2.4 Rolling Stock

2.4.1 Design Concept of Rolling Stock

In deciding performance for the electric railcar and the diesel railcar, it is necessary to give consideration to enhance the merits of the railway that is fast, reliable, safe, comfortable, inexpensive, suitable for large volume transport, environment-friendly, etc., with introduction of up-to-date technology, in order to compete with intercity buses or private automobiles.

Major equipment and facilities of the electric railcar and diesel railcar to enhance the merit of railway are as follows.

(1) Electric railcar for commuter service and SBIA access

1) VVVF (Variable Voltage Variable Frequency) inverter traction motor control system

This is used for induction motor, by combining the system with a regenerative brake, it is possible to reduce power consumption much more than the conventional system. Furthermore, it ensure smooth motor control and reduce the maintenance cost because of few moving parts. It controls 4 traction motors (for motor car) with a control unit.

2) Induction motor

An induction motor is used for the traction motor. It is lighter (about a half per kw) and smaller compared with a DC motor and effective in reducing weight of a railcar and maintenance work because of no commutator and brush.

3) Bolsterless bogie

By using bolsterless bogies, maintenance is made easier because of the simplification of the bogie structure, and each car is made lighter by approximately 1 ton per bogie.

4) TIS (Train Information System)

The linkage of microcomputers in the VVVF control, brake control and ATS-P equipment can promptly displaying the driver's cab any Equipment irregularities. Consequently this leads to easier inspection, efficient maintenance work and greater safety.

(2) Diesel railcar for intercity express service

1) Motive power

By combining the powerful diesel engine with the two stage direct drive torque converter, it can be produced high speed and high acceleration.

2) Passenger equipment

The passenger room is very comfortable with the large size double-pane window to ensure good lighting and silence space and reclining seats for riding relaxedly and the airconditioner which performs the most advanced control using microcomputer to provide passengers with sensitive service. A lavatory equipped with circulation type excreta disposer is arranged on every other coach. Furthermore, the telephone for communicating with subscribers on the ground.

2.4.2 Principal Specification

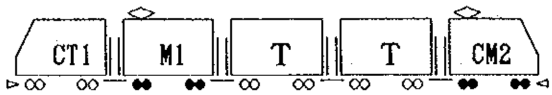
(1) Electric railcars

1) Type of car : Unpainted light stainless steel body

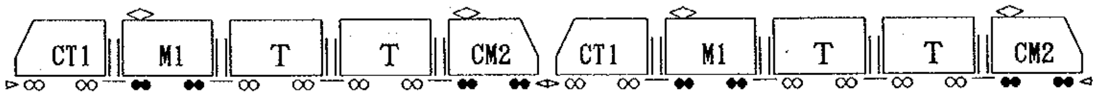
2) Train formation :

The basic composition of the train is 5-cars (2M3T), however it can be varied from 2-cars (1M1T) 3-cars (2M1T) to 10-cars (4M6T) or more, according to passenger transport demand. The following are examples of a 5-car composition and a 10-car composition.

5-car composition (2M3T)



10-car composition (4M6T)



Remarks <> --- Pantograph | --- Gangway sliding door

• --- Driving wheel — --- Semi-permanent type coupler

▹ --- Tight lock coupler (with electric coupler)

3) Track condition : Gauge 1,000 mm

4) Electric power supply : AC. 25 KV , Single phase , 50Hz

5) Principal dimension :

Max. dimension --- 22,700mm (Length) × 2,800mm (Width) × 4,050mm (Height)

(Height : When pantograph is folded)

Height of floor --- 1,100 mm (Step height of side door is 800mm)

Distance between bogie centers --- 16 m

Wheel base --- 2.1 m

6) Number of doors : 4 (The total of entrance doors at each side wall is 4)

7) Seats : Longitudinal type-seats

8) Passenger capacity : Head car 160 (Standing 106, Seating 54)

Middle car 176 (Standing 112, Seating 64)

9) Performance : Acceleration --- 3.0 km/h/sec

Deceleration --- 3.5 km/h/sec (Service)

4.5 km/h/sec (Emergency)

Max. operating speed (on service) --- 120 Km/h

10) Bogie : Bolster-less air spring bogie, with unit type foundation brake rigging

11) Traction motor : 180 Kw (continuous rating) × 4 , 3 phase induction motor

12) Control system : VVVF (Variable Voltage Variable Frequency) inverter

13) Brake system : Electric command regenerative brake combined with pneumatic brake
AC. motor drive compressor

14) Auxiliary power source : Static inverter
Alkaline battery

15) Door engine : Single cylinder double acting door engine
Belt linked dual motion mechanism
Width of the door opening -- 1,300 mm

16) Lighting equipment : Interior light --- AC fluorescent light (40W) and DC inverter-fluorescent light for emergency (40W)
Head light --- Sealed beam (150W/150W)
Tail light, car side pilot lamp for door close indication and emergency warning --- LED

17) Ventilation : 8 cm line flow fan

18) Air conditioner : 42,000 Kcal/car

19) Safety system : ATS-P
Train radio --- Air wave radio

20) Destination display : Automatic package setting by display setter

21) Station display : Automatic character display with LED
(With ringing of chime at door operation)

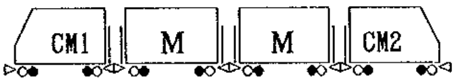
22) TIS (Train Information System)

(2) Diesel railcars

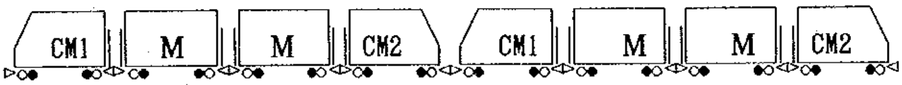
1) Type of car : Unpainted light stainless steel body

2) Train formation :
The basic composition of the train is 4-cars (4M), however can be varied 2-cars (2M) to 8-cars (8M) or more, according to passenger transport demand. The following are examples of a 4-car composition and an 8-car composition.

4-car composition



8-car composition



Remarks　　| --- Gangway sliding door

▷ --- Tight lock coupler

● --- Driving wheel

3) Track condition : Gauge 1,000 mm

4) Principal dimension :

Max. dimension --- 22,700mm (Length) × 2,800mm (Width) × 3,785mm (Height)

Height of floor --- 1,100 mm (Step height of side door is 800mm,500mm)

Distance between bogie centers --- 16 m

Wheel base --- 2.1 m

5) Number of doors : 2 (The total of entrance doors at each side wall is 2)

6) Seats : Reversed , Reclining seats

7) Passenger capacity : Head car 64 (Seating)

Middle car 72 (Seating)

8) Performance : Acceleration --- 2.0 km/h/sec

Deceleration --- 3.5 km/h/sec (Service)

4.5 km/h/sec (Emergency)

Max. operating speed (on service) --- 120 Km/h

9) Bogie : Bolster-less air spring bogie, with unit type foundation brake rigging

10) Diesel engine : 350 PS × 2

11) Brake system : Dynamic brake combined with pneumatic brake

12) Lighting equipment : Interior light --- AC. fluorescent light (40W) and DC inverter fluorescent light for emergency (40W)

Head light --- Sealed beam (150W/150W)

Tail light, car side pilot lamp for door close indication and emergency warning --- LED

13) Ventilation : 8 cm line flow fan

14) Air conditioner : 38,000 Kcal/car

15) Safety system : ATS-P

Train radio --- Air wave radio

(Only Commuter service Section)

16) Destination display : Automatic package setting by display setter

17) Toilet

18) Public telephone

2.4.3 Railcar Procurement Plan

The necessary number of railcars is estimated based on the demand forecast of the passenger and transport plan and is shown in Table 2.4.1.

Table 2.4.1 Railcar Procurement Plan

Kind of railcars ＼ Year	1998	2001	2006	2010
Electric railcars for commuter service	—	62	129	160
Diesel railcars for intercity express service	20	40	56	72

2.5 Station

2.5.1 Station Facilities

(1) Basic policy to improve station facilities

The existing station facilities are not for urban transport but for trunk line transport of not so high density. For the proposed commuter transport of high speed and high frequency with a large number of passengers, the target section between Yommarat and Chachoengsao will require innovative up-to-date station facilities.

The other MRT projects in the Bangkok Metropolis ongoing at present such as the Hopewell Project, Tanayong Project and Sky Train Project will have high-grade facilities of the newest standard. Therefore, the SRT improvement project will not be able to avoid having high-grade facilities to manage as expected and must not be an extension of the existing line.

Transport service can not live without patronage. Therefore, integrated urban development which creates customers is essential and a convenient interface between railway and urban development should be prepared. The plan for a station plaza and interface with access means are described in "2.10".

Noteworthy items concerning station facilities are as follows:

i) Elevated platform

The existing platforms of the SRT are not elevated and at most stations installed only along the track just nearby the station main building. With on such low platforms, the following problems occur.

- Passengers enter tracks easily. This is very dangerous especially in the case of the proposed train operation of high speed and high frequency.

- Passengers are forced to get on/off coaches via steep two-step stairs, about one meter in height. This is dangerous and prevents a large volume of commuting passengers from getting on/off smoothly..

- Requirements of such two-step stairs make it impossible to design electric railcars of multiple wide doors because of the interference with bogie trucks. This prevents providing appropriate commuter transport electric railcars.

- Passengers can easily enter/leave station areas without their tickets being checked. This affects the earnings of the project, making it difficult to manage.

Taking into account those situations, elevated platforms are proposed in the section for commuter service.

It is best that the height of the platform is the same as the height of the floor of the cars. However, in the case of SRT lines, along the improved platforms the existing coaches (which are equipped with two-step stairs and whose doors are impossible to be shut and locked) will still be operated. The height of elevated platforms is proposed to be 50cm from the rail level (about 65cm from the ballast level) the same as the height of the first (lower) steps of the existing coaches, because if higher, both the second (upper) steps and platforms are higher than the first steps, which affects of getting on/off smoothly, and passengers who ride outside the coaches on the first steps hit the platforms. Thus electric railcars for commuter service are forced to install one-step stairs, which allows multiple wide doors. Getting on/off through one-step stairs is much better than through two-step stairs.

The height of platforms along which only the commuter electric railcars proposed in this Study passes/stops will be 80cm because there are none of the problems mentioned above and they are better for getting on/off the electric railcars.

Efforts to raise the height of the platform for commuter service up to the height of the car floor (1,100㎜) should be continued, and in designing electric railcars the height of the entrance should be high enough to get on/off from/to such raised platforms.

ii) Overbridge

Now passengers who move among platforms and a station entrance cross tracks at any place because of the low platforms. This is very dangerous at stations on lines with high speed and high frequency train operation such as the proposed commuter service. For this reason and other related reasons elevated platforms are proposed and this requires over-bridges (underpasses) or at grade-crossings for passengers to cross the tracks.

Thus an overbridge at each station for the commuter service is proposed. At some stations, especially stations around which strategic urban developments are executed, overbridges combined with station offices and concourses will be proposed.

iii) Ticketing system and fences

Sure acquisition of fares is essential for the railway management and to return the investment. Checking only in the train is carried out at present but this system can not collect fares with certainty and requires too many conductors to deal with a large volume of commuter passengers. Therefore, for the proposed commuter service, ticketing system at stations and limiting entering/getting off the stations with ticket barriers with fencing is recommended. Automatic ticketing system and automatic ticket barriers will be installed.

iv) Convenient and comfortable station building

A station building is a contact point between a railway and a city area. It must attract people and make them want to use the railway. A station should be a place/spot where people gather not only for getting on/off trains, but also for multiple daily purposes.

According to conditions of location and the scale of a station, a commercial complex or a convenience store, coffee shop and others will be prepared at/around the station.

v) Elevators and/or escalators

Elevators and/or escalators should preferably be provided. However, they require so much costs. Therefore, taking into account the number of passengers, role of the station and balance with return of investment installation will be proposed at stations in centers of strategical development and related closely to the SBIA access service (Yommarat, Makkasan, Hua Mak, Lat Krabang [for transferring], SBIA NT).

In the future, these services will become more necessary as a social requirement, and increase of demand will bring room to make investments. Therefore, it is preferable to keep the possibility of installing them open within the extent of a slight prior investment. If overall installation is required as a social welfare measure, it should be executed by another budget category than transport.

vi) Station front plaza and interface with access means

A station front plaza and interface with access means in the plaza are important items to connect both an urban area and a railway. (cf. 2. 10)

Among these items, at stations of the CBD side for SBIA access service, Yommarat and Makkasan, convenient porches for a station building for secondary access by private automobiles and taxis are necessary, because airport passengers, especially international passengers have large baggage and use railway access only in a radial direction instead of traveling a long way on a congested road and finally use automobiles from/to their doors.

(2) Possibility of future expansion

Fortunately the SRT lines in the study area (Hua Mak - Map Ta Phut) have a broad right-of-way of 40m (more in station areas), which enables them to provide 4 or more tracks between stations and 6 tracks and 2 island-type platforms at stations easily without acquiring additional land. That is, it is easy to expand capacity from that proposed in this Study targeting the year 2010. Therefore, to plan facilities keeping the possibility/room for future expansion is essential. Especially, extension of platforms to the length of 15 cars and track-quadrupling between Hua Mak and Chachoengsao will come after as the next projects. As for reinforcement of freight transport, increase of refuge tracks and crossing loops will be executed easily at any place avoiding at-grade crossings with roads and gradient sections.

(3) Design standard for station facilities

Design standard for station facilities is as follows:

i) Effective length of tracks

530m (Train length-500m including room and visibility for signal)

360m (Tracks used only for commuter service; train length-340m, including room and visibility for signal)

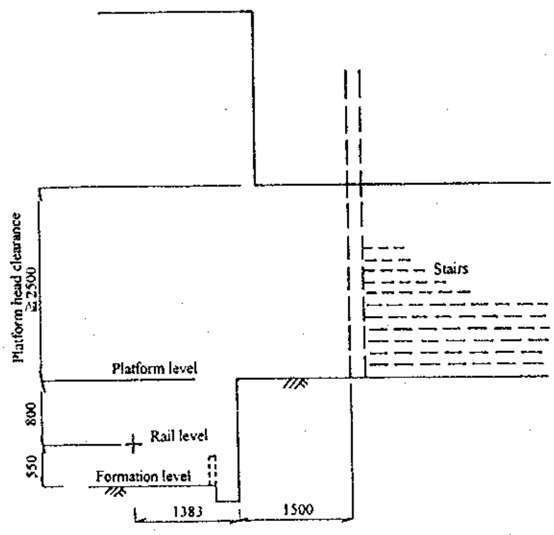


Fig. 2.5.1 Platform for Electric Railcars

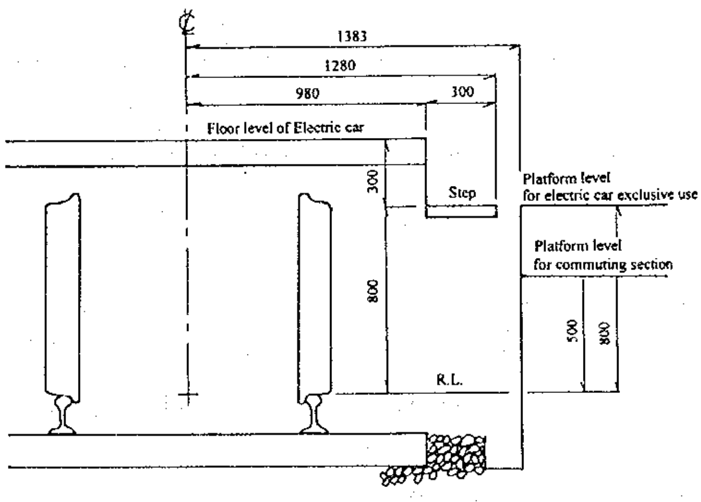


Fig. 2.5.2(1) Relation Between Ordinary Passenger Coaches and the Platforms

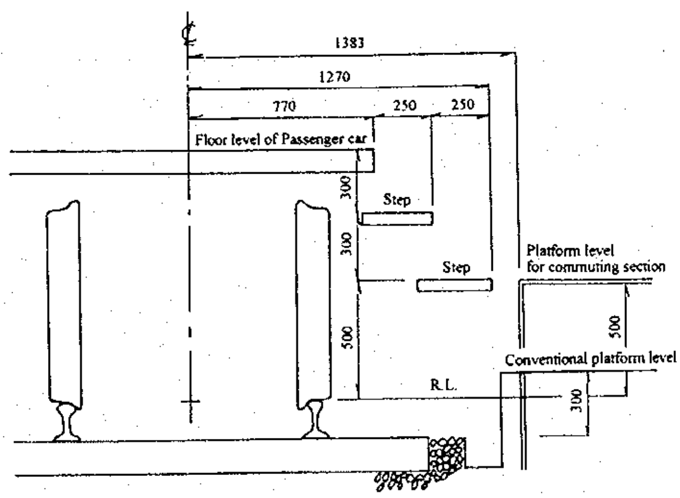


Fig. 2.5.2(2) Relation Between Electric Railcars and the Platforms

250m (Taking into consideration only the necessities within the project life; train length-230m, including room and visibility for signal)

ii) Length of platforms

240m (Taking into consideration future possibility of 350m)

iii) Safety allowance for over running

200m

vi) Minimum width of platforms

2m (Both side use)

1.5m (One side use)

The practical width of platforms are to be decided taking into account the future possibility of demand increase beyond the target year 2010 because of the difficulty of expanding especially at those with both-side use. In this regard for platforms of both-side use at the center of strategic urban development, therefore, 8m is proposed.

v) Height of platforms

0.50m (Within the section of commuter service)

0.80m (Platforms along which only electric railcars pass/stop)

vi) Distance between tracks (Within station areas)

5.0m

4.0m (At stations with elevated platforms because passengers are not permitted to get on/off from/to the ground between the tracks; except one of the adjacent spaces between tracks)

2.5.2 Station Track Layout

Policy of station track layout is explained as follows:

i) Hua Mak East - Chachoengsao

This section will have been double-tracked by the ongoing SRT project. Based on the transport plan, sufficient refuge tracks for rapid-local-combining operation and operation of faster intercity express/commuter trains and slower freight trains are required.

A depot and workshop for commuter electric railcars are to be provided at Khlong Luang Phaeng.

ii) Chachoengsao - Map Ta Phut

Between Chachoengsao and Si Racha requires reinforcement of capacity for intercity express service and expected freight demand is required.

Additional crossing loops and refuge tracks are proposed. Location of these loops are to be decided taking into consideration further addition of crossing loops.

Between Si Racha and Map Ta Phut, expected freight demand will not be so much, and a refuge track as a counter measure for confused train operation is proposed.

These operation plans and station track layout based on the transport plan are planned on the basis of the existing signalling system. If an automatic block signalling system which allows successive train operation is introduced, capacity will be increased without any improvement of track facilities. Station track layouts of each station are shown in Fig.2.5.3 - Fig.2.5.10.

In the 8th National Economic Plan double-tracking between Chachoengsao and Si Racha will be adopted and is expected to be completed shortly after the year 2000. It would be very convenient for raising the service level for both intercity express and freight.

