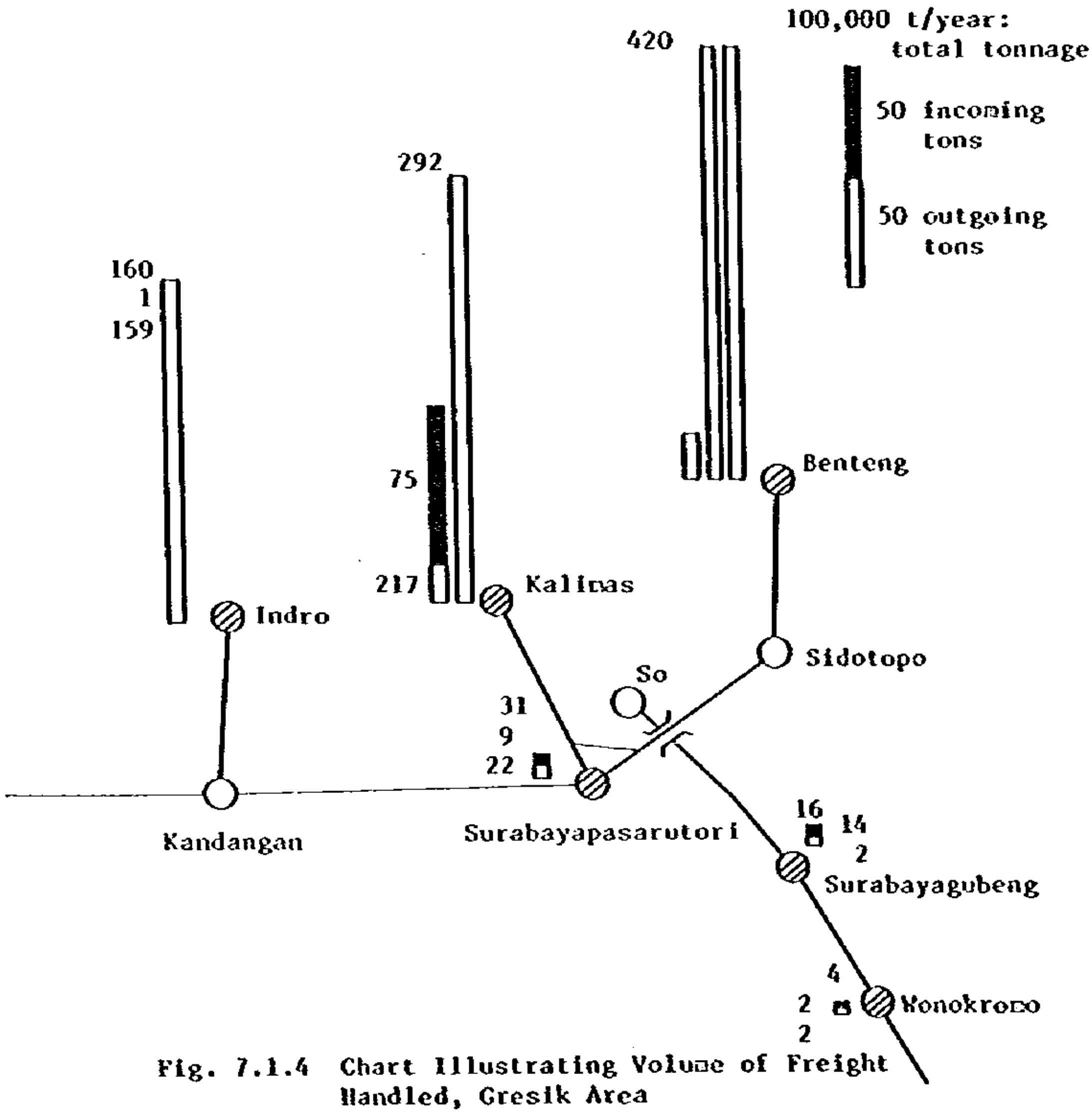


Fig. 7.1.4 Chart Illustrating Volume of Freight Handled, Gresik Area

Table 7.1.8 Volume of Freight Handled in Gresik Area (by Station and by Item)

1981 Unit: ton

Item	Out/In	SURABAYA PASARTORI	INDRO	SURABAYA KUBENG	BENTENG	KALIMAS	WONOKROMO		Total
Rubber	Out								
	In					22			22
Latex	Out	99							99
	In			85					85
Rice	Out	2,111							2,111
	In					669			669
Maize	Out	18,821							18,821
	In	3,642							3,642
Teak logs	Out		57						57
	In								
Tea	Out								
	In				33				33
Coal	Out			2,219					2,219
	In								
Petroleum products	Out				419,811				419,811
	In					13,018			13,018
Cement	Out		155,673						155,673
	In			13,692					13,692
Sand	Out				47				47
	In		31						31
Gravel	Out								
	In		1,359						1,359
Steel	Out	33							33
	In	4,755							4,755
Fertilizer	Out				216,662				216,662
	In	99							99
Paper	Out								
	In	93							93
Bagasse	Out								
	In	10							10
Sugar	Out	1,218							1,218
	In					1,049			1,049
Molasses	Out					6			6
	In					60,152			60,152
Salt	Out		2,533						2,533
	In								
Asphalt	Out						2,358		2,358
	In						1,938		1,938
Wheat	Out								
	In								
Total of outgoing freight		22,273	158,269	2,219	419,858	216,658	2,358		821,635
Total of incoming freight		8,590	1,359	13,777	33	74,901	1,938		100,668
Grand total		30,863	159,658	15,936	419,871	231,559	4,295		922,253
Ratio (%)		3.3	17.3	1.7	45.5	31.6	0.6		100%

2) Jakarta area

The Jakarta Area handled the second largest volume (387,000 ton/year). Its station's sphere of influence is as shown in Fig. 7.1.5. Stations with large volumes of handled freight are Tandjung Priok Gudang (155,000 tons), Kebayoran (109,000 tons) and Jakarta Gudang (57,000 tons) (see Fig. 7.1.6). By item, petroleum products represented 36%, sand 28% and maize 12% (see Table 7.1.9).