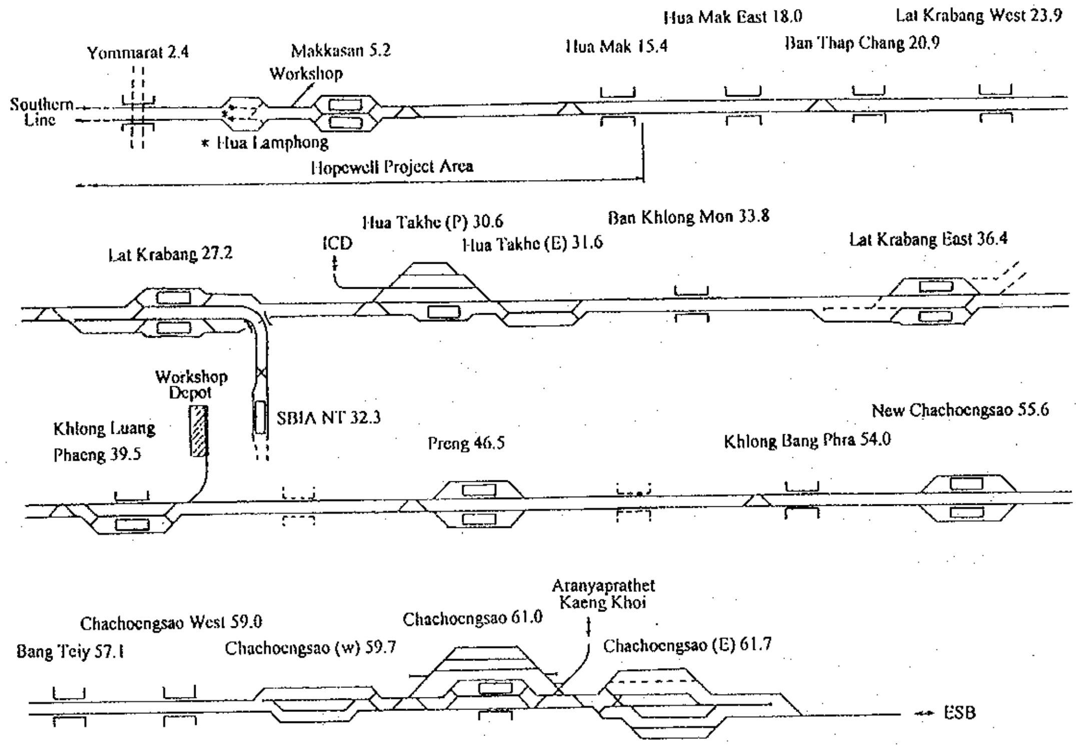


Fig. 2.5.3 Station Track Layout (Yommarat - Chachoengsao)

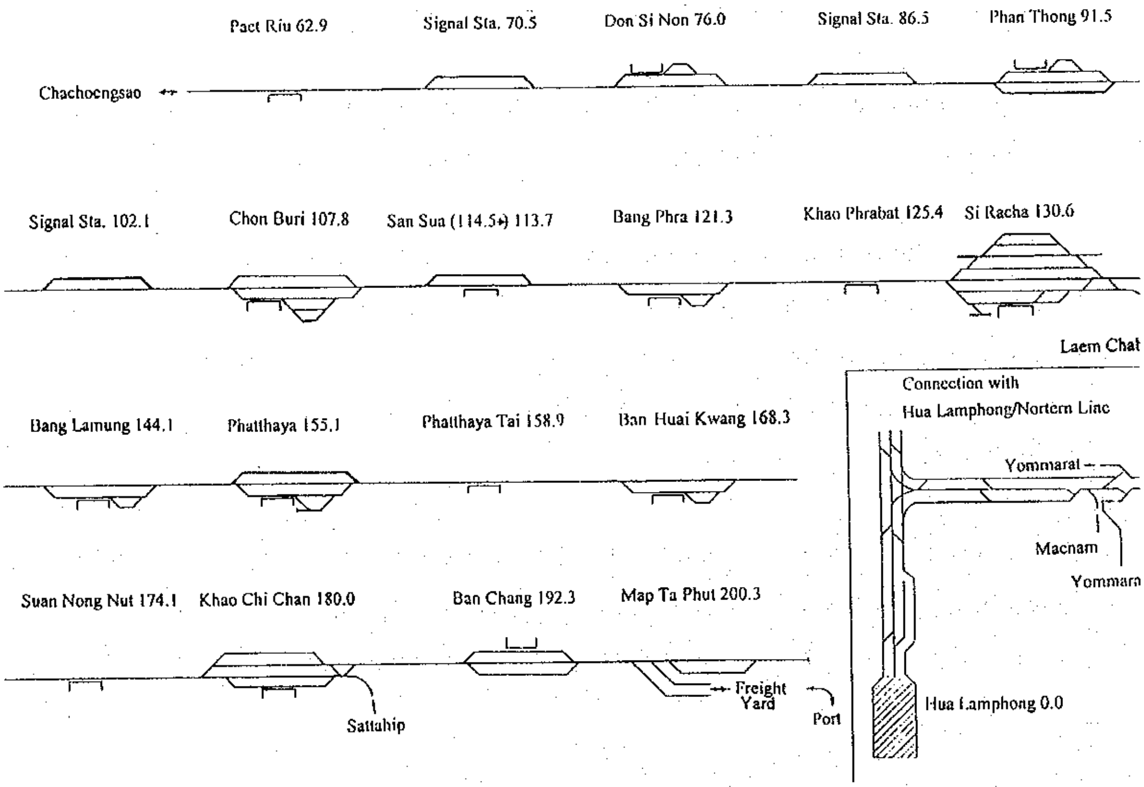


Fig. 2.5.4 Station Track Layout (Chachoengsao - Map Ta Phut)

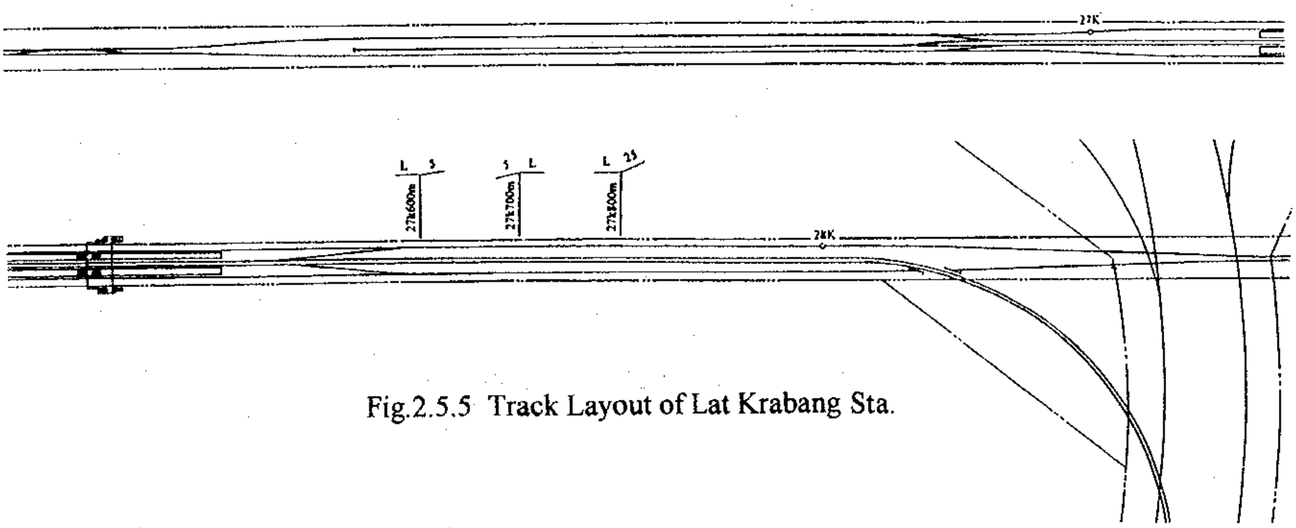


Fig.2.5.5 Track Layout of Lat Krabang Sta.

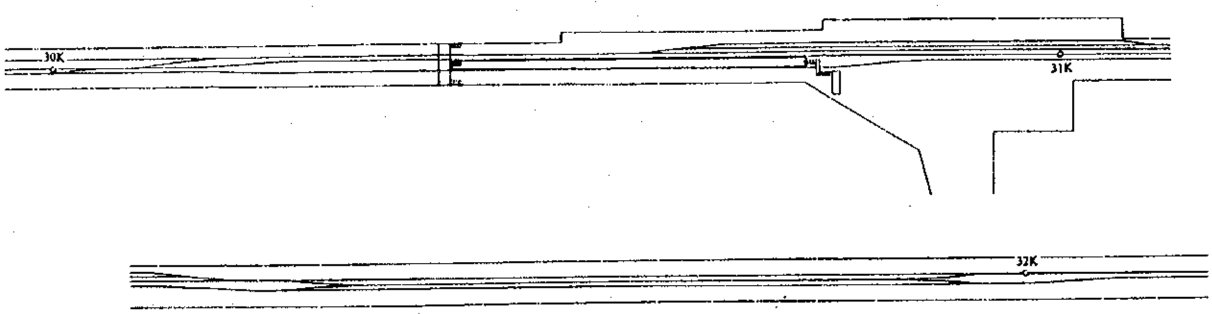


Fig.2.5.6 Track Layout of Hua Takhe Sta.

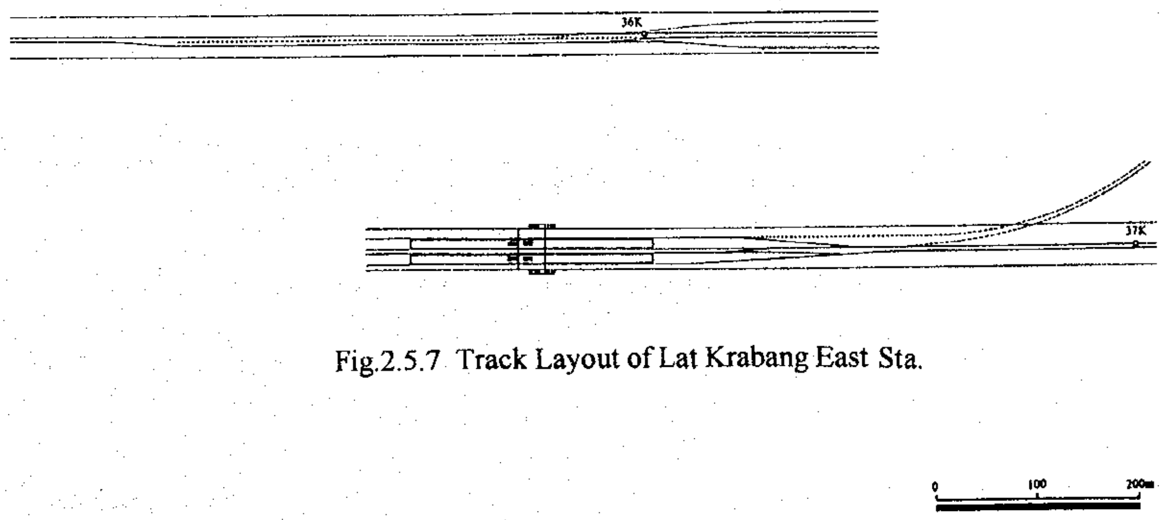


Fig.2.5.7 Track Layout of Lat Krabang East Sta.

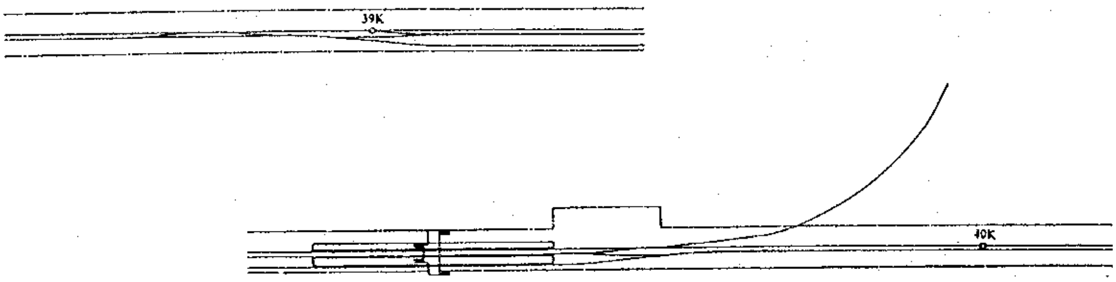


Fig.2.5.8 Track Layout of Khlong Luang Phaeng Sta.

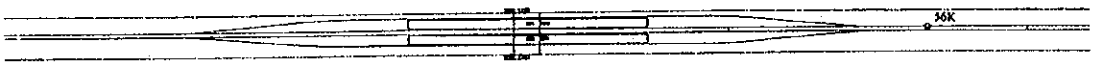


Fig 2.5.9 Track Layout of New Chachoengsao Sta.

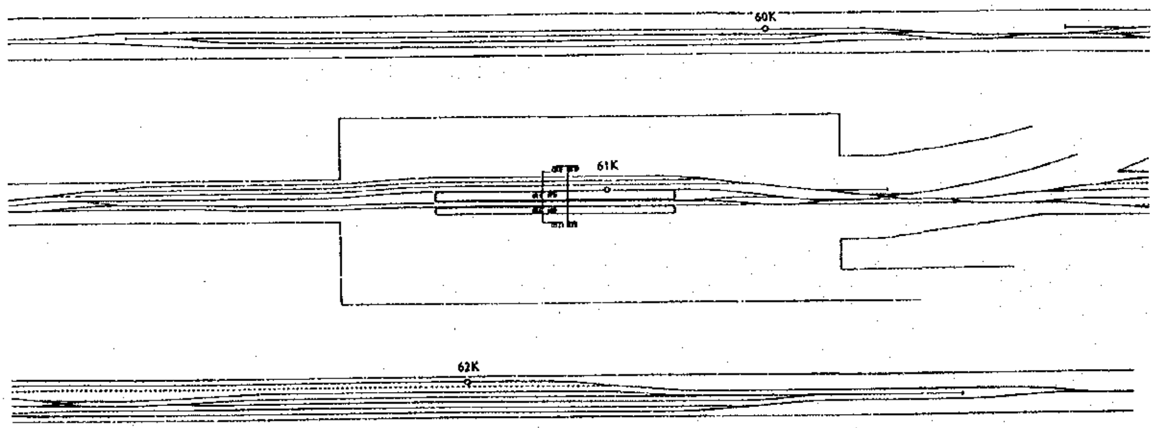
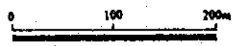


Fig.2.5.10 Track Layout of Chachoengsao Sta.



2.6 Track and Structure

2.6.1 Standards for Track and Structure

The standards for tracks and structures are as follows;

1) Gauge		: 1,000mm
2) Minimum curve radius		: 400m
		: 300m (special case)
3) Maximum gradient		: 10 ‰
		: 25 ‰ (for exclusive use of electric railcar)
4) Distance between track center		: 4m (out of station area)
5) Rail		: 50kg/m long welded rail
6) Sleeper		: Monoblock PC sleeper 60 cm pitch
7) Ballast depth		: 25cm
8) Turnout	main track	: 1:12 simple, manganese steel frog
	side track	: 1:10
	depot	: 1:8
9) Effective track length		: 530m
		: 360m (for exclusive use of electric railcar)
10) Platform length		: 240m (1st stage)
		: 350m (in future)
11) Platform width in general		: 8m (use both sides)
		: 4m (use one side)
12) Platform height from rail surface		: 800mm (for exclusive use of electric railcar)
		: 500m (others for commuter service)
13) Design live load		: 20 ton/axle (U-20)
		: 15 ton/axle (for exclusive use of electric/diesel railcar)
14) Maximum cant		: 90mm
15) Allowable cant deficiency		: 50mm.

The construction gauge and loading profile are shown in Fig. 2.6.1
The standard sections of an elevated bridge and a side wall bank are shown in Fig. 2.6.2.

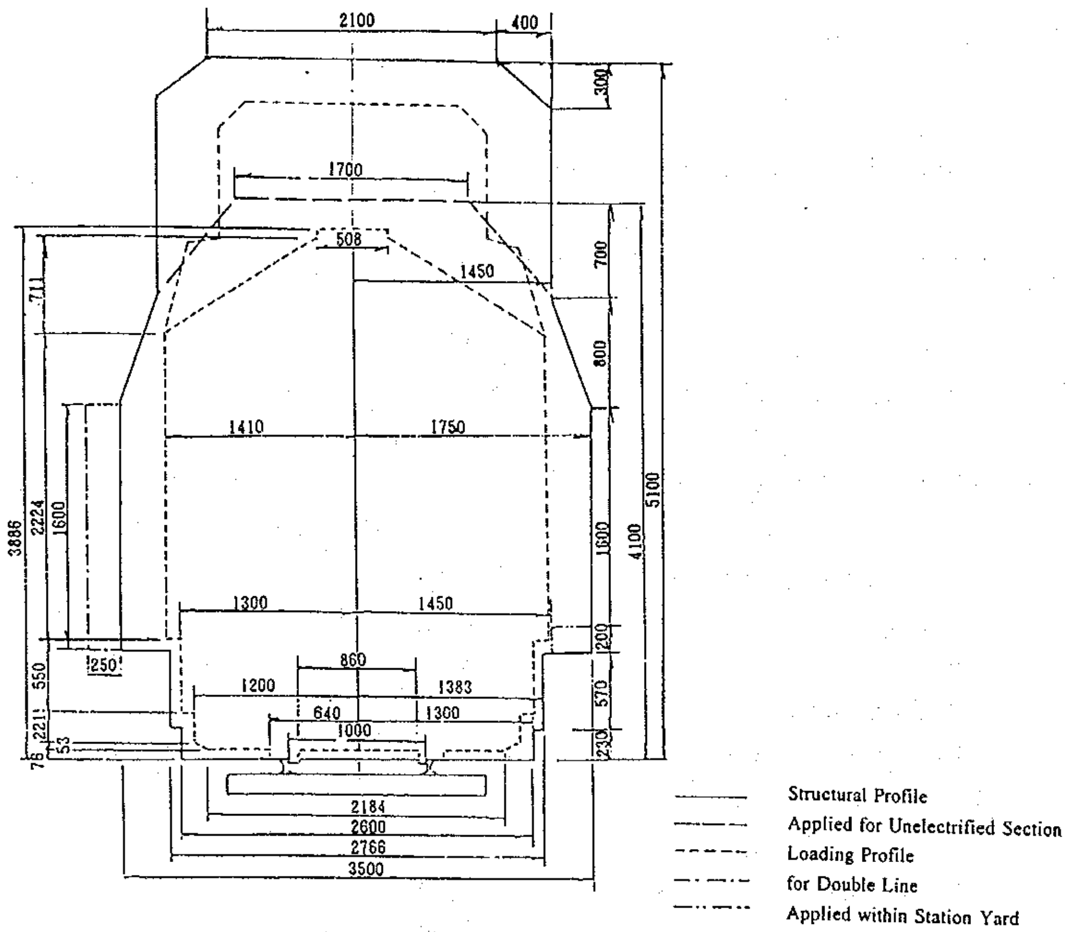
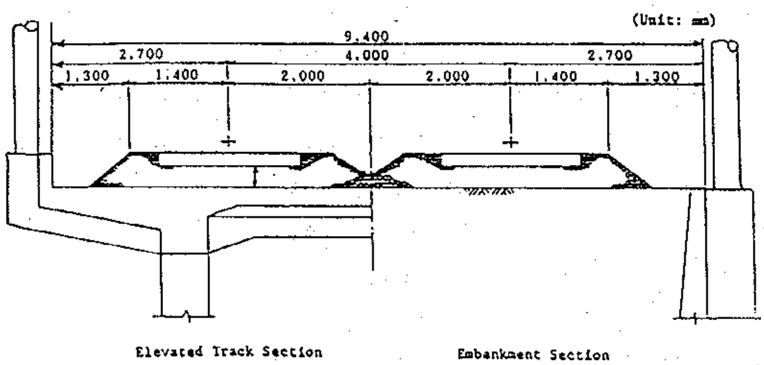


Fig. 2.6.1 Construction Gauge



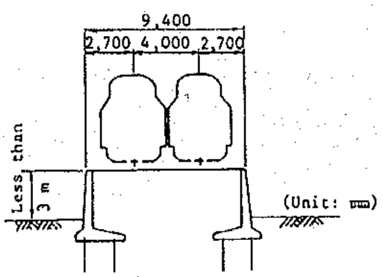


Fig. 2.6.2 Standard Sections of Elevated Bridge and Side Wall Bank

2.6.2 Eastern Line Commuter Service Section

The track sketch of the Eastern Line commuter service section is shown in Fig. 2.6.3.

From Yommarat to Hua Mak, new elevated double track will be the constructed by Hopewell Project. Between Hua Mak to Chachoengsao, reconstruction of 20 bridges into new ones by the SRT is ongoing. The double tracking project between Hua Mak and Chachoengsao by the SRT is also ongoing. The double tracking projects planned by the SRT and Hopewell are to be completed by the year 2000.

After those construction works, the structures will be strong enough to operate commuter trains. Some track improvement will be necessary for the existing track according to the standard described in 2.6.1.

2.6.3 SBIA Branch Line

The SBIA Branch Line will branch at Lat Krabang station with a double track. The line will cross over the Eastern Line with an elevated bridge, and will retain its height until the edge of the airport area. The highway approach to SBIA will cross over the SRT main line and branch line. At the airport terminal building, an SRT station will be constructed underground.

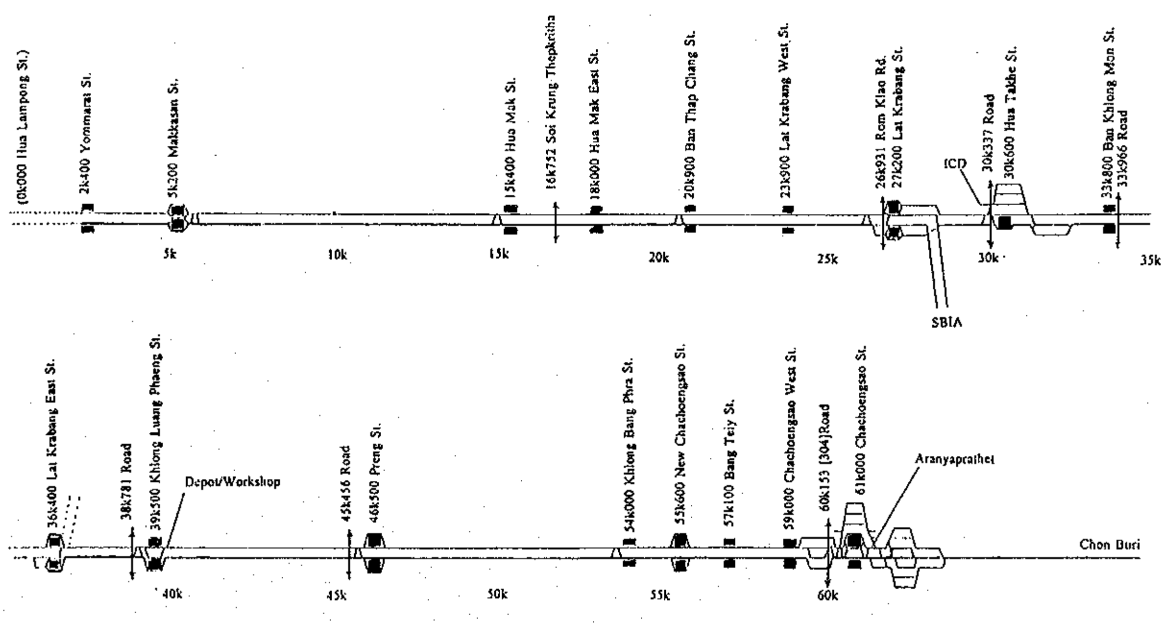


Fig. 2.6.3 Track Sketch of the Eastern Line Commuter Service Section

The profile of the SBIA Branch Line is shown in Fig. 2.6.4. The cross section of underground box is shown in Fig. 2.6.5.

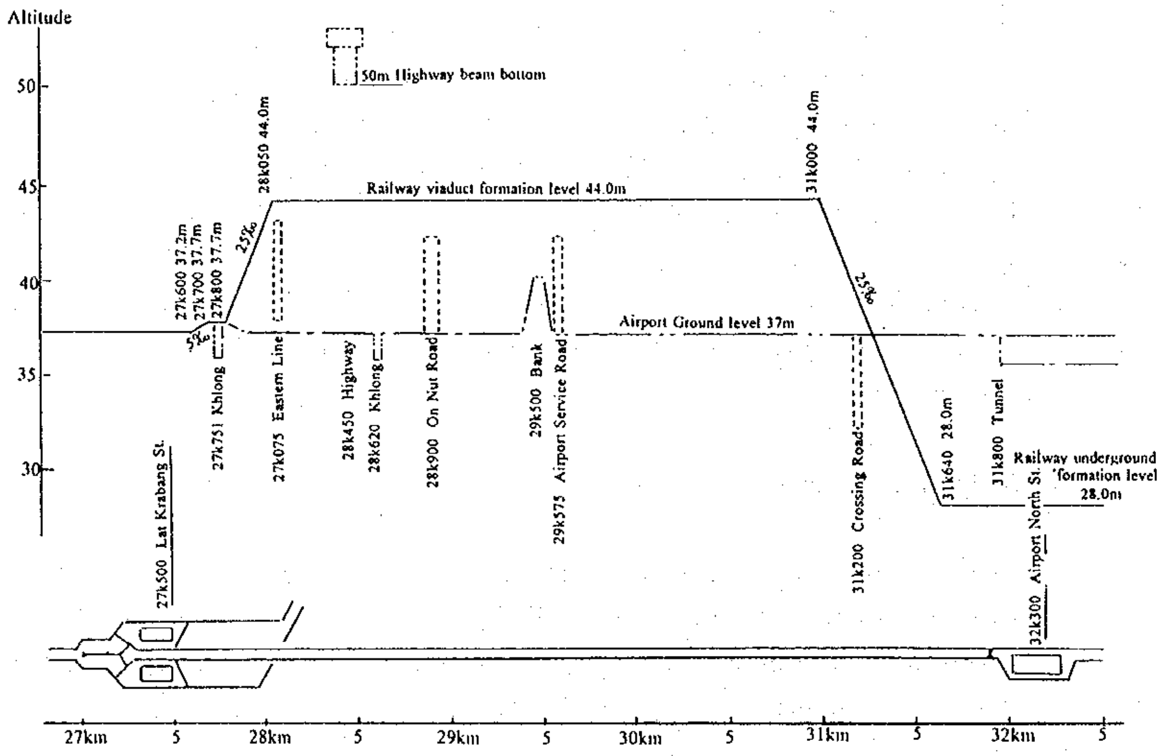


Fig. 2.6.4 SBIA Branch Line Profile

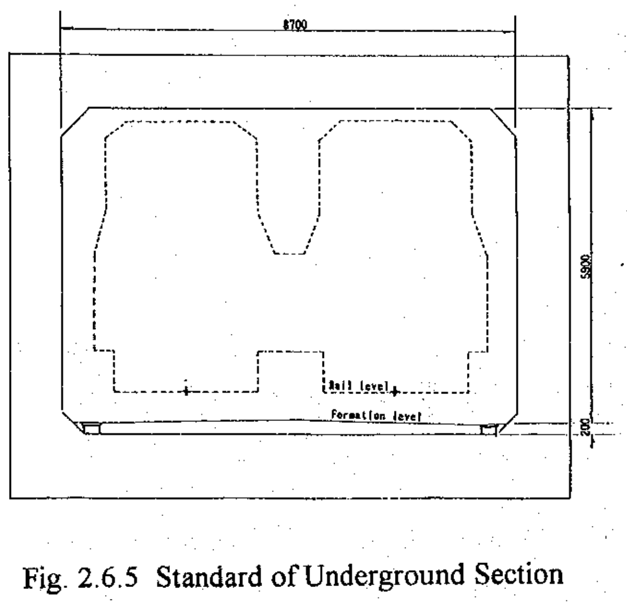


Fig. 2.6.5 Standard of Underground Section

2.7. Signalling and Telecommunication

The Hopewell Project's Eastern line section (Yommarat ~Hua Mak) and the Eastern Line Track Doubling Project by SRT (Hua Mak ~ Chachoengsao) will be completed by 1998, and will adopt the advanced signalling and telecommunications systems, i.e. the PCM transmission system using optical fibre cables, the CTC system, the all relay interlocking system with bi-directional operation function and the automatic block signals.

On the premise of the completion of these two projects mentioned above, some further improvements of the signalling and telecommunications systems necessary for AC electrification, high speed, high traffic density operation in this project are proposed as follows.

2.7.1 Signalling

(1) Improvement of DC track circuits for AC electrification

Composition of traction current return circuits are required for the proposed AC electrification between Yommarat and Chachoengsao station in this project.

AC-immune type DC track circuits have been adopted by SRT in the past resignalling projects, therefore, only slight improvements are required for composing the traction current return circuits as follows.

The existing double rail type DC track circuits will be changed to single rail type DC track circuits by removing rail insulators of the common rail and electrically connecting by rail bonds as shown in Fig.2.7.1.

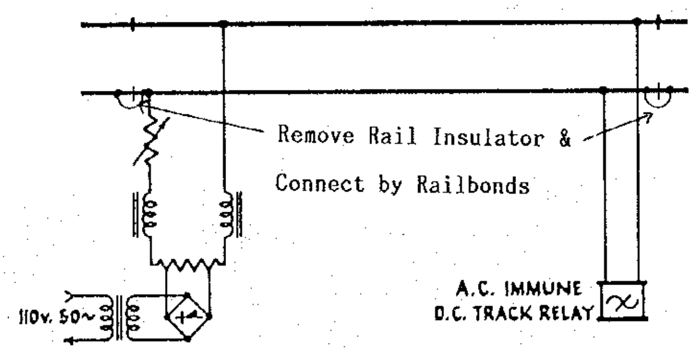


Fig. 2.7.1 Change Over from Double Type to Single Type DC Track Circuit

The AC-immune function of these single rail DC track circuits will have to be assured by an examination in a condition of flowing actual traction currents when AC electrification is completed. In order to assure the safety of maintenance work, especially to avoid generating dangerous voltages if the rail composing a traction return circuit is broken by failure or by necessity for maintenance work, any traction return circuits must have double routes. Therefore, traction current return circuits of Up and Down tracks should be connected electrically with each other by cross bonds at least at approximately 1 km intervals, and also be connected with a Negative Feeder at approximately 5km intervals along the tracks, as shown in Fig.2.7.2. However, as a result of this loop circuit composition in such short intervals, the function of the rail- breakage detection function of the track circuit will have to be abandoned.

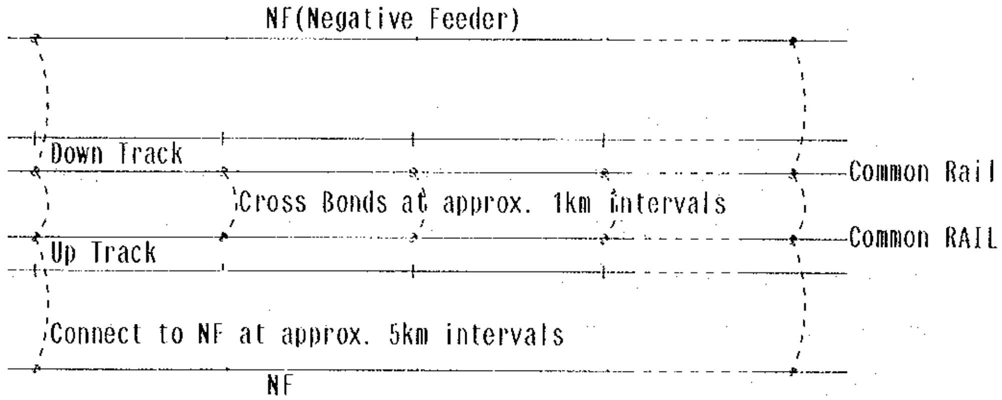


Fig.2.7.2 Cross Bonds between Up and Down Tracks and NF

In the case of maintenance work accompanying rail cutting off, it is necessary to connect the rails electrically in advance to avoid generating dangerous AC voltages between both rail ends, as shown in Fig.2.7.3.

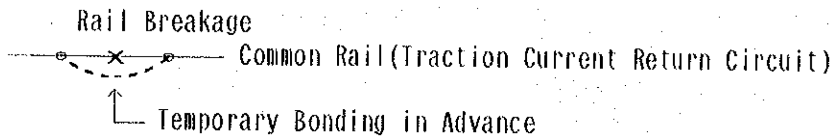


Fig. 2.7.3 Temporary Bonding before Rail Breakage Work

(2) ATS-P system

ATS-P wayside systems will be installed between Yommarat and Chachoengsao and newly introduced rolling stock in this project, i.e. electric railcars and diesel railcars will carry ATS-P cab systems.

Fig.2.7.5 shows the ATS-P whole system constitution. Wayside information such as signal aspect conditions, after being processed by a code processor, are transmitted via a repeater and a ground coil to the cab coil of a passing train. Then the receiver of the train generates a "speed pattern" according to the information from the wayside, and hands it over to the controller which control the train speed. Train information such as the train number, which is necessary for train operation, are transmitted to wayside code processors.

a. Frequencies for ATS-P System

ATS-P system uses 3 frequencies, i.e. 1.7MHz for cab-to-ground information, 3.0MHz for ground-to-cab information, and 245kHz for power transmission, and adopting the FSK (Frequency Shift Keying) modulation method, transmits the information at the speed of 64bit/s, as shown in Fig.2.7.4.

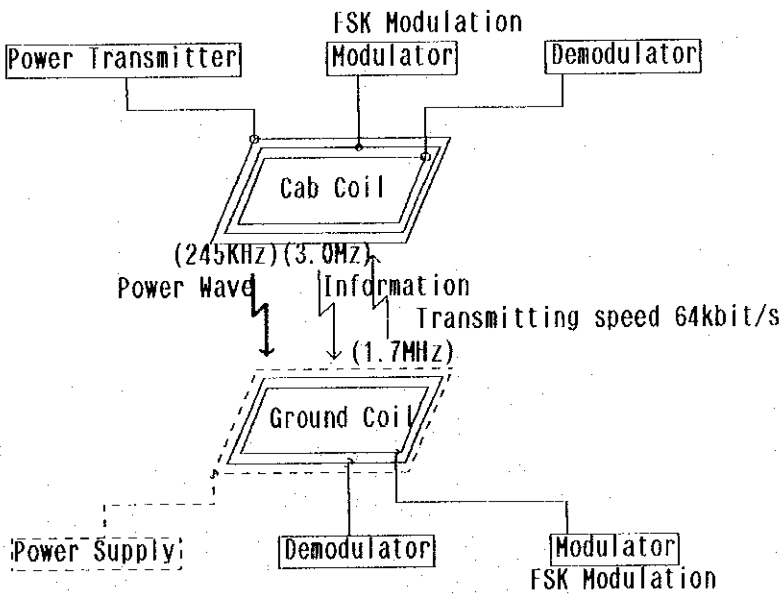


Fig.2.7.4 Transmitting Frequencies between Cab and Ground Coils

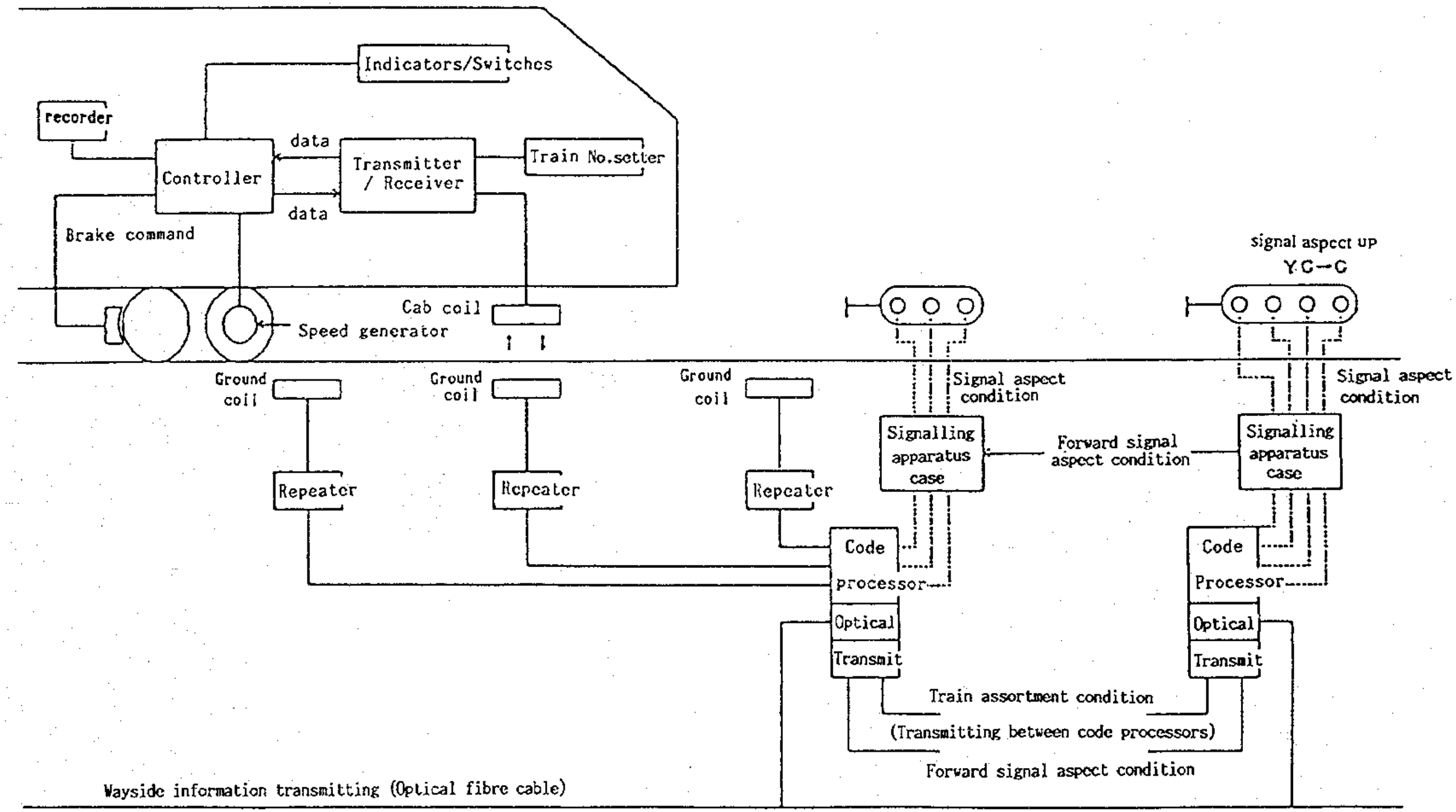


Fig. 2.7.5 Constitution of ATS-P Whole System

b. Code Processor

Fig.2.7.6 shows the constitution of the code processor. The micro processor is made up of a bus synchronized dual system, if there are any discord between both data bus lines, it immediately de-energizes CHR and cuts off the power supply line for the repeaters. The code processor always supervises all the repeaters and will also de-energize FR1 when it detects the failures of a repeater so that it makes it stop.

Control information is made out according to the content of the telegram ROM which is prepared in advance and is transmitted, by FSK 1,700 ±400Hz, polling method, to the repeater which has its own number.