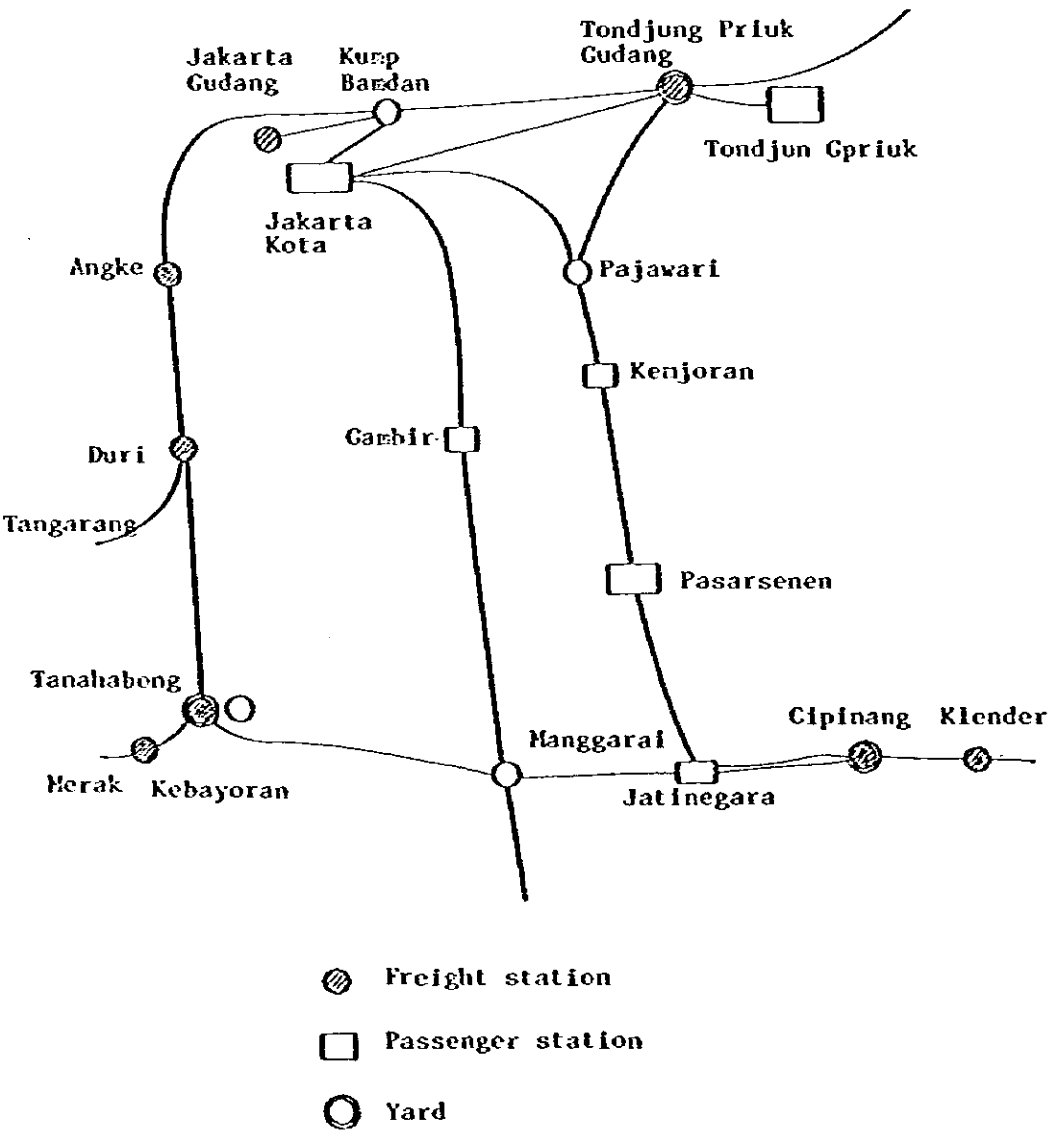


Fig. 7.1.5 Sketch of Jakarta Area

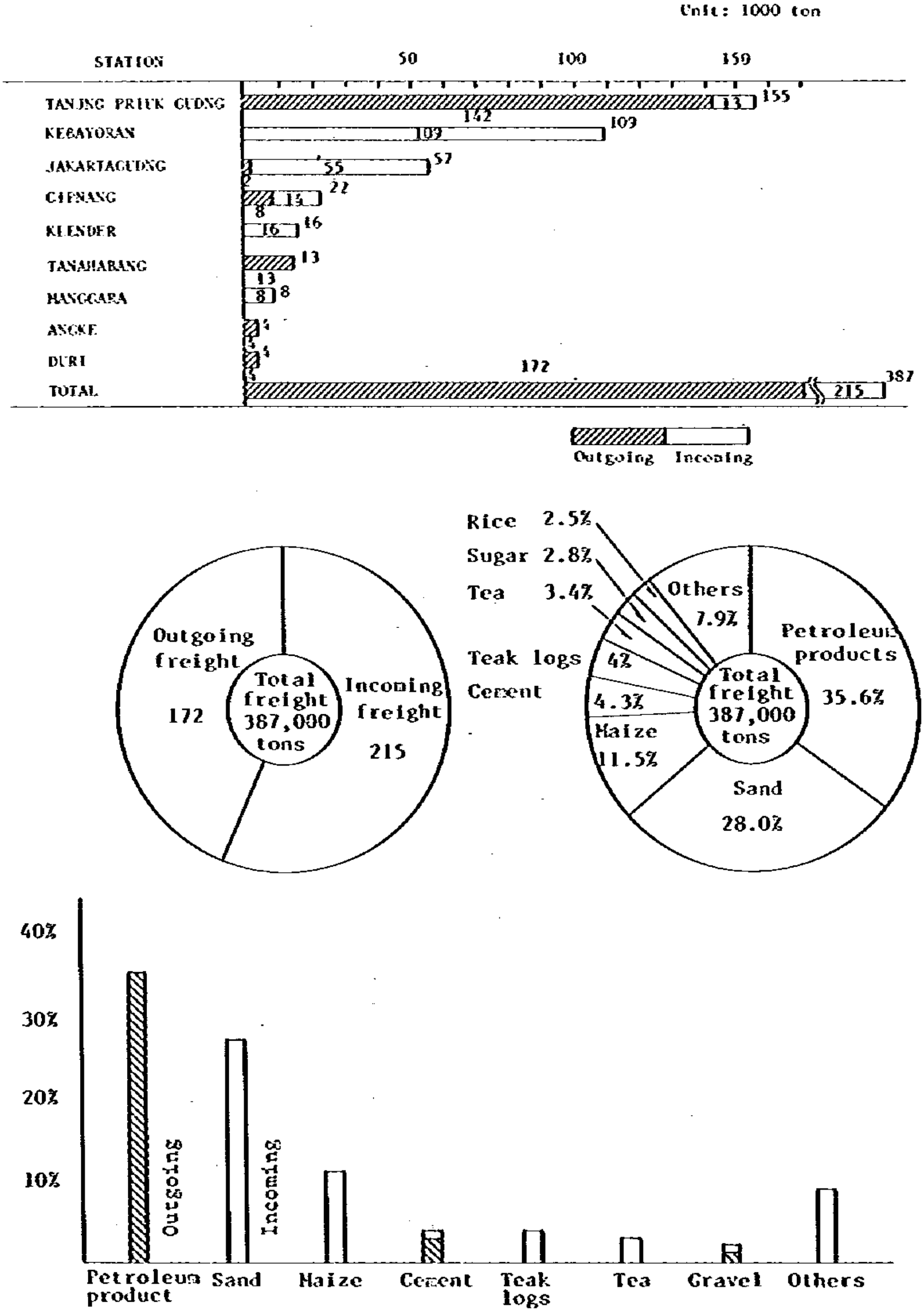


Fig. 7.1.6 Freight Volume of the Jakarta Area

Table 7.1.9 Volume of Freight Handled in Jakarta Area (by Station and by Item)

1981 Unit: ton

Item	Out/In	TANAH-ABANG	JAKARTA-GUDANG	TANJUNG-PRIUKGU-DANG	CIPINA-NG	ANGKE	DURI	KLENDER	KEBAYO-RAN	MANGGA-RAI	Total
Rubber	Out	107									107
	In										
Latex	Out		132								132
	In		169								169
Rice	Out		139								139
	In				9,452						9,452
Maize	Out		36								36
	In		44,493								44,493
Teak Logs	Out										
	In						15,319				15,319
Tea	Out										
	In			13,297							13,297
Coal	Out										
	In										
Petroleum Products	Out			137,608							137,608
	In					204					204
Cement	Out	13,359									13,359
	In		3,179								3,179
Sand	Out										
	In								168,343		168,343
Gravel	Out		393								393
	In								920		920
Steel	Out				7,371						7,371
	In										
Fertilizer	Out			3,337							3,337
	In		151								151
Paper	Out			582							582
	In					10					10
Bagasse	Out		10								10
	In							212			212
Sugar	Out					3,765					3,765