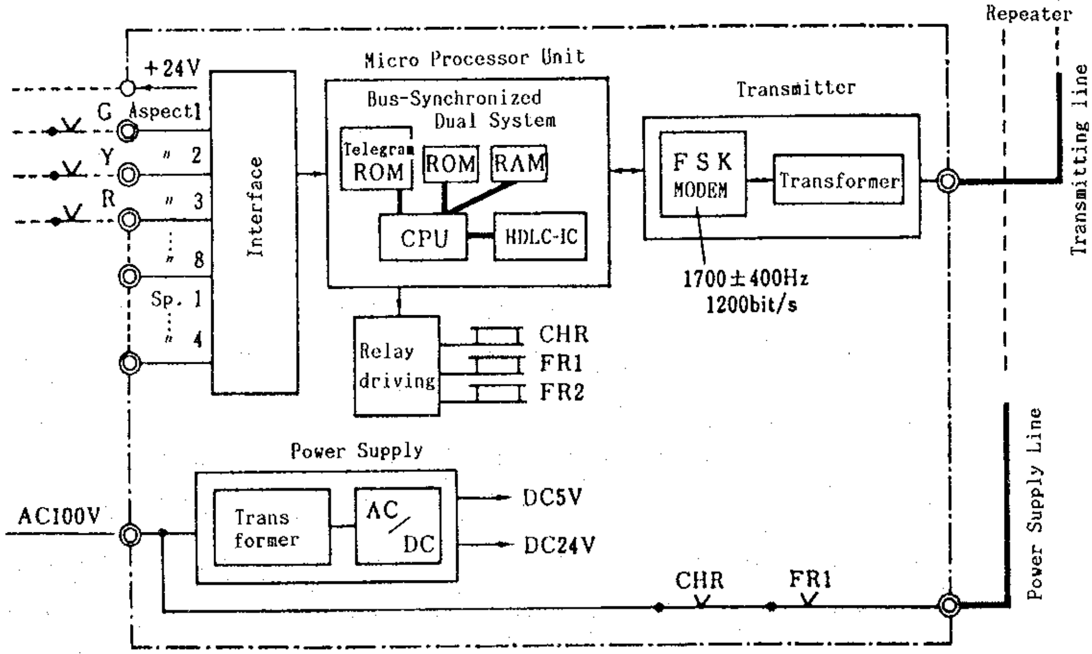


Fig.2.7.6 Constitution of Code Processor

c. ATS-P Repeater

Fig.2.7.7 shows the constitution of the ATS-P repeater. A repeater memorizes the control information in its ROM if the polling number is the same as its own, then transmits the information via its ground coil to the cab coil of the passing train after reforming it to frequency 1.7MHz, FSK 64kbit/s. This information is sent back to the code processor to check if it is the same as the original one or not.

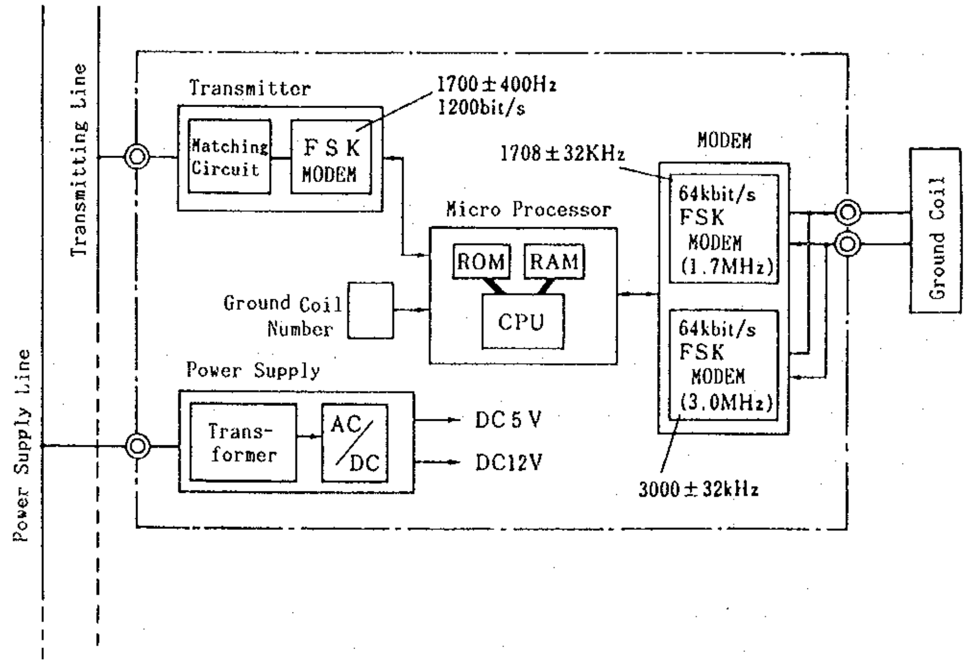


Fig.2.7.7 Constitution of ATS-P Repeater

d. Ground coil

ATS-P ground coil mainly falls into two types, i.e. the standard type and the self-exciting fixed information type, and the latter has single information type and multi-information switching type.

Fig.2.7.8 shows the standard type ground coil which has to be controlled by a code processor as mentioned above. The shape and size of the ground coil is designed so that it is able to receive continuously at least 4 frames of telegram from a cab coil passing at 160km/h. The 1.7MHz waves sent out to a cab coil are partly returned through antenna back to the code processor for checking as mentioned before.

Ground Coil

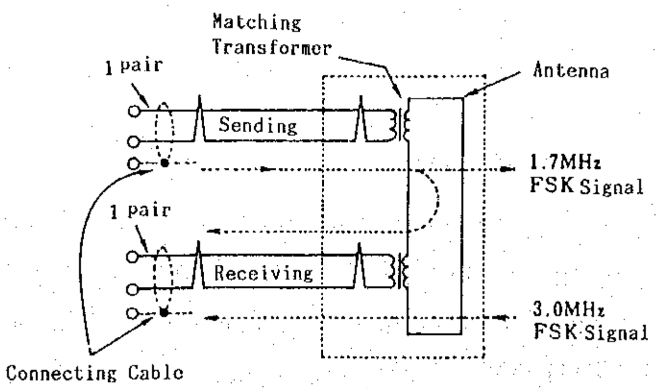


Fig. 2.7.8 Standard Type Ground Coil

Fig.2.7.9 shows a self-exciting fixed-single-information-type ground coil. This type ground coil has fixed information in a ROM, receiving electric power waves from a passing train that activate its circuits, and transmits the information which concerns speed restriction of turnout, curve and downgrade to the train.

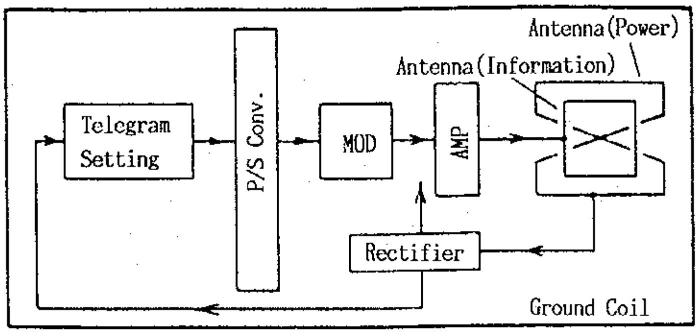


Fig.2.7.9 Self-exciting Fixed-single-information-type Ground Coil

Fig.2.7.10 shows the Self-exciting multi-information type ground coil which was developed recently. This type ground coil has various information in its ROM which are switched by internal relay contacts, so it can be controlled by signal conditions directly without help of code processors and repeaters.

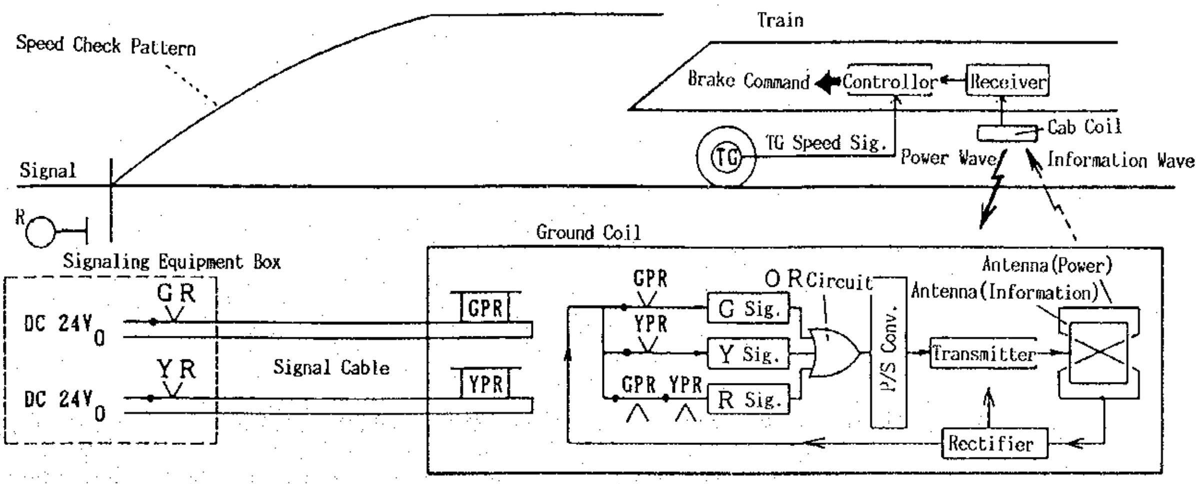


Fig.2.7.10 Self-exciting Fixed-multi-information-type Ground Coil

d. Concept of cab speed pattern

Fig.2.7.11 shows fundamental cab patterns. There are three patterns, i.e.

① Deceleration pattern --- Train deceleration curve to be expected.

② Basic pattern --- Brake command point necessary for the deceleration.

③ Check pattern --- Basic pattern + Brake command delay (0.5sec)

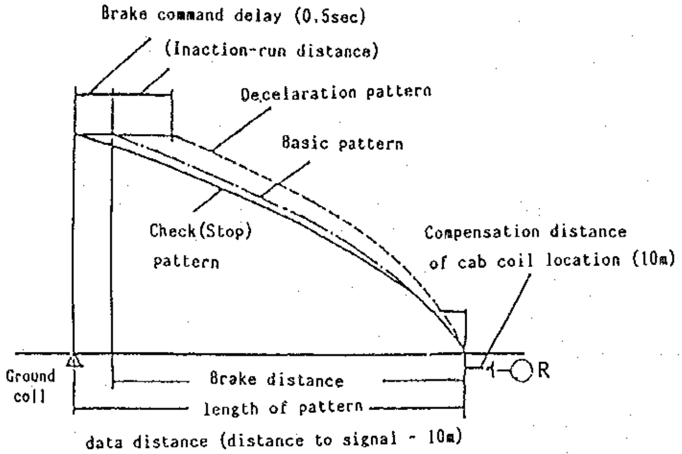


Fig. 2.7.11 Fundamental Cab Pattern

Fig.2.7.12 shows the make up of the cab pattern. It defines the shape of patterns for a train approaching a stop aspect block signal, which enables the train to enter inside of the signal at the minimum speed after once being stopped outside of the signal.

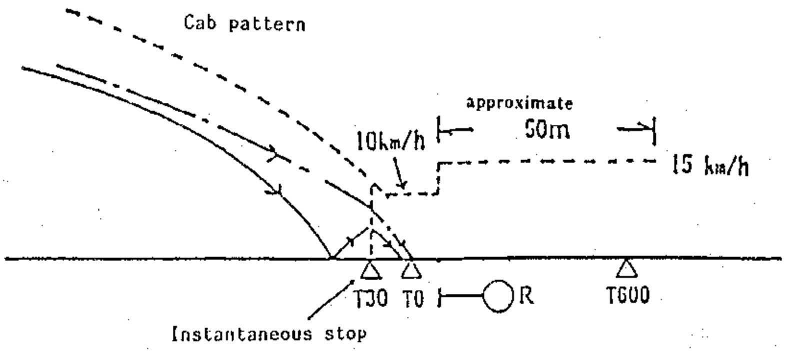
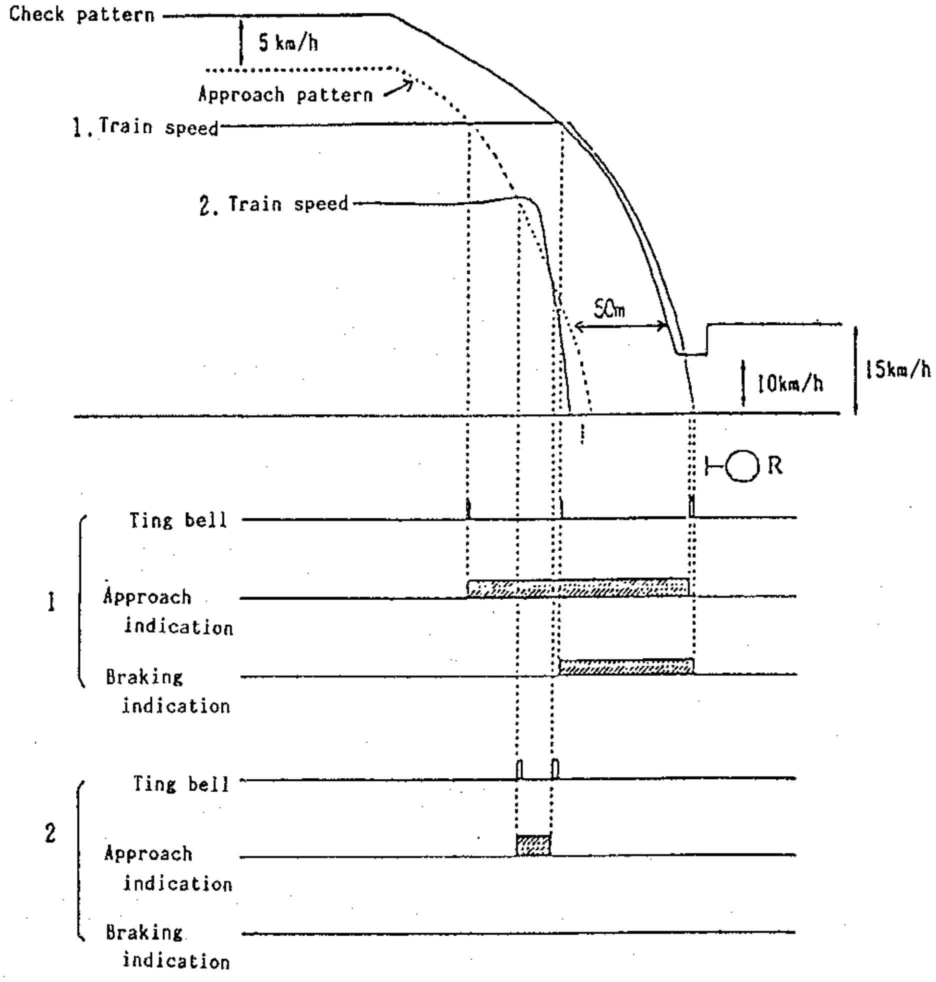


Fig. 2.7.12 Making up of Cab Patterns

Fig.2.7.13 shows the relation between check-pattern and approach-pattern. Approach-pattern is defined as giving drivers notice of approaching to a check-pattern. The driver will be able to apply normal brake before entering inside of the check-pattern area which would activate the maximum normal brake or emergency brake automatically.



Brake ;

a. If train speed>Check-pattern → Normal maximum brake or emergency brake.

b. Can not be loosen before complete stop except received new information.

c. Can be loosen after complete stop by restoration handling of driver.

Approach indication ;

a. Light if the train approached within less than 50m of check-pattern limit,

b. or the train speed increased within less than 5km/h(10km/h) of check-pattern limit.

Ting bell ;

a. Ring when the train cross the approach-pattern.

b. Ring when the train speed increase and cross the check-pattern.

Fig. 2.7.13 Relation between Check-pattern and Approach-pattern (Signal)

e. Protection against violation of signals

Fig.2.7.14~18 shows protection against violation of signals and other speed-restriction sections such as turnouts, curves and down-grade sections.

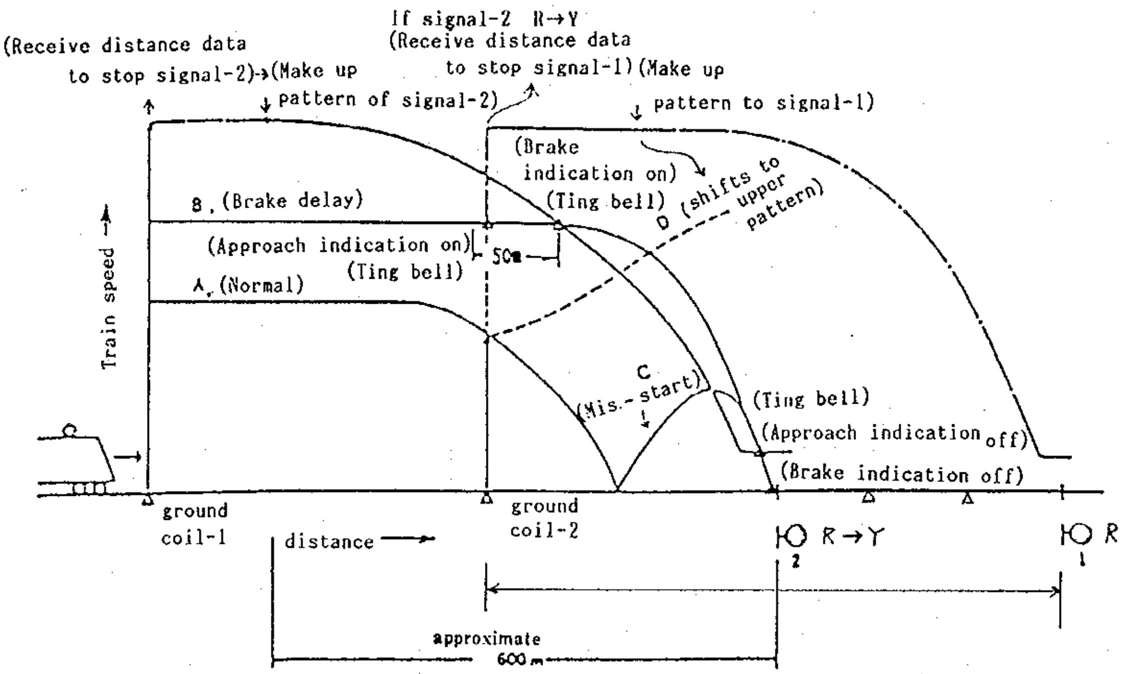


Fig.2.7.14 Protection against Violation of Signals (Home,Starter,Block Signal)