	In		7,185								7,185
Molasses	Out										
	In		60								60
Salt	Out			163							163
	In									7,670	7,670
Asphalt	Out		909								909
	In				4,863						4,863
Wheat	Out						3,629				3,629
	In										
Total of outgoing freight		13,466	1,615	142,030	7,371	3,765	3,629				171,936
Total of incoming freight			55,227	13,297	14,305	214		15,531	169,263	7,670	215,507
Grand total		13,466	56,842	155,387	21,676	3,979	3,629	15,531	169,263	7,670	387,443
Ratio (%)		3.5	14.7	40.1	5.6	1.0	0.9	4.0	28.2	2.0	100%

3) Cilacap area

An annual total of 38,100 tons was handled by the eight freight stations included in this area. Stations with large volumes of handled freight are Karang Talun (135,000 t/year), Cilacap Pelasuhan (117,000 t/year), Maos (74,000 t/year) and Cilacap (49,000 t/year). Items with large volumes handled are cement (156,000 t), fertilizer (116,000 t), petroleum products (75,000 t) and asphalt (20,000 t).

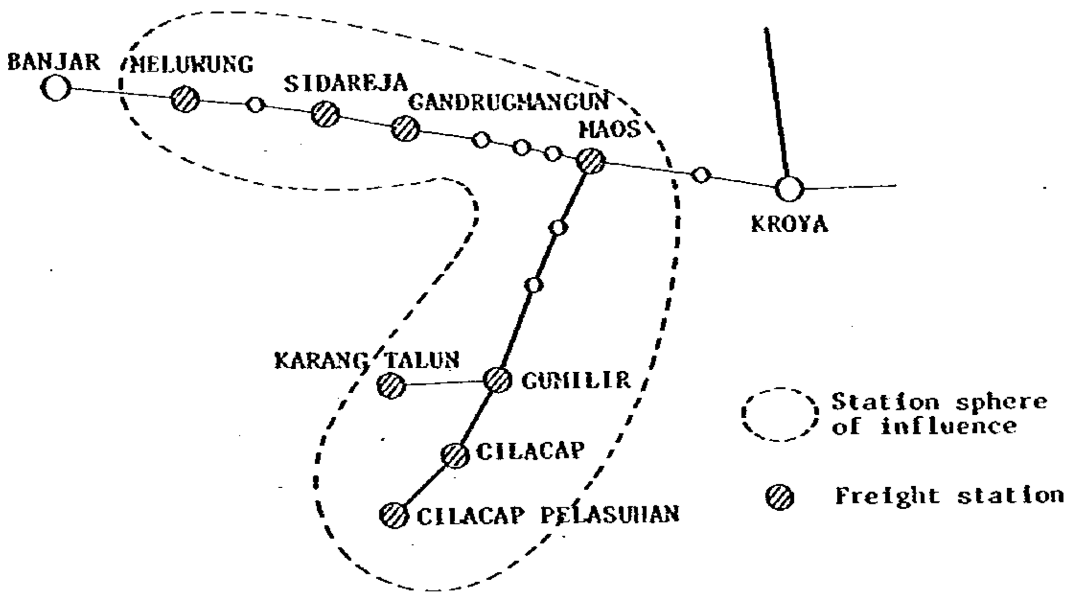


Fig. 7.1.7 Sketch of Cilacap Station Sphere of Influence

Table 7.1.10 Volume of Freight Handled in Cilacap Area (by Station and by Item)