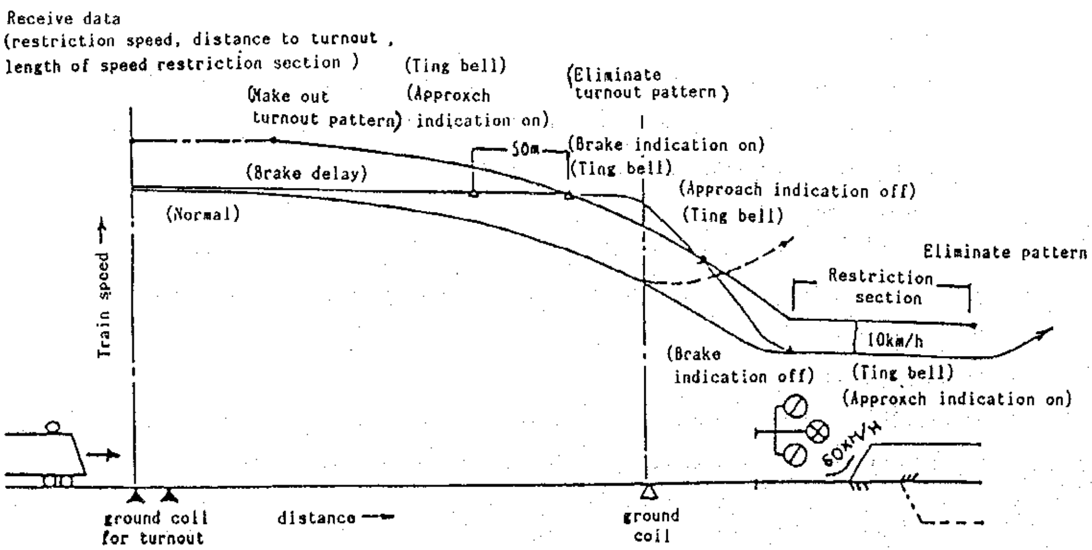


Fig.2.7.15 Protection against Violation of Signals (Turnouts)

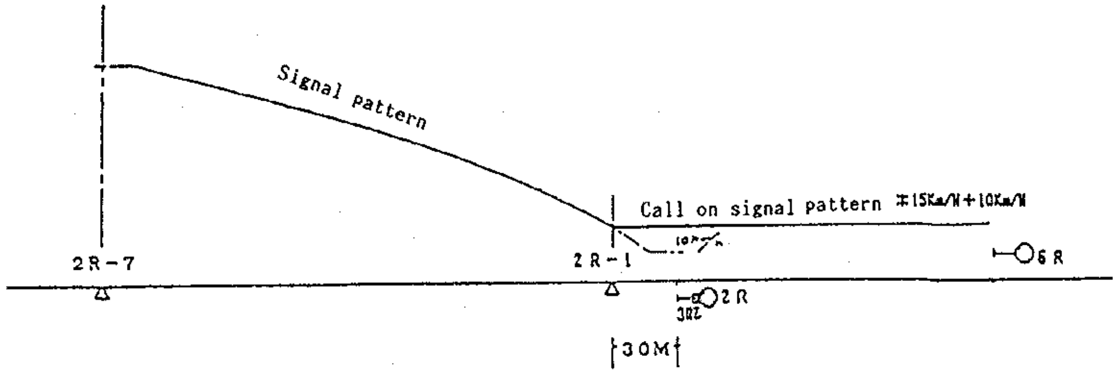


Fig. 2.7.16 Protection against Violation of Signals (Call-on Signal)

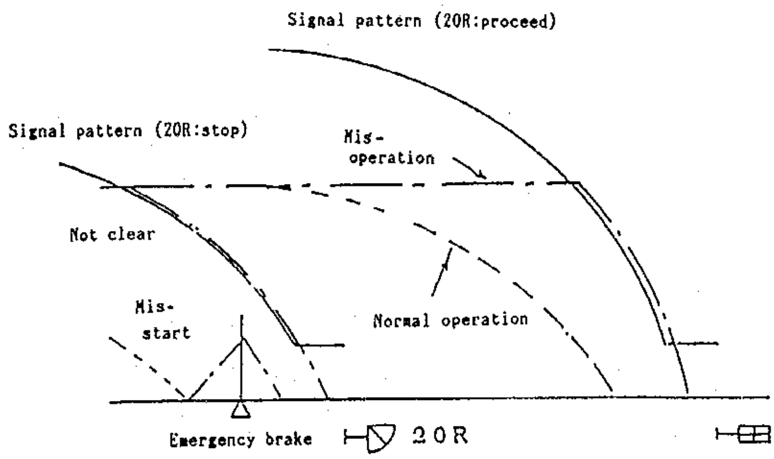


Fig. 2.7.17 Protection against Violation of Signals (Shunting Signal)

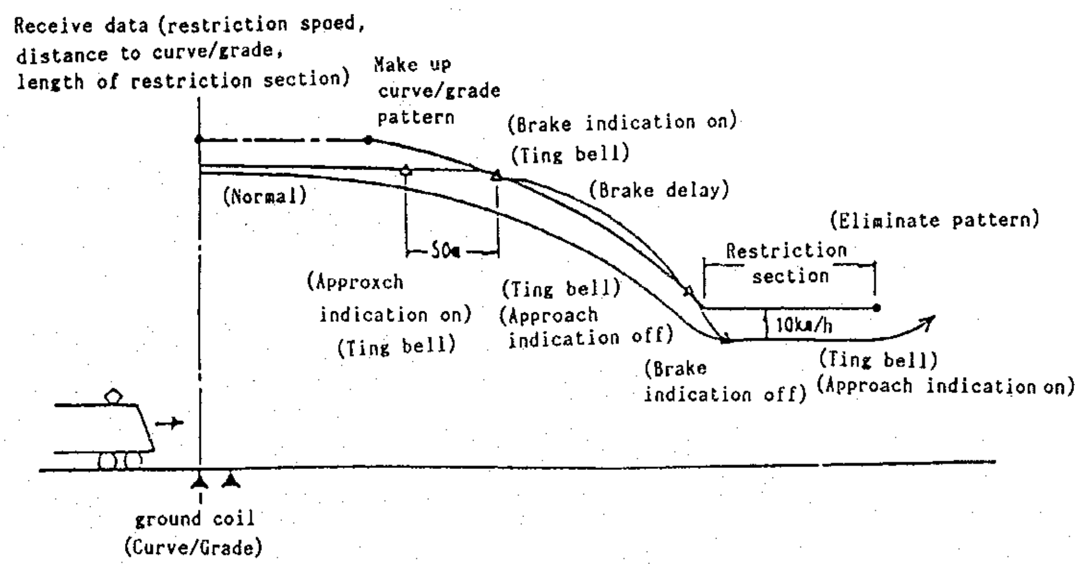


Fig. 2.7.18 Protection against Violation of Signals (Curves, Down Grades)

f. Control of ahead signal aspects

Fig.2.7.19 shows control of ahead signal aspects when a high speed train needs it.

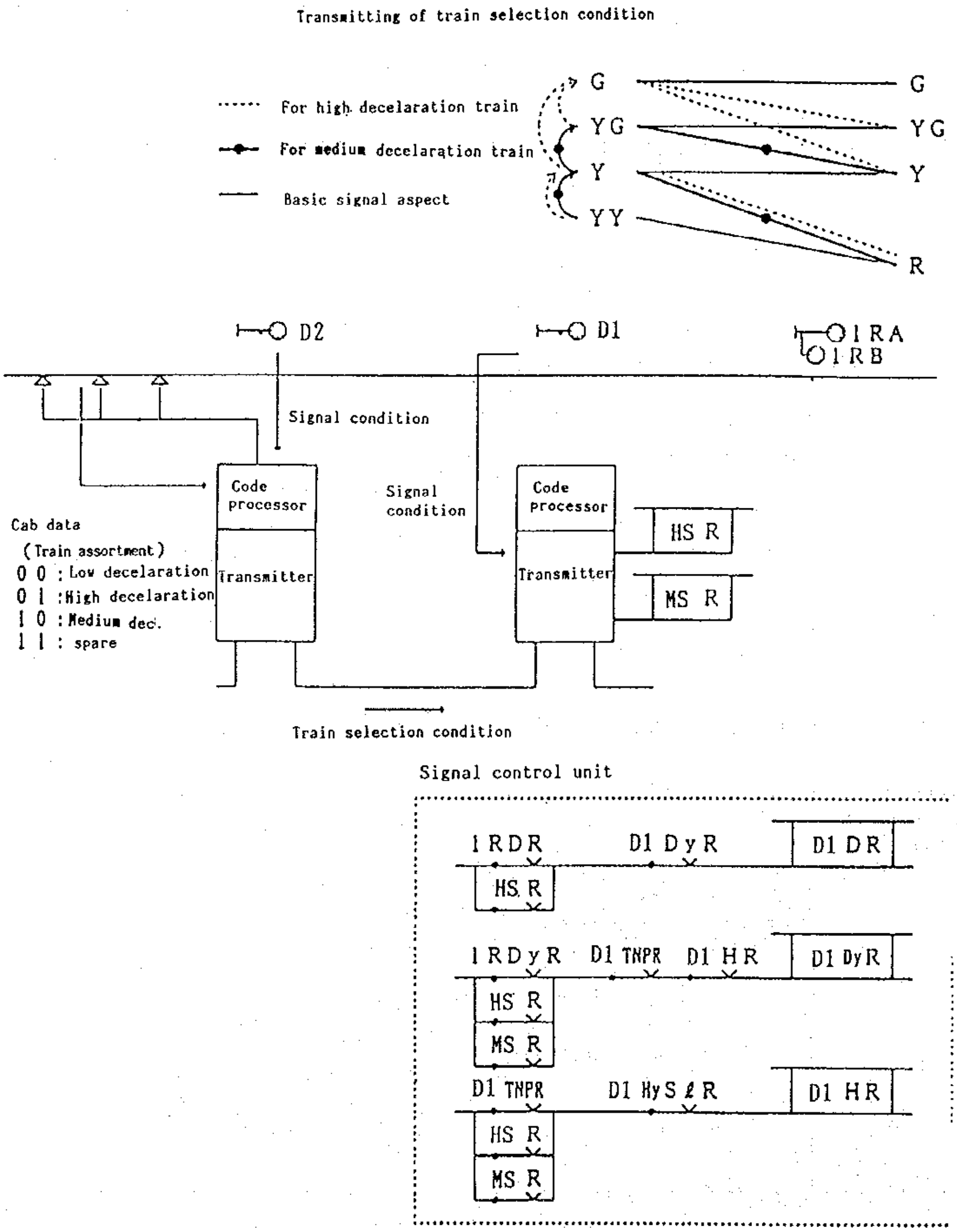


Fig.2.7.19 Control of Ahead Signal Aspects

g. Allocation of ground coil

ATS-P is a kind of point control system. The information received from a ground coil is being memorized until new information is received from the next ground coil. This means that if it would fail to receive information from the next ground coil the train will stop in an early stage and the fail-safe principle will be maintained.

However, if there are some changes of information such as signal aspect, it is better to renew as early as possible so as to avoid the bad influence caused by the old information. For this purpose, it is better to increase the number of ground coils installed, but on the other hand, for maintenance and construction costs, the number of coils are to be decreased. Typical allocation of ground coils is as follows.

Fig.2.7.20,21 shows ground coil allocation.

The distance of the farthest ground coil from a signal, 600m in this figure, is decided according to the maximum braking distance of trains. Therefore, if trains with longer braking distance would carry the ATS-P system in the future, the locations of ground coils will have to be revised according to the braking distance.

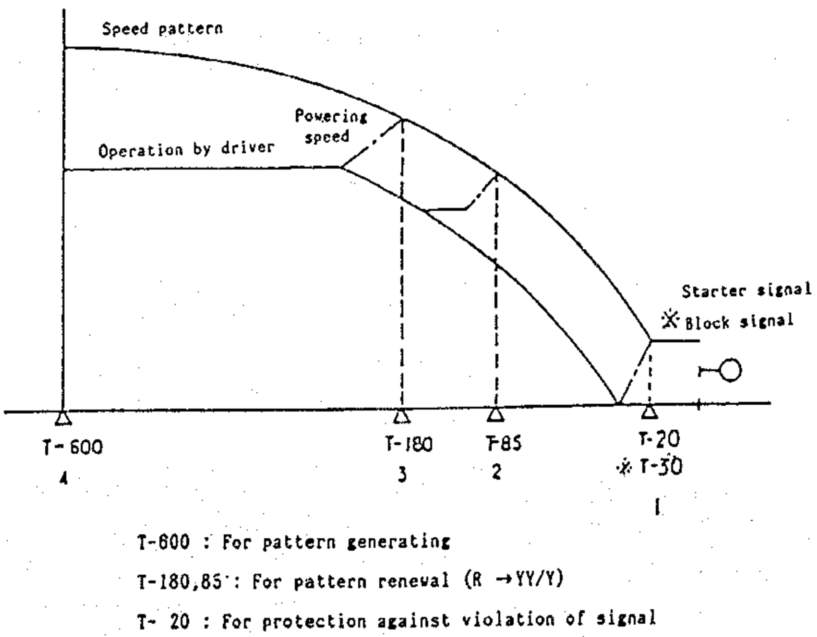
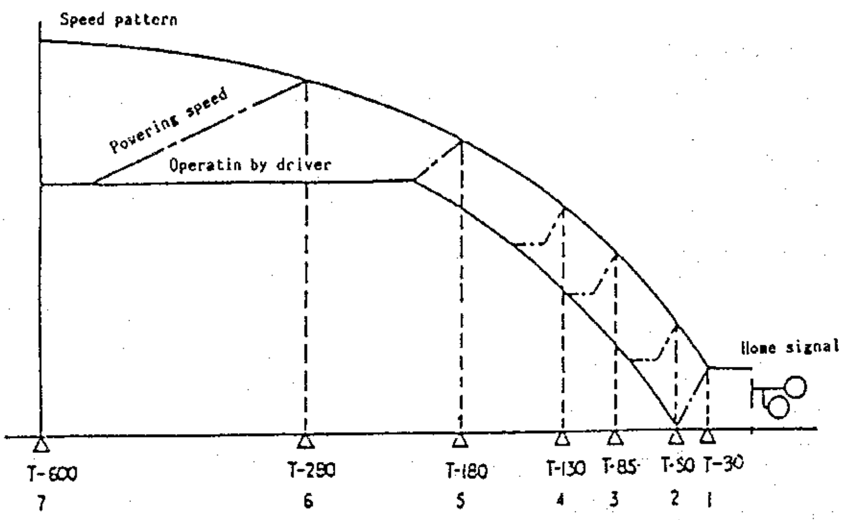


Fig. 2.7.20 Location of Ground Coils (Starter/Block Signals)



T-600 : For pattern generating

T-280,180 : For pattern renewal (R→Y)

T-130,85,50 : For pattern renewal (R→YY/Y/G)

T- 30 : For protection against violation of signal

Fig. 2.7.21 Location of Ground Coils (Home Signals)

h. Constitution of data frame

An information data frame consists of 80 bits in which 16 bits are used for synchronizing, another 16 bits for CRC check, and the remaining 48 bits are allotted to actual information use. Fig.2.7.22 shows fundamental data frame constitution, and Fig.2.7.23,24 shows Data frame constitutions for various information assortments.

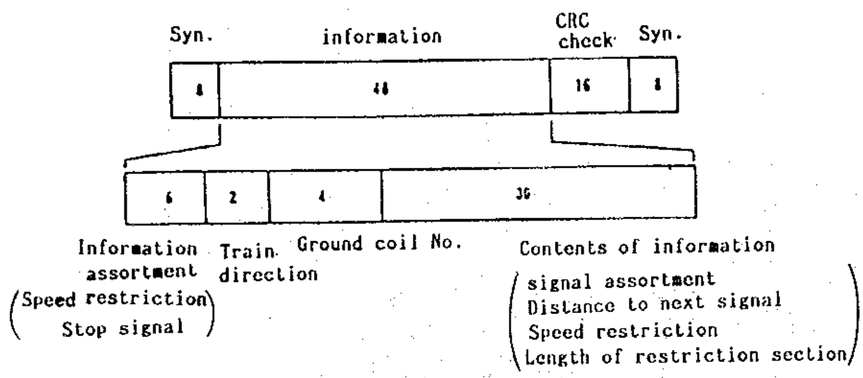


Fig. 2.7.22 Fundamental Data Frame Constitution

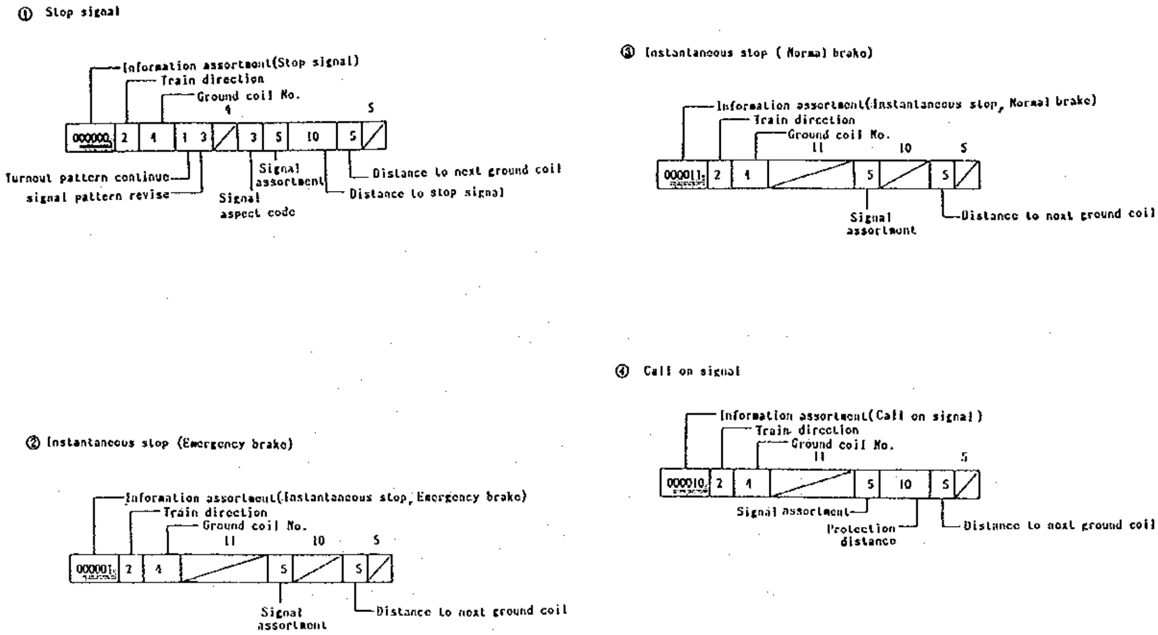


Fig. 2.7.23 Data Frame Constitution for Various Information No.1

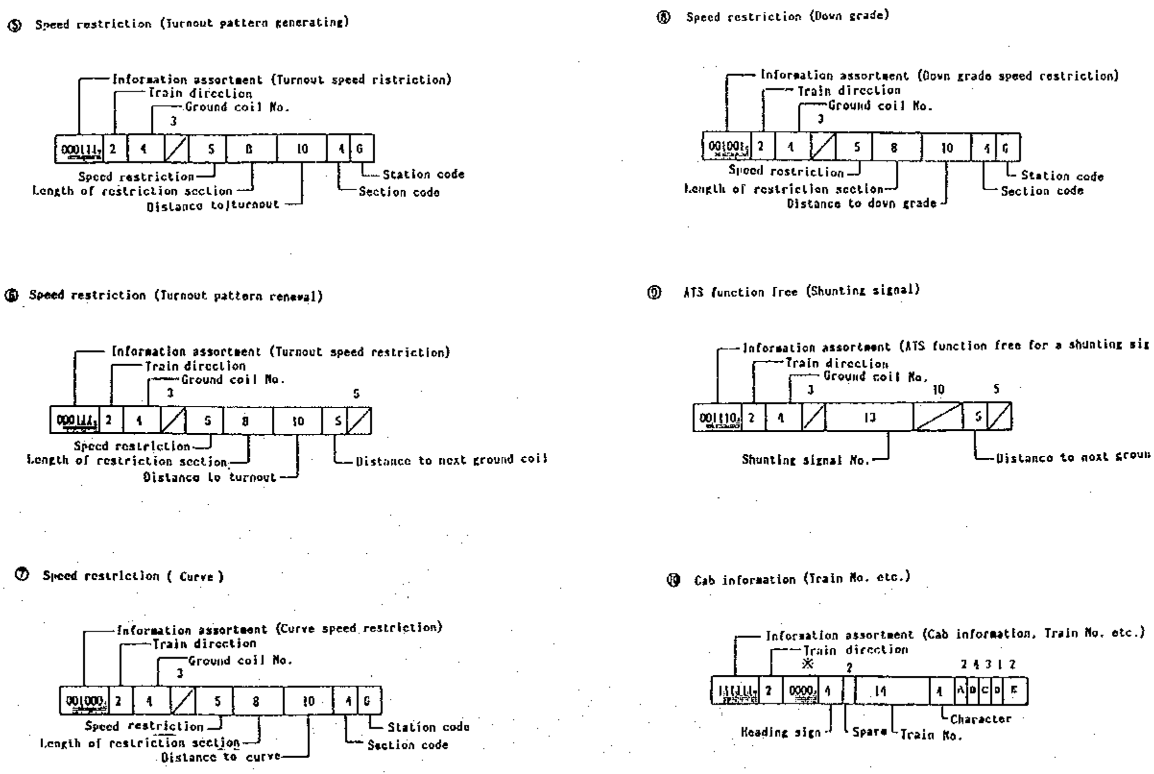


Fig. 2.7.24 Data Frame Constitution for Various Information No.2

(3) Improvement of the signalling facilities in this project

a. Yommarat ~ Chachoengsao st. --- Electrification, 120km/h, ATS-P.

As for this section, the improvements in this project are planned on the premise that the Hopewell Project and SRT Track Doubling Project are completed.

Signalling systems which are basically the same specification as the existing systems will be installed for new stations with turnouts, i.e. Lat Krabang East, New Chachoengsao, and Second Bangkok International Airport (SBIA) North Terminal, 3 stations.

Fig.2.7.25 shows the whole signalling system.

The signalling systems include mainly next sub-systems/equipment.

① CTC station system (via PCM transmission system to CTC center system)
② All relay interlocking system (with bi-directional function)
③ Track circuits (DC track circuit, AC immune type)
④ Electric switching machines (AC220v 50Hz single phase, trailable type)
⑤ Color light signals (3 aspect, Double filament lamp)
⑥ Call on signals, shunting signals, etc.
⑦ Power supply (AC220v 50Hz from MEA/PEA, Stand-by alternator, Battery)
⑧ ATS-P wayside system --- Newly proposed in this project.

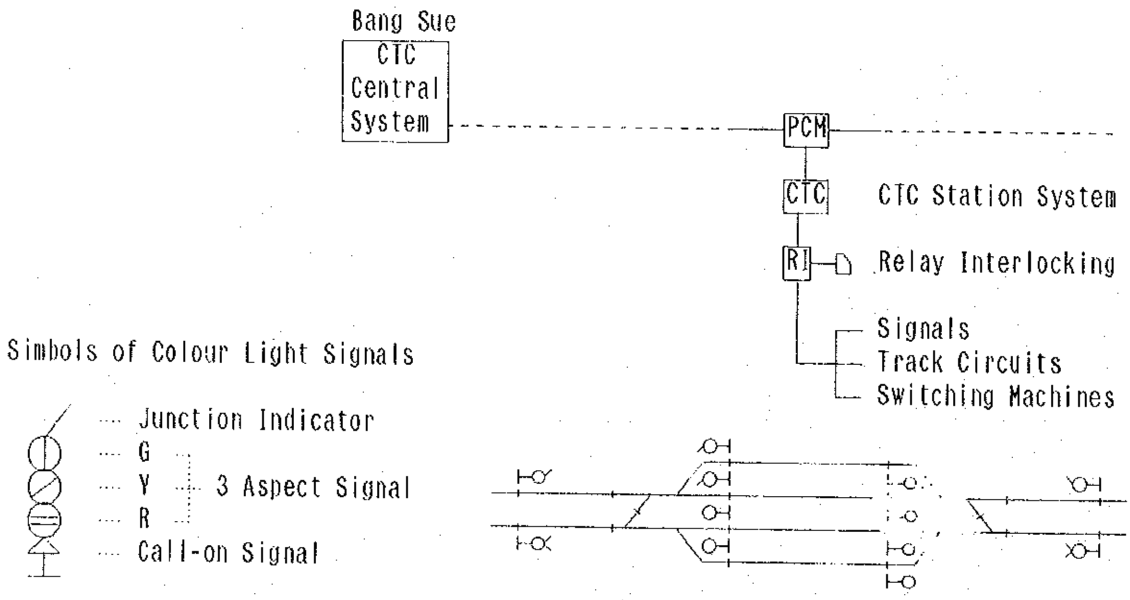


Fig.2.7.25 Whole signalling System

Fig.2.7.26 shows signalling plan between Yommarat and Chachoengsao.

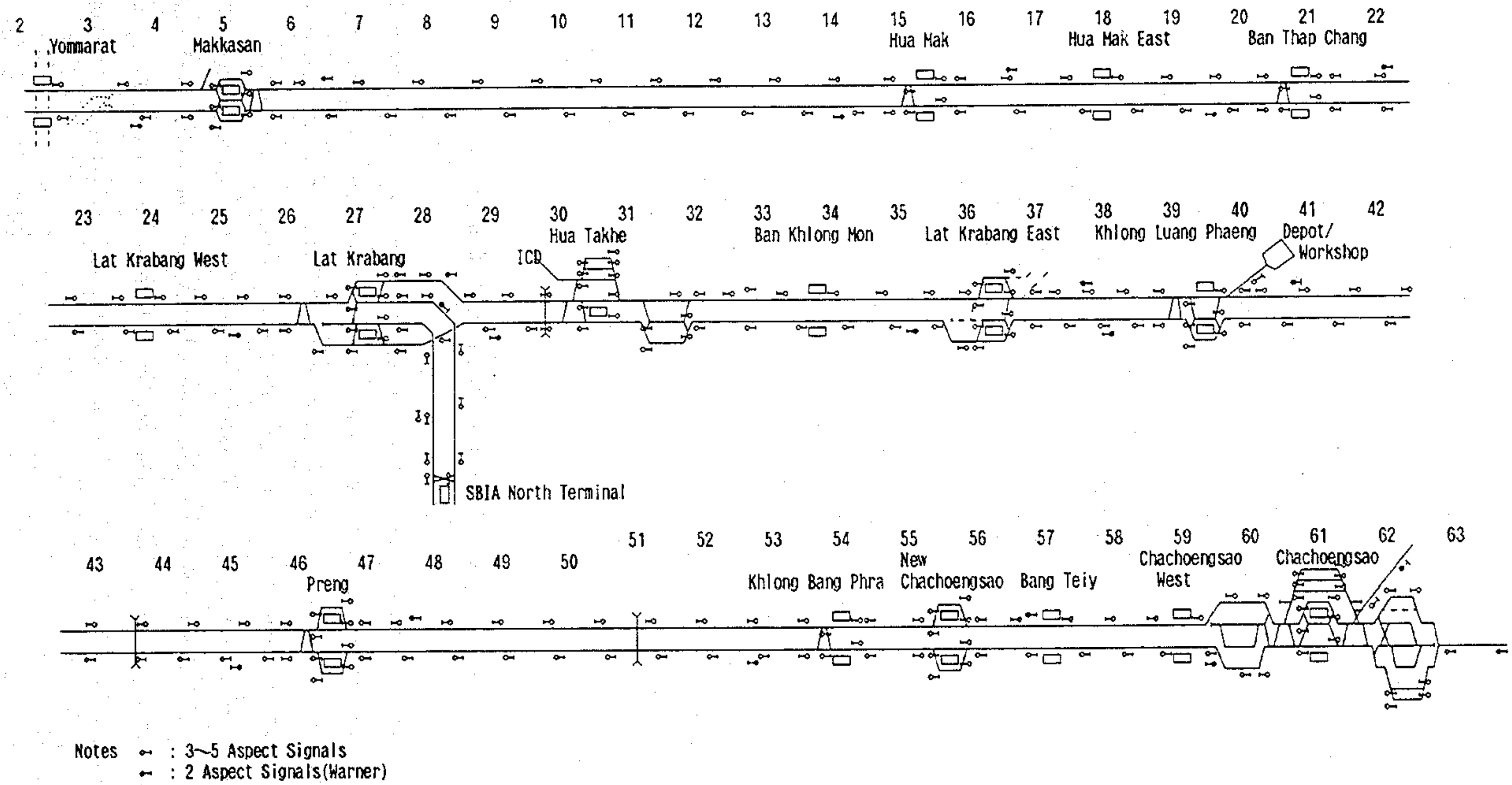


Fig. 2.7.26 Signalling Plan (Yommarat - Chachoengsao)

Fig.2.7.27 shows 3 aspect signal with call-on signal.

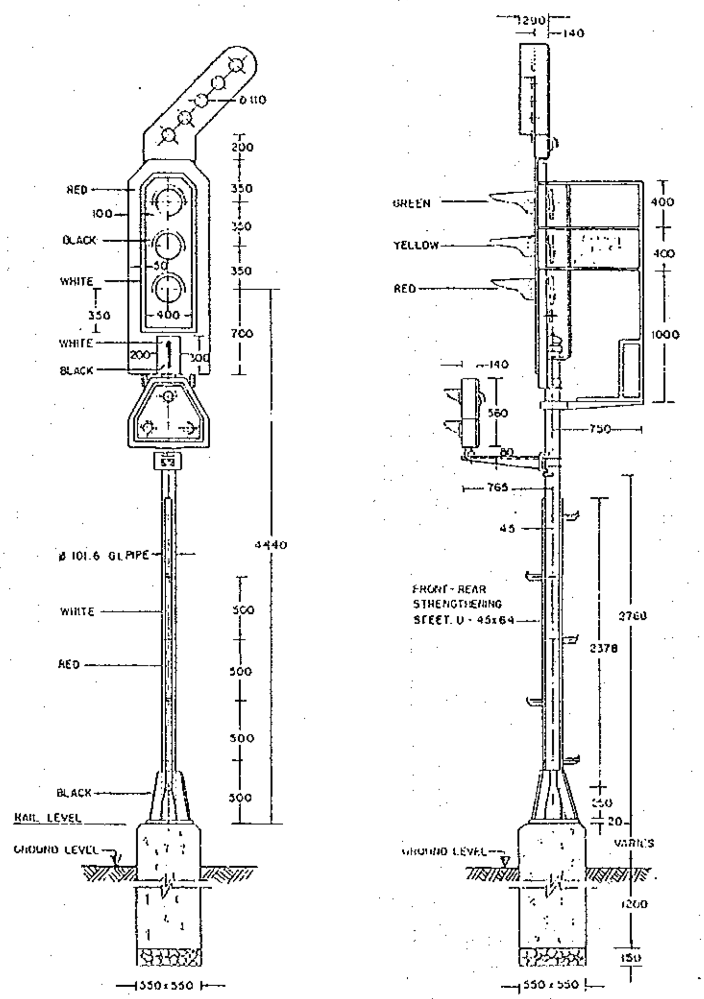


Fig.2.7.27 3 Aspect Signal with Call-on Signal

As for other stations, their existing signals, electric switching machines, and track circuits will be transferred or increased in accordance with the track layout changes in this project. DC track circuits should be improved from double rail type to single rail type for composition of traction current return circuits. ATS-P equipment and ground coils will be newly installed.

The newly constructed Depot/Workshop next to Khlong Luang Phaeng will have its interlocking system as an independent station, however, it will not be included in the CTC control area, using shunting signals controlled by track circuits for train operation, main running signals and the ATS-P wayside system will not be installed because of low speed operation.

Location of existing block signals and block section lengths between stations will be improved so as to attain the high speed, high density traffic operation which this project aims for. As for some stations without turnout, block signals will be located properly as substitutes for home and starter signals but not controlled.

Improvement of safety devices for at-grade crossings will be described later in 2.9.2.

Concerning the CTC central system, the mimic diagrams of the indication boards and the data of the control computer and VDU should be improved or increased according to the track layouts of the stations modified or newly constructed in this project, however, other CPU hardware and programs are expected to be able to cope with some increasing stations in the future. Fig.2.7.28 shows a sample of the CTC central system.

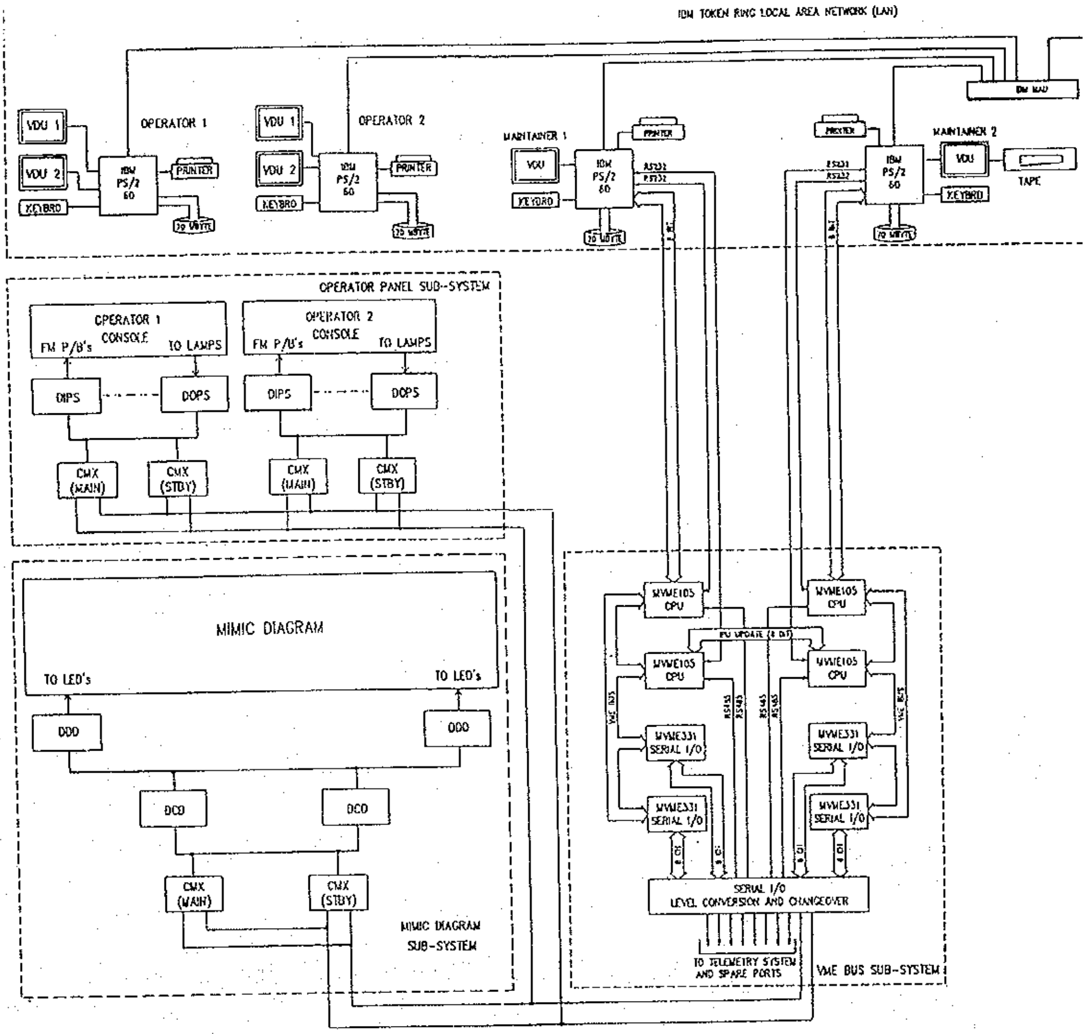


Fig.2.7.28 A Sample of the CTC Central System

b. Chachoengsao(exclusive) ~ Map Ta Phut st. --- Diesel railcar, 120km/h.

SRT has already finished the re-signalling project in this section.

The existing signalling system will be improved according to changes in the track layout, but a new signalling system will not be introduced in this project.

The existing signalling system mainly consists of:

① Tokenless block system for single track line

② All relay interlocking system

③ Track circuits (DC)

④ Electric switching machines (AC220v 50Hz single phase, trailable type)

⑤ Color light signals (2,3 aspect, Double filament lamp)

⑥ Call-on signals, shunting signals, etc.

⑦ Power supply (AC220v 50Hz from MEA, Stand-by alternator, Battery)

Fig.2.7.29 shows the signalling plan between Chachoengsao and Map Ta Phut.

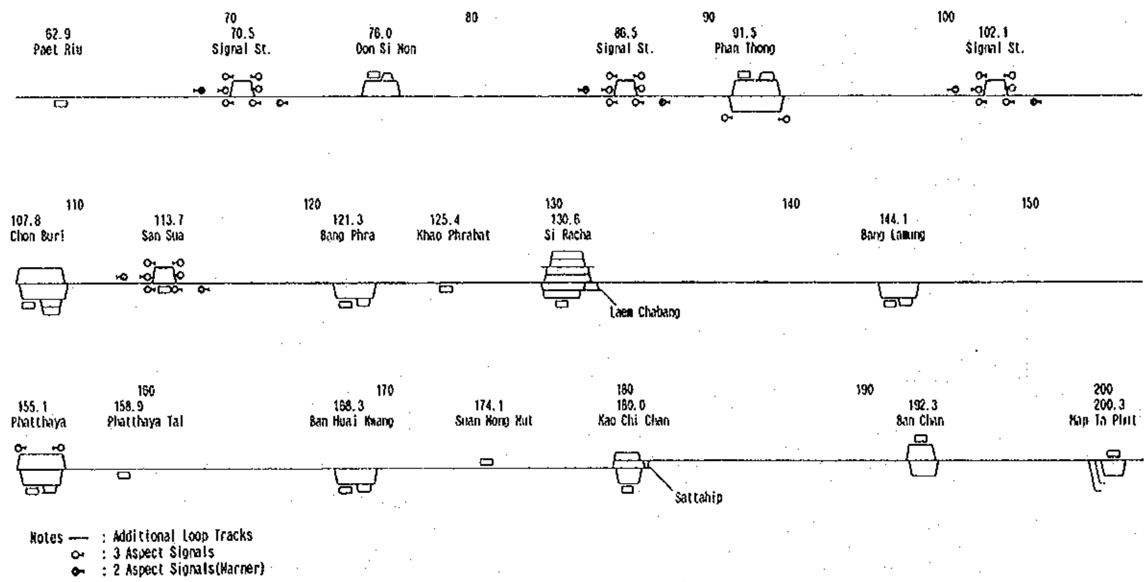


Fig. 2.7.29 Signalling Plan (Chachoengsao - Map Ta Phut)

2.7.2 Telecommunication

(1) Train radio system (Yommarat ~ Chachoengsao)

The present methods of communication, i.e. a train despatcher directs via a station master to a train driver, are not enough for high density traffic operation. A train radio system which enables communication directly between train despatchers in the CTC center and train drivers will be installed in this project.

The system shall be a two-frequency duplex operation and be a discrete self-contained communication link allowing the despatcher to selectively call any or all trains within his jurisdiction and allowing any driver to call the despatcher.

a. Frequency for train radio system

As for the frequency range for this train radio system, 150 MHz band has been secured by the SRT as shown in Fig.2.7.30.