1981 Unit: ton

Item	Out/In	KELUW-ING	GANDR-UNGMAN-GUN	KARANG-TALUN	MAOS	CILACAP	CILACAP-PELABUH-AN	GUMILIR	KAWUN-GANTEN	SIDARE-JA	Total
Rubber	Out			-							-
	In			43							43
Latex	Out	1,469									1,469
	In	-									-
Rice	Out		4,480			-					4,480
	In		-			5,056					5,056
Maize	Out			83							83
	In			-							-
Teak Logs	Out								111	-	111
	In								-	3	3
Tea	Out										-
	In										-
Coal	Out				18						18
	In				-						-
Petroleum Products	Out				74,181		-				74,181
	In				-		952				952
Cement	Out			132,891							132,891
	In			-	-	23,307					23,307
Sand	Out			-	10	-					10
	In			30							30
Gravel	Out			-							-
	In			1,537							1,537
Steel	Out					40					40
	In					-					-
Fertilizer	Out						116,004				116,004
	In						-				-
Paper	Out										-
	In										-
Bagasse	Out										-
	In										-
Sugar	Out							273			273
	In							-			-
Molasses	Out				14						14
	In				-						-
Salt	Out						45			-	45
	In						-			348	348
Asphalt	Out			-		20,193					20,193
	In			11		-					11
Wheat	Out										-
	In										-
Total of outgoing freight		1,469	4,480	132,974	74,223	20,233	116,050	273	111	-	349,813
Total of incoming freight		-	-	1,621	-	28,333	952	-	-	351	31,317
Grand total		1,469	4,480	134,595	74,223	48,626	117,002	273	111	351	381,130
Ratio (%)		0.4	1.2	35.3	19.5	12.8	30.7	-	-	0.1	100%

(4) Freight unloading equipment

Petroleum products, which are massive freight, are transported by exclusive lines of the Pertamina Petroleum Public Corporation and are automatically loaded by pipe from a storage tank.

Fertilizer can be efficiently loaded because of an exclusive line connection to the fertilizer bagging plant located at the quay. On arrival, it is unloaded by another exclusive line provided for the fertilizer warehouse.

Cement is loaded by cargo handling machines from the cement mill. On arrival, it is delivered to the cement warehouse.

Molasses is automatically loaded, using an exclusive line connected to the loading place in the sugar plant. It is also automatically unloaded into storage tank provided at the quay.

The equipment for these four types of freight are modernized.

However, the volume of other handled freight is extremely small because it is handled at elevated and ground-level platforms in the station yards. The platforms and the passages are unpaved and the platforms are too narrow to use modern cargo-handling machines.

7.1.3 Yards

There are two main marshalling yards, one at Cipinang and the other at Sidotopo.

(1) Cipinang

1) Yard facilities

Site area: Approx. 121,000 m^2 (excluding main lines)

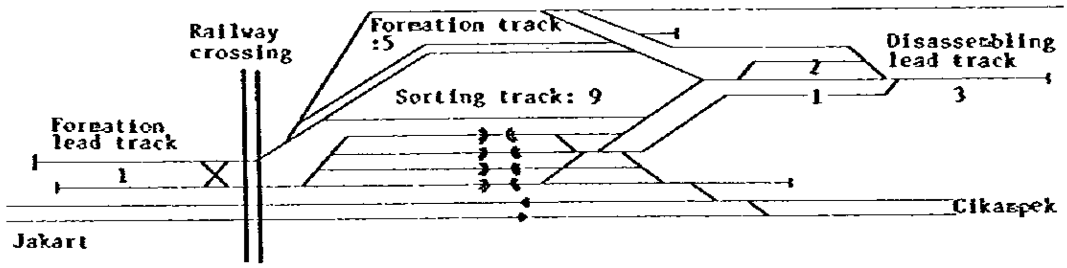


Fig. 7.1. 8 Track Layout Sketch (Cipinang)

As indicated in the above sketch, there are four secondary main tracks, nine sorting tracks, five formation tracks, two disassembling lead tracks and a formation lead track. The effective length of each track is as follows:

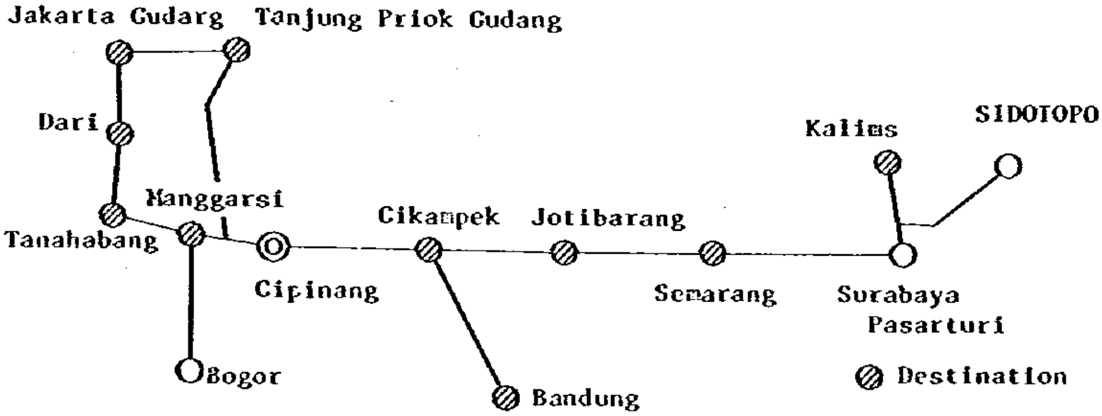
Name of track	Secondary main track	Name of track	Sorting track	Name of track	Formation track	Name of track	Lead track
1	350^{m}	5	410^{m}	14	400^{m}	Disas-sembling 1	200^{m}
2	350	6	440	15	370	2	170
3	370	7	420	16	370	3	200
4	220	8	440	17	290	Formation 1	300
		9	420	18	260		
		10	380				
		11	350				
		12	300				
		13	280				
		Total	3440				

The number of cars held by the sorting tracks is:

Total effective length of sorting tracks ÷ car length

= 3440 ÷ 8.2 = 419 cars.

2) Functions of yard



Sorting is performed as follows:

Sorting	Station order formation
JAKARTA	TANJUNG PRIOK GUDANG JAKARTA KOTA GUDANG DURI For TANAHABANG and MERAK For MANGGARAI and BOGOR
BANDUNG	
CIKAMPEK	
JATIBARANG	
SEMARANG	
KALIMS	

Merak-bound trains and Bogor-bound trains are respectively formed at Tanahabang and Manggarai.

3) Handling capacity: 600 cars a day

(2) Sidotopo

1) Yard equipment

Site area: Approx. 131,000 m²

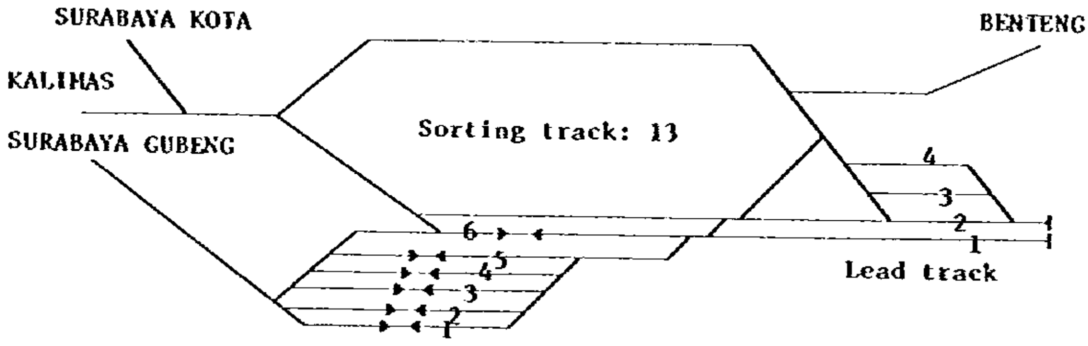


Fig. 7.1.9 Track Layout (Sidotopo)

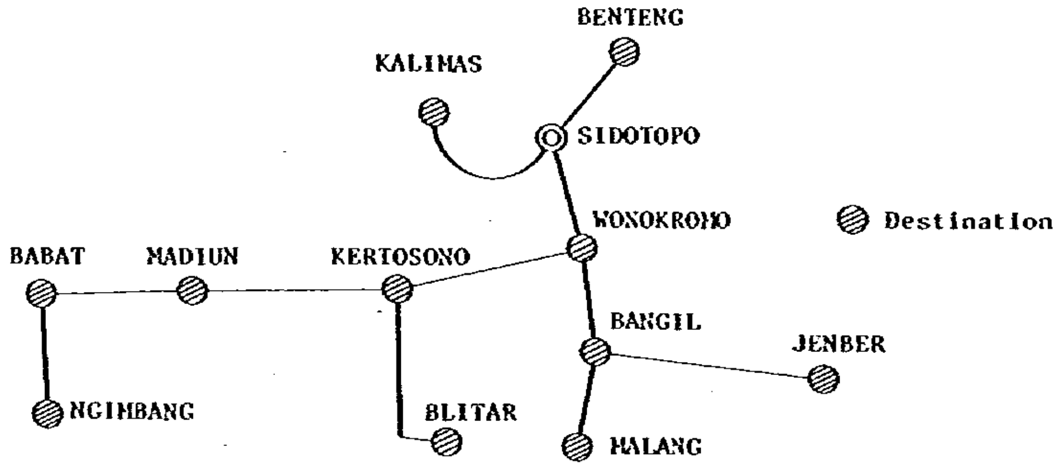
Effective length

Name of track	Secondary main track	Name of track	Sorting track	Name of track	Lead track
1	590m	7	890m	1	710m
2	660	8	920	2	710
3	700	9	910	3	320
4	870	10	910	4	360
5	880	11	760		
6	770	12	800		
		13	810		
		14	750		
		15	690		
		16	630		
		17	570		
		18	520		
		19	520		
Total	4470	Total	9680	Total	2100

Number of cars held by lead track:

$9680^m \div 8.2$ m/car = 1180 cars

2) Functions of yard



Trains bound for the northern line are sorted and formed at Kalimas.

3) Handling capacity: 1,000 cars a day

7.2 Conception of Electrification Measures

7.2.1 Passenger Equipment

(1) Forecasting of Boarding and Alighting Persons

The daily number of persons boarding or alighting medium and long-distance railway transportation was 81,000 in 1981. If the electrification of Javanese main railway lines is completed by 2002 and trains are operated at 100 km an hour, the number of railway users will greatly increase and is expected to reach 1,163,000 a day in 2002. (See Table 7.2.1).

The area with the largest number of boarding and alighting persons is the Jakarta Area (228,000 a day), followed by Surabaya Area (118,000 a day), Semarang Area (79,000 a day), Bandung (74,000 a day), Yogyakarta Area (59,000 a day), Solo Area (53,000 a day) and Cikampek Area (53,000 a day).

Table 7.2.1 Survey on Number of Boarding and Alighting Persons, by Area

Unit: 100 person/day

Number of boarding and alighting persons, by year / Area	Number in 1981	Number in 1989	Number in 1994	Number in 2002
1 MERAK	13.8	35.5	424.1	482.6
2 RANKASPITUNG	19.7	40.4	126.6	171.9
3 JAKARTA	201.0	1,187.3	1,826.6	2,277.5
4 CIKAMPEK	49.2	277.5	377.7	527.4
5 SUKABUMI	27.0	54.3	78.6	419.4
6 BANDUNG	51.6	575.1	696.8	735.5
7 CIREBON	34.1	307.1	360.1	352.6
8 TASIKMALAYA	32.5	161.1	169.7	412.1
9 KROYA	24.2	61.2	272.1	485.0
10 PEKALONGAN	11.0	49.5	73.8	315.1
11 KEBUMEN	26.0	52.8	168.4	296.1
12 SEMARANG	29.0	84.9	193.7	789.4
13 PURWODADI	15.4	30.9	44.7	105.0
14 YOGYAKARTA	27.7	67.1	379.4	588.1
15 SOLO	28.3	75.3	411.5	529.1
16 MADIUN	12.9	26.7	231.1	244.7
17 BOJONEGORO	12.6	25.3	52.7	221.5
18 SURABAYA	97.5	198.6	1,017.1	1,183.5
19 KERTOSONO	28.1	56.3	184.2	263.7
20 TULUNGAGUNG	18.8	37.6	156.2	337.2
21 BANGIL	6.9	13.8	35.2	64.4
22 MALANG	17.1	35.9	97.4	386.7
23 PROBOLINGGO	2.7	5.5	83.9	91.4
24 JEMBER	9.3	18.6	115.6	163.2
25 BANYUWANGI	10.9	21.9	123.8	182.8
Total	807.3	3,500.1	7,700.9	11,625.8
Ratio	1	4.3	9.5	14.4