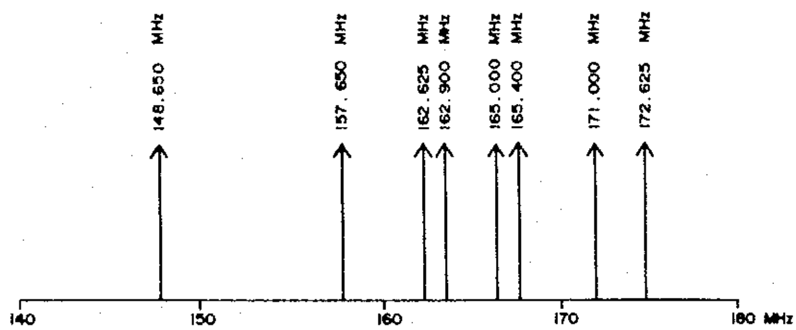


Fig. 2.7.30 SRT Existing Frequencies (150 MHz Band)

b. System description

Fig.2.7.31 shows the whole train radio system.

The train radio control station is located at Bang Sue CTC center, and shall control the train network for the length of track under the jurisdiction of the center.

Broadcast stations shall be located at intervals of 10~15km, in stationyards of manned stations. In order to cover the area between Yommarat~Chachoengsao st., Makkasan, Ban Thap Chang, Hua Takhe, Preng, Chachoengsao, 5 stations will be selected for the location of broadcast stations.

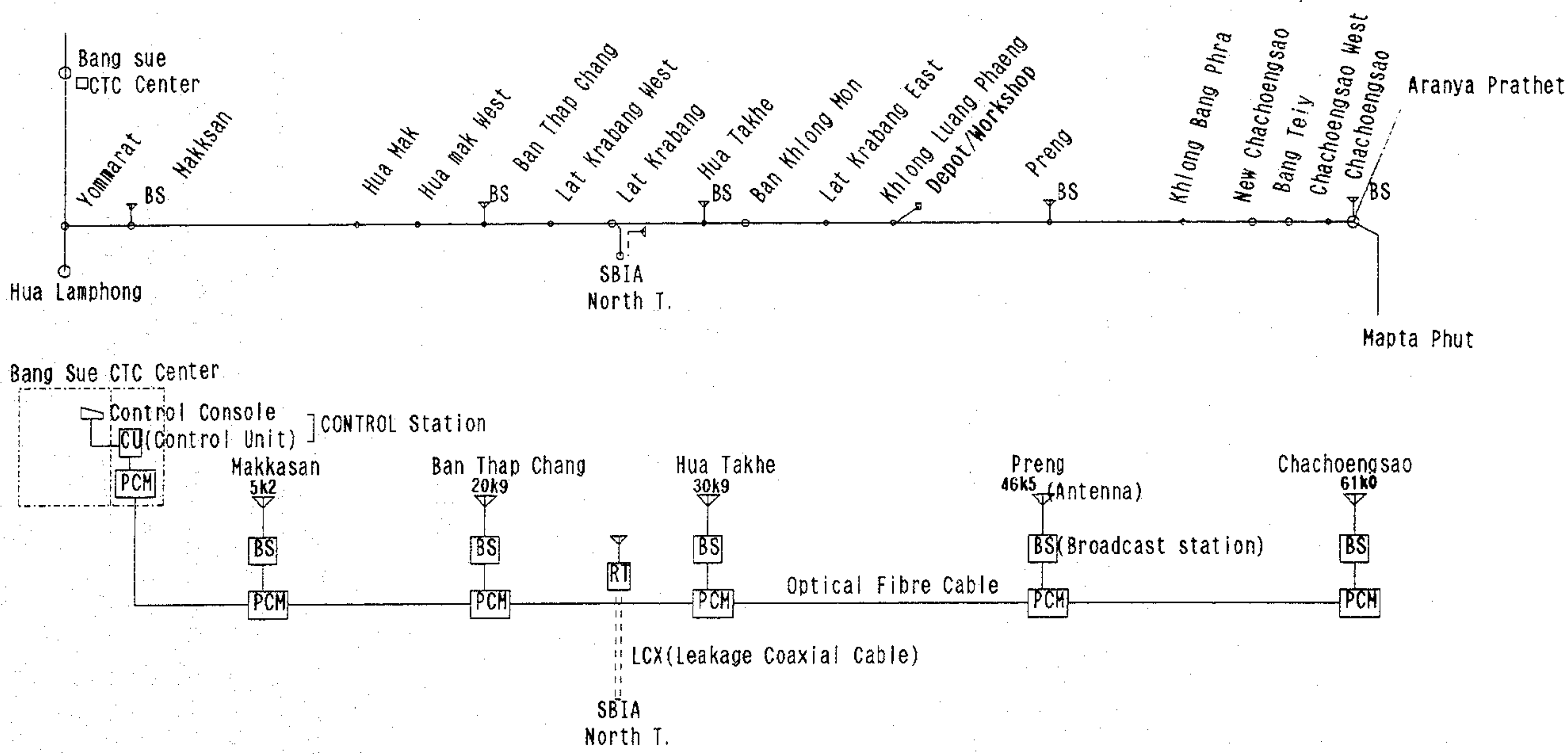


Fig. 2.7.31 Train Radio Whole Plan (Yommarat - Chachoengsao)

As the Second Bangkok International Airport underground station is constructed, the Leakage Coaxial (LCX) cable transmission method will be adopted.

c. Control station

Fig.2.7.32 shows a control station plant which consists of control console, control unit and power supply. Existing optical fibre cables and PCM system will be used as approach links between the control station and broadcast stations.

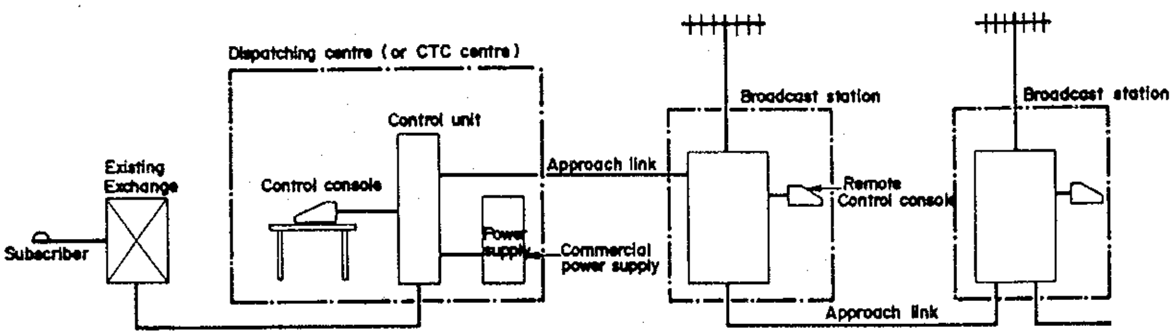


Fig.2.7.32 Schematic Diagram of Control Station Plant

Fig.2.7.33 shows a sample of a building layout and schematic layout of a control panel for a control station.

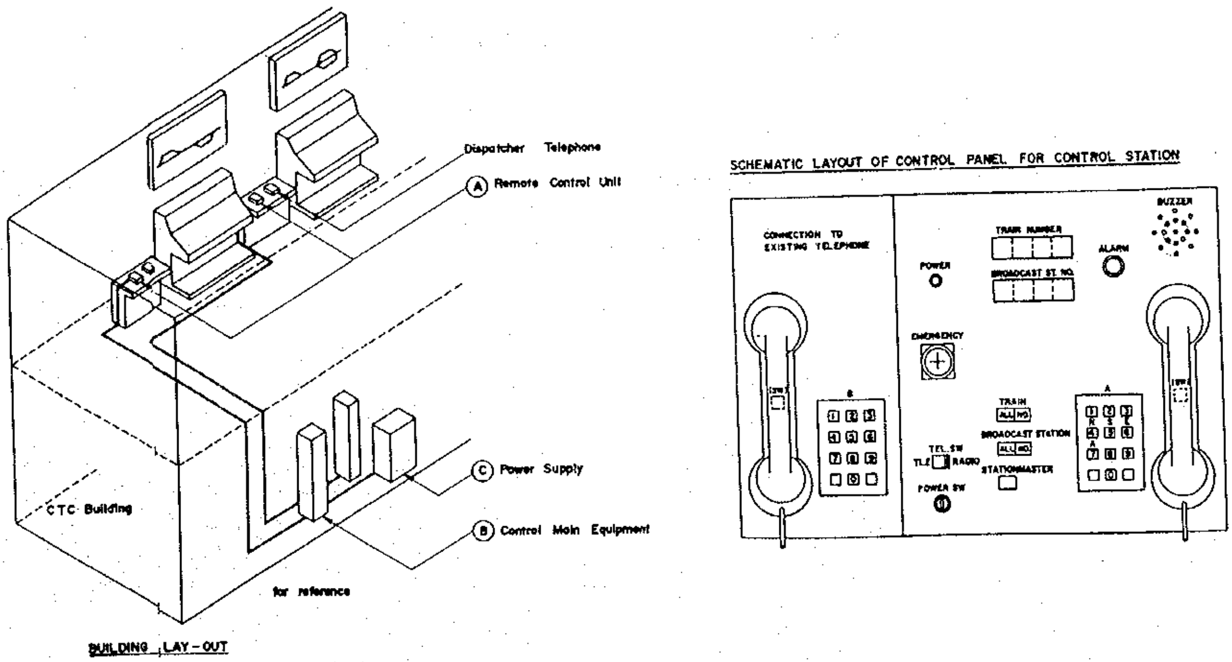


Fig.2.7.33 Building Layout and Control Panel for a Control Station

d. Broadcast station

Fig.2.7.34 shows a local broadcast station which consists of radio equipment, remote control box, power supply and antenna.

Existing aerial masts of the train despatcher UHF radio will be available for mounting new 150MHz Yagi antenna in Hua Takhe and Chachoengsao stations. Other stations require new aerial masts erected in this project.

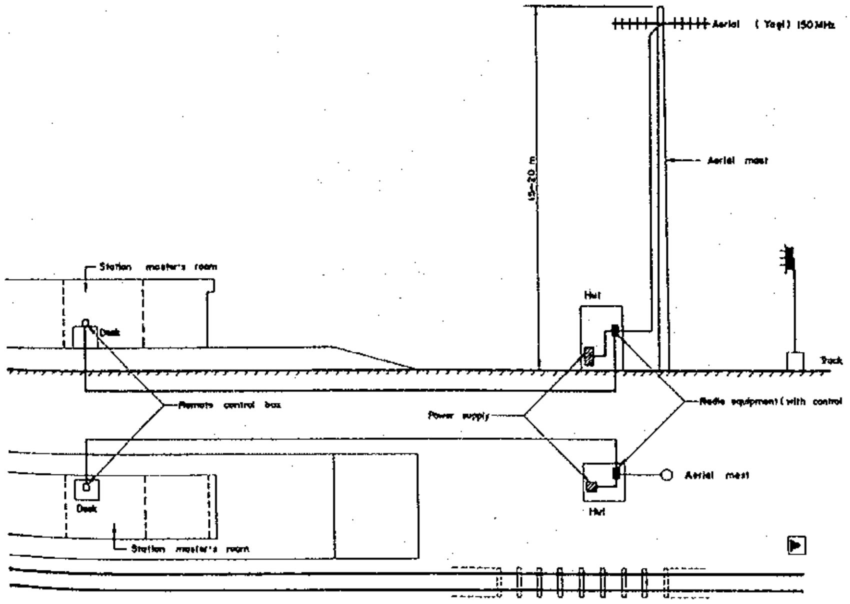


Fig.2.7.34 Local Broadcast Station for Train Radio

e. COAX cable transmission

Fig.2.7.35 shows the composition of COAX cable transmission which will be adopted along the underground part of the SBIA line. Repeaters will be required if the COAX cables are longer than 1.5km.

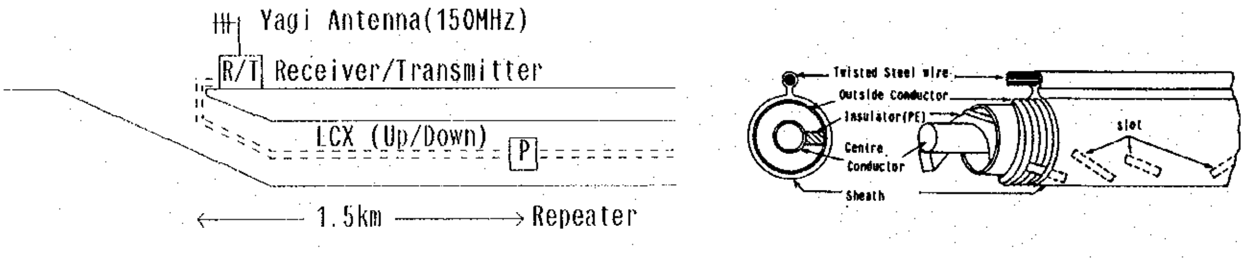


Fig.2.7.35 Composition of COAX Cable Transmission

(2) Improvement of the telecommunication facilities in this project

Existing stations after completion of the Hopewell Project and SRT's Track Doubling Project will have already advanced telecommunication systems, i.e. optical fibre cable and PCM transmission systems.

Therefore, as for the newly constructed stations in this project, PCM(Drop/Insert) devices will be installed and be connected with the existing optical fibre cables or copper cables. New stations will have the same facilities as existing stations, i.e. telephone concentrator, train despatcher telephones and automatic telephones, etc.

Fig.2.7.36 shows the telecommunication network between Makkasan and Chachoengsao after this project is completed.

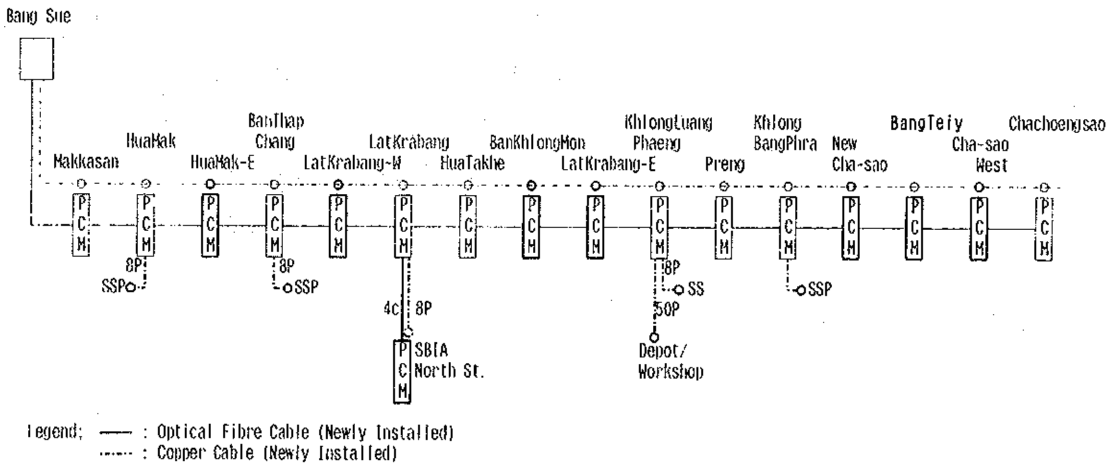


Fig. 2.7.36 Telecommunication Network (Makkasan - Chachoengsao)

2.8 Electrification

2.8.1 Traction Substation Facilities

(1) Power receiving

Modernization of the railway system will be planned in this project along with the development plan for the urban area of Bangkok, in which electrification of the railway will be considered to increase transport capacity for the commuters in the urban area. AT (autotransformer) feeding commercial frequency single-phase AC 25kV system will be selected to supply traction power for the electrical train operation of the railway. Electric power to a railway substation will be supplied from a grid substation of the Metropolitan Electricity Authority (MEA). Exclusively a dual 3-phase 115kV power receiving system, which will be alternatively on standby, will be adopted to ensure continuous power supply to the railway when power failure or maintenance of a power transmission line occurs such as an attack of lightning. A parallel power receiving system will not be considered to avoid the complicated protection system and increasing equipment cost of the railway substation.

(2) Feeding system

1) Location of substation

A traction substation should be located at a place where:

- To receive power from the MEA's grid substation which provides enough back power,
- To be located near the MEA's grid substation for construction of a transmission line as short as possible, and
- To be an adequate location in the railway section electrified.

It will be possible that the traction substation is provided at Bang Sue on the Northern Line to feed traction power for the four lines (Northern, Eastern, Southern, and Maeklong Lines); however, electrical train operation will be impossible on the 4 lines if the substation fails. Therefore, construction of a substation which covers each line will make an alternative standby relationship and more stabilized power supply system.

Location of the traction substation will be planned at Khlong Luang Phaeng taking into account the following:

a) Eastern Line is the first railway line to be electrified.

b) The traction substation will be installed within the first stage construction section between Yommarat and Khlong Luang Phaeng.

c) Extended feeding up to Bang Sue substation will be possible if the substation fails.

d) It is easy to provide individual feeding line for the depot and workshop since access track will be branched at Khlong Luang Phaeng station.

e) An overhead transmission line is crossing the railway at Khlong Luang Phaeng, and also the lines crossing at Khlong Tan, Ban Thap Chang and Bang Teiy. Moreover, as a result of the site survey, the transmission lines are crossing the railway at the east side of Khlong Tan (where the MEA's substation is also located), the east side of Ban Thap Chang and the west side of Bang Teiy.

f) It will be possible to supply power for both the future plans of extending electrification sections beyond Chachoengsao and dual double tracking of the Eastern Line. Feeding circuits of the Eastern Line will be provided for each bound track toward Yammarat and Chachoengsao.

2) Location of sectioning post and sub-sectioning post

Khlong Luang Phaeng traction substation will cover the whole commuter section of the Eastern Line. The Northern Line will be electrified in the near future, and a traction substation will be prepared at Bang Sue. Locations of the ground facilities of the electrification system will be as shown in Fig.2.8.1. A sectioning post will be required midway on the railway line between Bang Sue and Khlong Luang Phaeng to isolate the different phased traction power supplied from neighbouring substations, to interrupt failed current and/or to extend feeding the power from one to another if it fails. The sectioning post, therefore, will be installed at Ban Thap Chang station.

A sub-sectioning post will be necessary to disconnect a railway section from others for maintenance or in failure. A sub-sectioning post will not detect a failure. The sub-sectioning post will be provided at each section between the substation and the sectioning post or an autotransformer post(ATP).

An ATP will be required at intervals of 10km or 15km and terminals of AT electrification sections. The autotransformers, therefore, will be installed at sectioning posts, sub-sectioning posts, substation(s) and terminals of the electrification section.

Locations of the traction substations, sectioning posts, sub-sectioning posts, autotransformer posts and feeding system will be as indicated in Fig.2.8.1 and Fig.2.8.2.

3) Central control system

A power despatching center will be provided in Bang Sue station yard to ensure unmanned traction-substation operation by introducing remote control equipment for integrated management of the railway electrification systems on the 4 lines which are the Eastern, Northern, Southern and Maeklong lines, as follows:

a) Supervision of the running conditions of the electrical facilities of the railway electrification system

b) Supervision of fault status of the electrical facilities of the railway electrification system

c) Supervision/management of power consumption

d) Switching of traction-power-feeding switchgears required for maintenance of the electrification facilities

e) Supervision of malfunction and arrangement for recovering of the traction-substation equipment when necessary

Configuration of the control circuits and system will be as shown in Fig.2.8.3. A control console of the system for the Eastern Line will be prepared as group A, which will be applicable to electrical train operation into the first and second stages; control consoles of the groups B, C and D will also be provided for progresses of railway electrification for the other lines.

(3) Study of feeding system and substation capacity

1) Power supply

MEA's grid substation that provides large enough capacity is located near the Bang Sue railway station. It is planned that a railway traction substation is located near the Bang Sue station; and the traction power is supplied from this traction substation to the 4 railway lines.