For 100 km/h

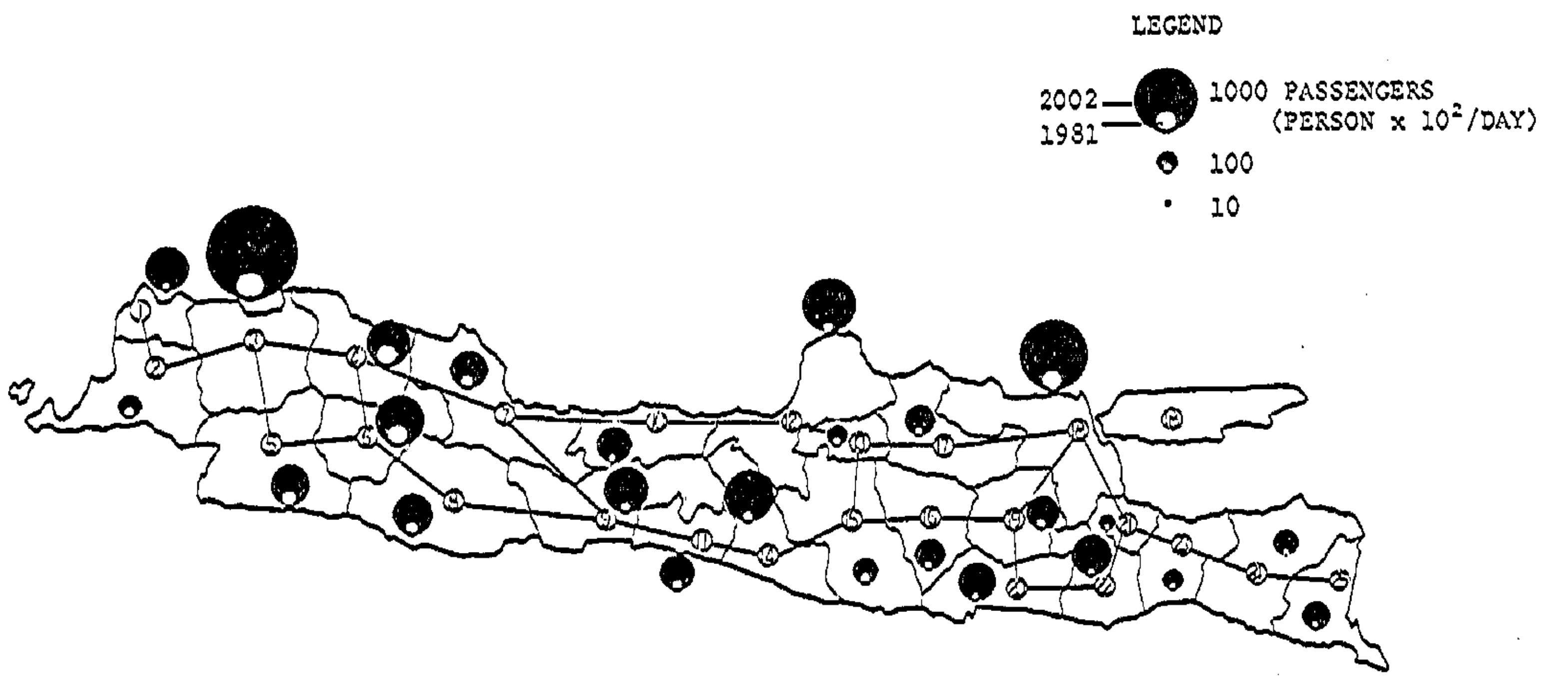


Fig. 7.2.1 Survey on Railway Boarding and Alighting Persons, by Area (A.D. 2002)

(2) Number of Trains

The number of electrified railway trains is as indicated in Figs. 7.2.2, 3 and 4 and the number of trains handled by the main stations is as follows:

Survey on Number of Trains, by Station (A.D. 2002)

Station	Departure or arrival passenger trains	Passing passenger trains	Freight trains	Total
MANGGARI	209	43	-	252
BANDUNG	28	53	5	86
KROYA	35	81	14	130
SEMARANG	80	31	9	120
SURABAYA-P	50	-	11	61
SURABAYA-K	149	-	26	175

The number of trains handled is largest with Manggarai (252), followed by Surabaya Kota (175).

(1989) Capacity adjustment completed WITH (100 KM/H)

( ): Number of freight trains/day

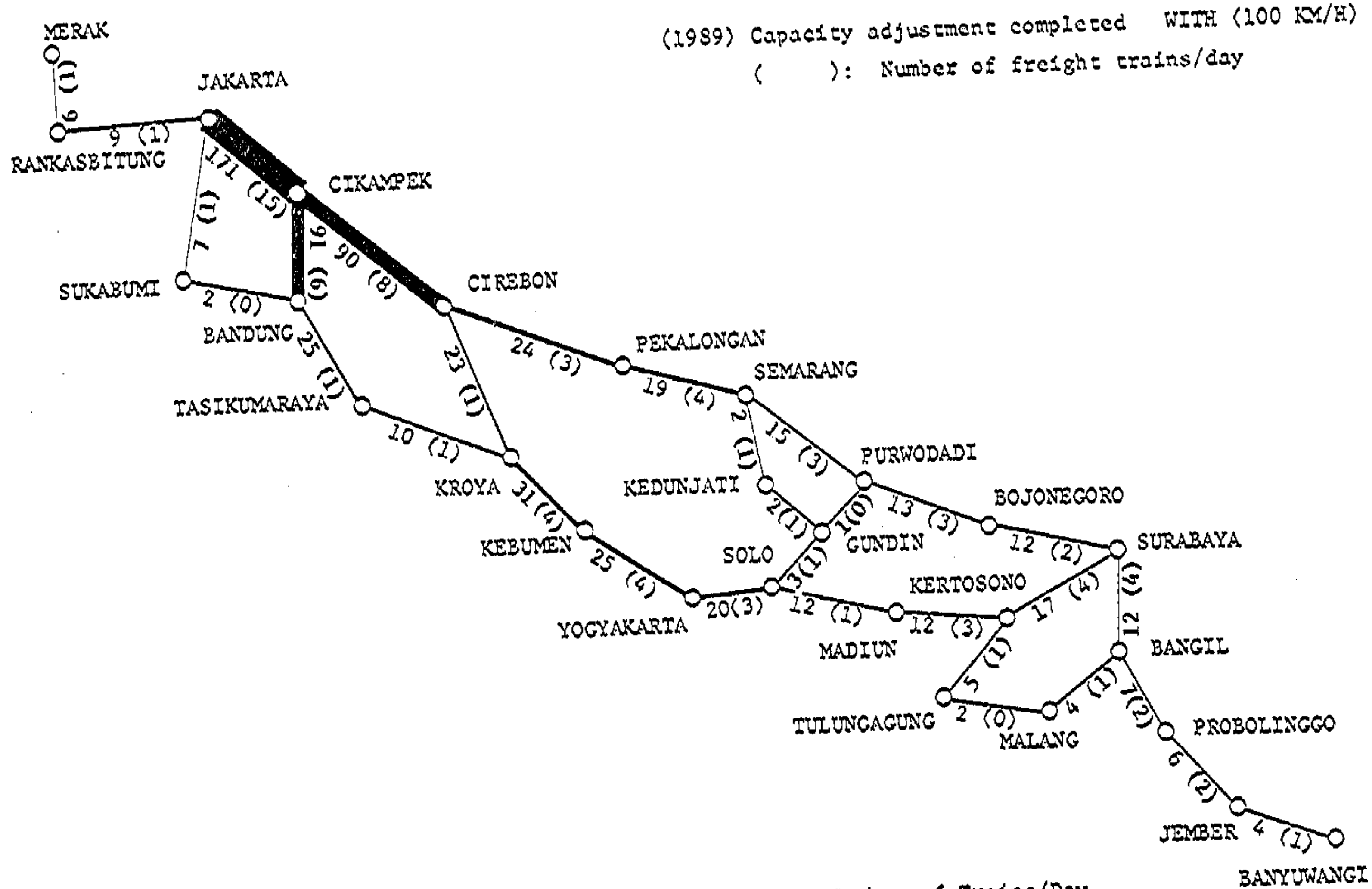


Fig. 7.2.2 Railway Link Traffic Volume — Total Number of Trains/Day

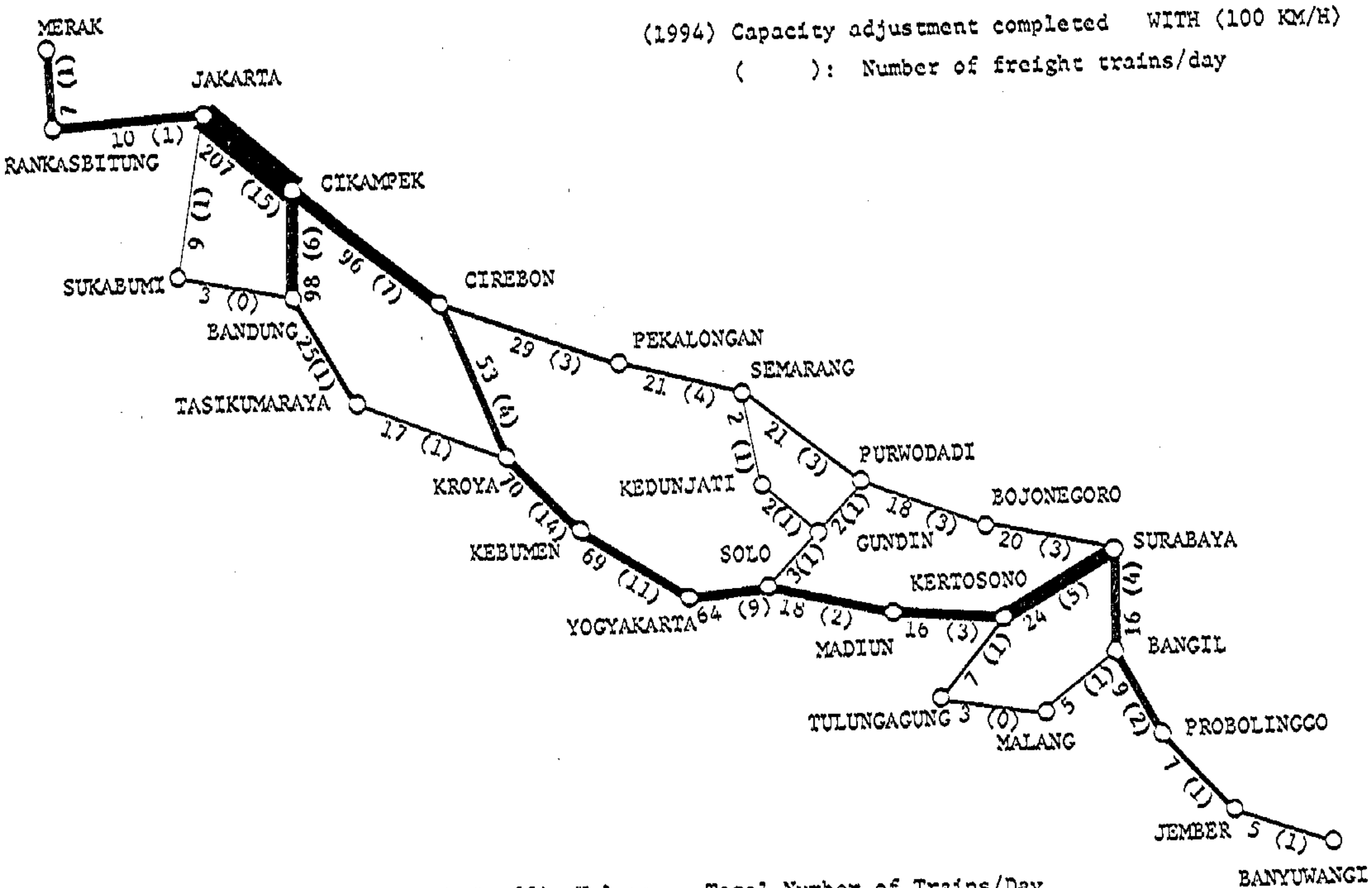


Fig. 7.2.3 Railway Link Traffic Volume — Total Number of Trains/Day

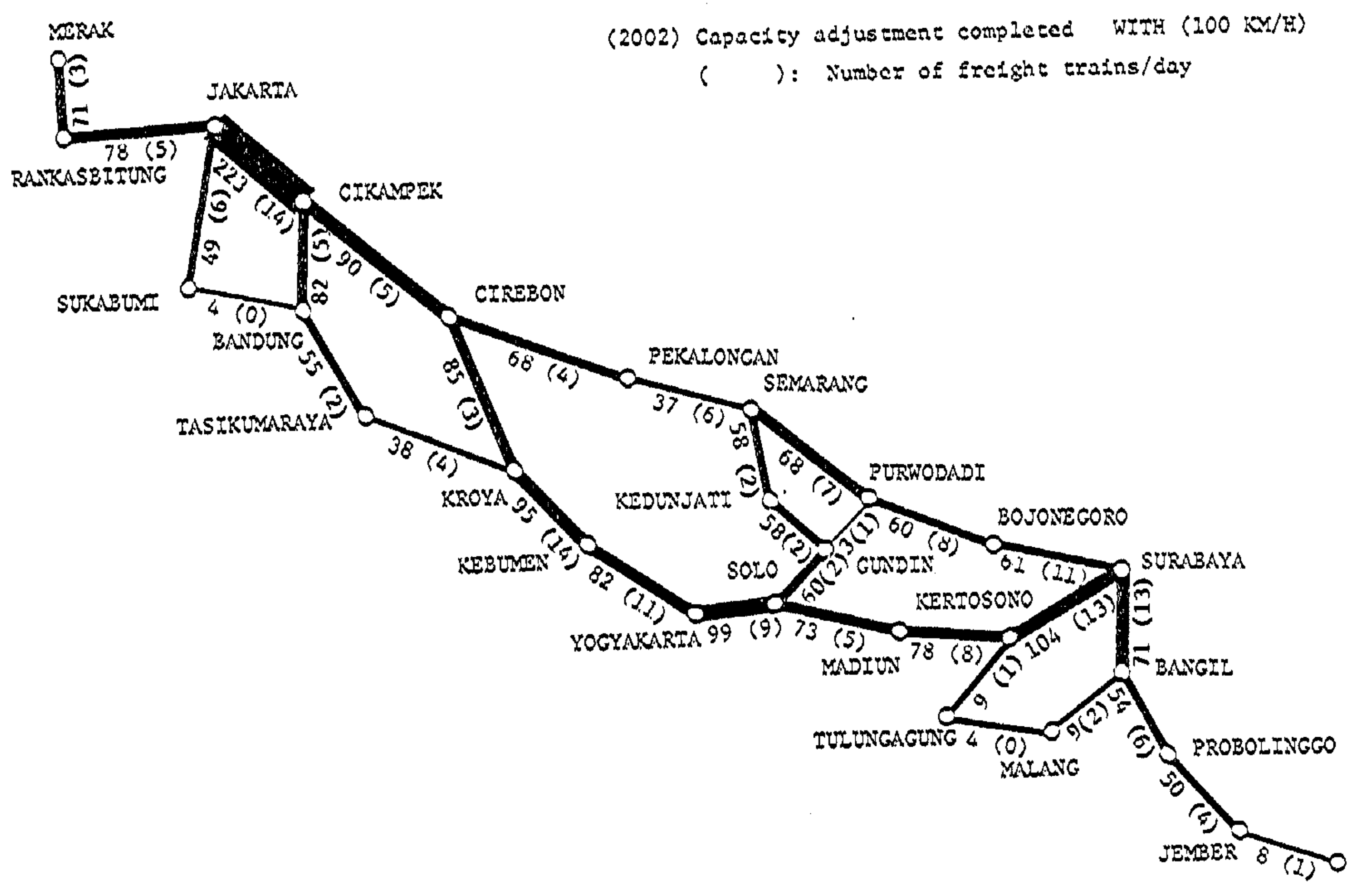


Fig. 7.2.4 Railway Link Traffic Volume — Total Number of Trains/Day

(3) Conception of Station Improvement

1) Basic Policy

a) As above, Manggarai will be the departure point for AC electrification.

b) Manggarai-Krawang will be an AC electrified double track section.

c) The existing passenger equipment will be used and the following will be added as a necessary minimum:

Effective length increase - Passenger train pass-by: 220 m
Effective length increase - Freight train pass-by : 460 m
Elevated platform construction:
To be provided at stations with starting trains.
Overbridge construction:
To be provided at stations with starting trains.

d) Plans for station main buildings, station plazas and railway crossings to cope with the increased handling of passengers are not included in this project. These facilities will be planned in accordance with future trends.

2) Station Improving Plan

a) Departure Stations in Jakarta Area

There is the JABOTAPEK improvement plan for Jakarta Area. Under this plan, the shift to electric train operation is being carried out by a circle route composition including the central, west and east lines so as to meet the transportation demands which will certainly increase in the future. Deciding on departure stations is particularly important in an electrification plan designed for the operation of medium- and long-distance trains and this must be studied after ascertaining the general trends of commuters and passengers in the Jakarta Area. But here, Manggarai Station was selected for reasons of easy connection to the JABOTAPEK Plan line, proximity to the heart of the city and a smaller construction cost, compared to the plan to use Jakarta as the starting station.