However, for the purpose of electrification to Chachoengsao, the Eastern Line will be divided into two stages of construction such as the first step to Khlong Luang Phaeng and the second step to Chachoengsao. Therefore, location of a traction substation will be decided at Khlong Luang Phaeng. Capacities of electrical equipment of the substation, including the power receiving system, will be assured for electrification up to Chachoengsao.

In the progress of electrification of the Northern Line and two other lines, a traction substation will be installed at Bang Sue, which will be capable of backup to the other substations on the 4 lines. The Bang Sue traction substations will provide power supply to the Northern Line up to the Khlong Luang Phaeng substation if interrupted, and vice versa. Before completion of the Bang Sue substation, the traction power will be supplied from only Khlong Luang Phaeng substation.

It is necessary to discuss power receiving system and construction of the traction substation with the MEA.

2) Load conditions

The capacity of the main power transformer at Khlong Luang Phaeng substation will be calculated taking into consideration electrification of the 4 lines under the following conditions and as indicated in Fig.2.8.1 and Fig. 2.8.2:

a) Rated power consumption per train (power factor: $\cos\theta = 0.9$)

Electric train	one unit	Rated output per hour (4motors/1M 200kW x 4= 800kW)
Rapid train	10 cars (2M3T x 2)	800 kW x 4 =3,200kW
Local train	5 cars (2M3T)	800 kW x 2 = 1,600kW

b) Train speed

Train	Maximum speed	Scheduled speed
Rapid train	120km/h	70km/h
Local train	120km/h	50km/h

c) Maximum starting current I and maximum current I_{max}

Rapid train: $I = P \times \alpha/(\cos\theta \times V) = 3{,}200 \times 1.3/(0.9 \times 25) = 184.9$ (A)

$I_{max} = I \times \beta = 184.9 \times 1.1 = 203$ (A)

Local train: $I = P \times \alpha/(\cos\theta \times V) = 1{,}600 \times 1.3/(0.9 \times 25) = 92.4$ (A)

$I_{max} = I \times \beta = 92.4 \times 1.1 = 102$ (A)

where:
- P: Rated power consumption per train.
- α: Load factor when starting; 1.3
- V: Overhead contact line voltage; 25 kV
- β: Auxiliary equipment factor for train; 10%
- $\cos\theta$: Power factor; 0.9

d) Total weight per train

Presuming that 1M(motorcar) 40ton, 1T(trailer) 30ton,
170 persons for nominal capacity of 1 car,

180% for average on-boarding factor in peak hours,

170 persons x 180% = 306 persons ----> 300 persons per car

0.06 ton for weight of 1 person

Rapid train 1 unit: 4M6T = 40ton x 4 + 30ton x 6 + 0.06ton x 300 x 10 = 520 tons

Local train 1 unit: 2M3T = 40ton x 2 + 30ton x 3 + 0.06ton x 300 x 5 = 260 tons

e) Power consumption factor

(This factor means necessitated electric power consumption to be run 1 km for 1000ton of electric car weight)

Regenerative braking factor is generally from 10% up to 15%; therefore, 10% will be applied in this calculation taking margin into consideration.

Rapid train: 37kWh/1000ton·km

Local train: 40kWh/1000ton·km

f) Train operation conditions for peak times (No. of trains per one way per one hour)

Lines	Northern	Eastern	Southern	Maeklong	Total
Rapid train	3	4	2	1	10
Local train	3	5	2	1	11

g) Voltage allowance at pantograph

Maximum voltage: 27.5kV

Nominal voltage: 25.0kV

Minimum voltage: 19.0kV

Instantaneous minimum voltage: 17.5kV

h) Traction transformer capacity

Maximum one hour power consumption W(kVA) for traction substation will be calculated as follows:

$$W = \frac{T(t) \times Q(kWh / 1000t.km) \times L(km) \times N(trains) \times 2(up \;\&\; down)}{1000(t) \times 1h \times \cos\theta} \ldots\ldots(kVA)$$

where:

T: Total train weight (ton)

Q: Power consumption factor (kW/1000ton.km)

L: Load coverage distance per one substation (km)

N: Number of operated trains per one hour (trains)

cosθ: Power factor; 0.9

$$W(\text{Eastern Line}) = \frac{(520 \times 37 \times 64.4 \times 4 \times 2) + (260 \times 40 \times 64.4 \times 5 \times 2)}{1000 \times 1 \times 0.9} = 11{,}014 + 7{,}442 = 18{,}456$$

$$W(\text{Southern Line}) = \frac{(520 \times 37 \times 50.8 \times 2 \times 2) + (260 \times 40 \times 50.8 \times 2 \times 2)}{1000 \times 1 \times 0.9} = 4{,}344 + 2{,}348 = 6{,}692$$

$$W(\text{Northern Line}) = \frac{(520 \times 37 \times 63.6 \times 3 \times 2) + (260 \times 40 \times 63.6 \times 3 \times 2)}{1000 \times 1 \times 0.9} = 8{,}158 + 4{,}410 = 12{,}568$$

$$W(\text{Maeklong L.}) = \frac{(520 \times 37 \times 40.6 \times 1 \times 2) + (260 \times 40 \times 40.6 \times 1 \times 2)}{1000 \times 1 \times 0.9} = 1{,}736 + 938 = 2{,}674$$

$$\begin{aligned} W(\text{Total}) &= (11{,}014 + 4{,}344 + 8{,}158 + 1{,}736) + (7{,}442 + 2{,}348 + 4{,}410 + 938) \\ &= 25{,}252 + 15{,}138 = 40{,}390 \text{ (kVA)} \end{aligned}$$

Maximum short time electric power (instantaneous) will be calculated by the following formula as the simplest empirical formula; this method is composed of following relationship between output of substation per one hour Y(kVA) and its instantaneous maximum electric power Z(kVA)

$$Z = Y + C\sqrt{Y}$$

where: $Y = W \times \cos\theta$, cosθ: power factor; 0.9

"C" is a constant that is determined by the conditions of train operation and conditions of location of substation.

For AC electrification system, the factor will be given by the following formula:

$$C = 6.21\sqrt{I_{max}}$$ (I_{max}: maximum running current of one train)

For Rapid Train, $C = 6.21\sqrt{203} = 88.48$

Therefore, $Z = Y + C\sqrt{Y}$

$$= 25,252 \times 0.9 + 88.48\sqrt{25,252 \times 0.9} = 36,066 \text{ kVA}$$

For Local Train, $C = 6.21\sqrt{102} = 62.72$

Therefore, $Z = Y + C\sqrt{Y}$

$$= 15,138 \times 0.9 + 62.72\sqrt{15,138 \times 0.9} = 20,945 \text{ kVA}$$

Total traction power (all lines) will be: 36,066+20,945 = 57,011 kVA

One the other hand, power consumption of the auxiliary equipment including air-conditioner and lighting will be a maximum 170kVA for 5cars per unit train (2M3T);

Therefore,

Rapid Train:	8trains X 2units X 170kVA =	2,720 kVA
Local Train:	10trains X 1unit X 170kVA =	1,700 kVA
	Total:	4,420 kVA

Then the grand total of power consumption for all lines will be:

57,011 + 4,420 = 61,435 kVA -----> 62 MVA

In the case of only the Eastern Line, it is the same as above,

$$Z = Y + C\sqrt{Y}$$

$$= 11,014 \times 0.9 + 88.48\sqrt{11,014 \times 0.9} + 7,442 \times 0.9 + 62.72\sqrt{7,442 \times 0.9}$$

$$= 30,553 \text{ kVA}$$

Aux. equipment will be: (4trains X 2units + 5trains X 1unit) X 170kVA = 2,210 kVA

Then, the grand total for the Eastern Line will be:

30,553 + 2,210 = 32,763 kVA ------> 33 MVA

As the railway electrification plan have not yet been studied enough,beside the Eastern Line capacities of the traction transformer will be decided including surplus marginal capacity and based on the nominal capacities as specified in a Japanese Standard established by the Japanese Electrotechnical Committee, JEC 204 (15, 20, 30, 45, 50, 60, 100 MVA) as follows;

Whole lines at Bang Sue substation: 45MVA x 2 banks

Eastern Line at Khlong Luang Phaeng substation: 20MVA x 2 banks

Two sets of Scott-connected transformer will be installed for parallel operation at each traction substation.

According to the above calculation, large and highly reliable electric equipment will be required if the Bang Sue substation is to cover the whole area. Therefore, it is necessary to proceed with construction planning of the traction substations considering conditions of mutual aid.

2.8.2 Overhead Contact System

(1) Selection of contact wire system and supports

The traction power for an electric vehicle is supplied through the contact wire and the pantographs; therefore, they have to cooperate with each other both mechanically and electrically. It is also necessary to consider the meteorological conditions such as atmospheric temperature and wind velocity, as design factors.

(a) Train speed

Train	Maximum speed	Scheduled speed
Rapid train	120km/h	70km/h
Local train	120km/h	50km/h

(b) Height of contact wire

a) Height of contact wire and effective height of pantograph (Refer to Fig.2.8.4)

Item	Height of contact wire	Effective height of pantograph	Notes (Unit: mm)
Standard	5,100		height of structure gauge: 4,100
Maximum	5,450	5,590	height of pantograph when hold: 4,050
Minimum	4,350	4,300	limited height of mobile cars: 4,500
At-grade crossing	5,100		(including distance of 300mm each for
			both margin and insulation)

Fig.2.8.5 shows the heights of the contact wires of the simple catenary system on the railway sections of the underground, beneath the viaduct and in the tunnel. The height of the contact wires in the section shall be 4,380mm taking into account 5,100mm: height of structures, 35m: supporting interval of the catenary and 150mm: minimum length of hangers for contact wires. The height of 4,380mm shall also be maintained when the contact wires are supported by the hinged cantilevers mounted on the drop arms beneath the structures.

b) Meteorological conditions

Meteorological conditions will be considered as follows;

Ambient temperature:	+10 up to 40℃ (average 27℃)
Wind velocity:	20 m/sec(Max.)
Precipitation(flat area):	1,500 through 2,500 mm/year,
No earthquakes	

Design load of electric transmission lines and their pylons are as follows;

Wind velocity:	34.9 m/sec. at 30m height
	40.4 m/sec. at 60m height
Gustiness factor:	1.3 100times/year(IKL base)
	(IKL:Isokeraunic Level)

(2) Selection of contact wire system

The contact wire systems adopted in the world at present are classified into the following 4 standard types; (Refer to Fig. 2.8.6)

- Simple catenary system
- Stitched catenary system
- Compound catenary system
- Directly suspended contact wire system

Combined systems, for example, twin simple catenary system is also used now. More over, they are classified in detail by the materials of contact wires and by the difference of tension of catenaries. (Refer to Table 2.8.1.) These various systems are adopted based on the conditions of train operation such as historical background of a country, train operation speed or train load.

The simple catenary system will be adopted for this study considering its high maintainability and low installation cost.

(3) Selection of supports

The supporting structures are key elements, which consist of poles and beams mainly; and are provided with stays, drop-arms and cross-arms to support overhead catenary lines and feeder-wires together with various signs and indicators, in electrical operation of the railways.

(a) Types of supporting structure

Various types of supporting structure are used and the following types of structures are adopted as the standard. (Refer to Fig. 2.8.7.) The selection of these types is made considering actual conditions of installation.

- Rigid cantilever
- Hinged cantilever
- Cross beam
- Truss beam
- Cross catenary

(b) Selection of poles and masts

a) Concrete poles

Concrete poles, which are manufactured by the prestressed centrifugal method, are rarely crack and are hard to bend. They provide enough strength and long life. Also they are cheap, and maintenance free since they do not need the special care of painting or metal coating that is usually necessary for steel masts.

The electric power company has already adopted square type concrete poles for distribution lines. Domestic manufacturers of concrete poles have been gradually established in Thailand. Therefore, it is recommended that concrete poles be mainly employed for electrification of this Project, and to establish specification for concrete poles guaranteeing their strength and durability for railway electrification use.

b) Steel mast

There are several types of steel masts; fabricated steel, rolled H-section, and steel pipe. Properly designed steel masts are simple in structure and appearance and have long life if they are effectively rust-proofed.

It is recommended that steel masts be employed where concrete poles are not suitable because of heavy loads such as those in station yards and restriction of standing/attaching them such as that at bridges.

c) Wooden pole

Properly preserved wooden poles have a life expectancy of about 30 years as long as they are not erected in damp areas of especially bad environment and not damaged by birds. They are inferior to concrete poles and steel masts in appearance, but practically can be used.

d) Pole foundations

It is important beforehand fully to work with civil engineers to check the soil of the railway banking, construction request of foundation over overbridge, and buried bolts on bridge and tunnel ceiling.

(c) Selection of beams

The beams are roughly classified into fixed beams, cross catenarys and cantilevers. They are used to correspond to specific erecting conditions.

a) Fixed beams

A fixed beam consisting of structural steels will be divided into the portal type, V-shaped truss type, warren truss type, and cross beam type, which will be installed within railway station yards and railcar depots. The employment of the fixed beams will be considered in this project when the manufacturing system for the steel products is completed and their prices is stabilized domestically.

b) Cross catenaries

Cross catenaries consist of wires stretched across the tracks to support the contact wire system. They are sometimes used where erection of poles is impossible due to a narrow space between tracks in a station yard or where long span fixed beams cannot be installed. They do not follow enough against shifting messenger wires, and require maintenance work to adjust them at the time of track layout changes. Therefore it is not recommended to employ cross catenaries in this project.

c) Cantilevers

The cantilevers include rigid type and hinged type. The hinged cantilever allows the contact system to move in the longitudinal direction freely because the joint of the cantilever is hinged to the pole. Because of this feature, it follows against the movement of messenger and contact wires, and easy to adjust the tension of the contact system, thus keeping good contact characteristics.

Furthermore the whole arm of the cantilever is isolated and has a large separation distance to the ground. The stem insulators are put on the deviated side position from the track center and not easily soiled by exhaust gas from diesel locomotives. It is recommended to employ the hinged cantilever mainly in the sections between stations.

2.8.3 Electric Power for Utilization

The exclusively high voltage power distribution lines will not be considered for the lighting and ordinary electric power utilization, considering the improved power distribution network of the Metropolitan Electricity Authority (MEA), full utilization of existing power receiving equipment in the railway stations, and reduction of the project cost. Therefore, electricity for telecommunication and signalling systems and other electrical utilization equipment in stations, such as lighting and machinery including new equipment for elevators and escalators, will be purchased and supplied from the MEA, as done at present.

It is necessary to provide standby generators for power supply to telecommunication and signalling facilities, including heavy duty electrical equipment, at major railway stations and railcar depots. Installation of an extra line transformer connected with the 25KV traction power circuit is a possible alternative power source, however, the quality is not good for the equipment because of its large voltage fluctuation.

It is necessary for the railway and MEA to discuss power receiving at each railway station and railcar depot including installation and maintenance limits of the properties.

2.8.4 Procurement of Major Materials

As a result of the market survey for the major materials to be procured locally, the following items can be successfully procured.

a) Concrete products

Concrete poles, concrete foundation and troughs will be procured domestically. The specifications should be prepared for square shape concrete poles.

b) Steel products

Steel masts, towers, beams and arms will be procured domestically.

c) Electric wire and cable

The electric wires and cables of 115 kV or less will be procured domestically except wires for contact wire systems (especially trolley wire). They will be imported because there is no experience of domestic manufacture.

d) Substation equipment

The transformers, circuit breakers, disconnecting switches, and related panels all will be imported. Recently, G.I.S (Gas Insulated Switchgear) equipment has been generally adopted. Employment of G.I.S, therefore, will be studied together with its cost and maintenance performance.

e) Various fittings

Insulators of 230 kV or more for transmission lines will be imported. However, insulators for the railway electrification will be procured domestically. Specific fittings for overhead contact systems will be imported.

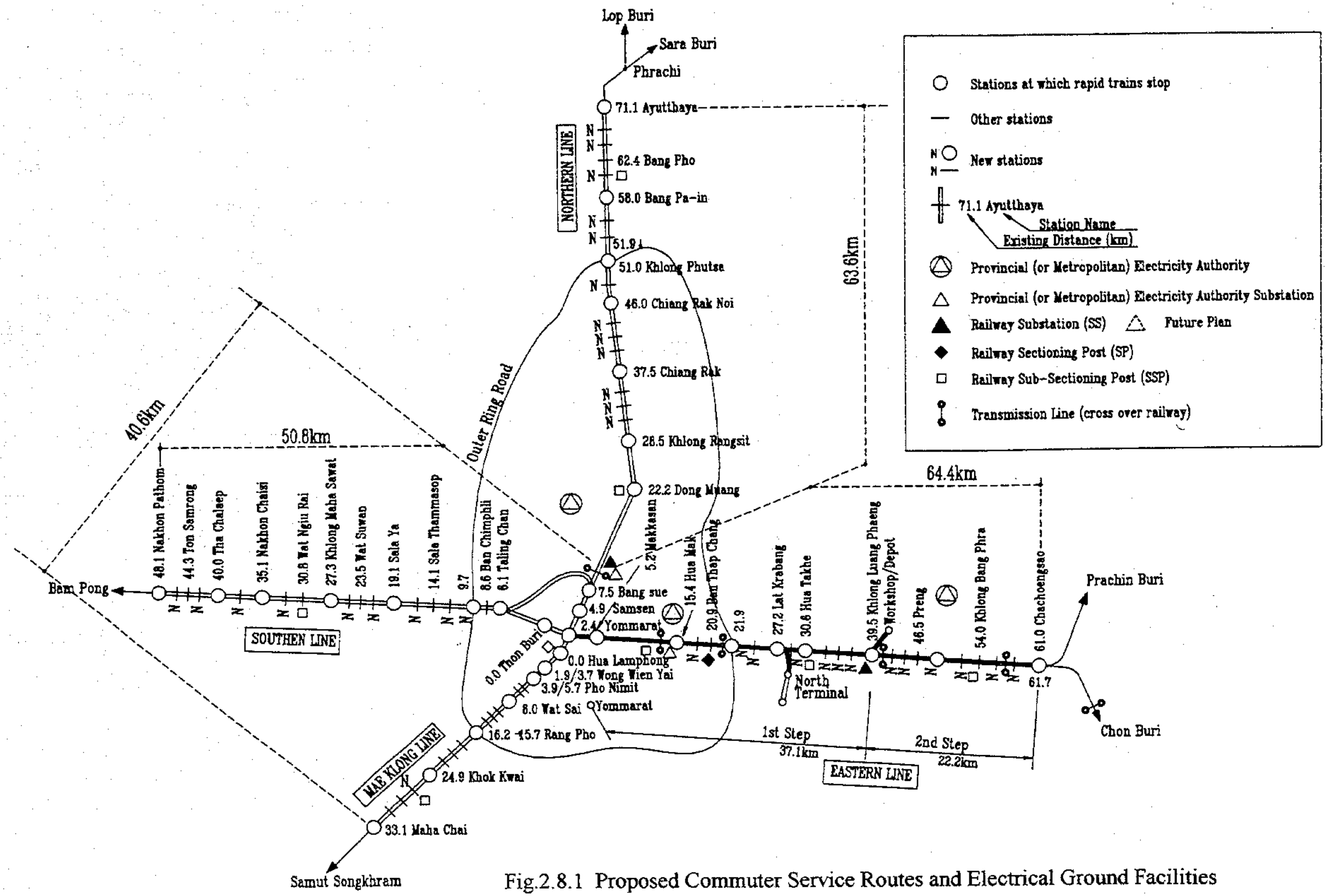


Fig.2.8.1 Proposed Commuter Service Routes and Electrical Ground Facilities

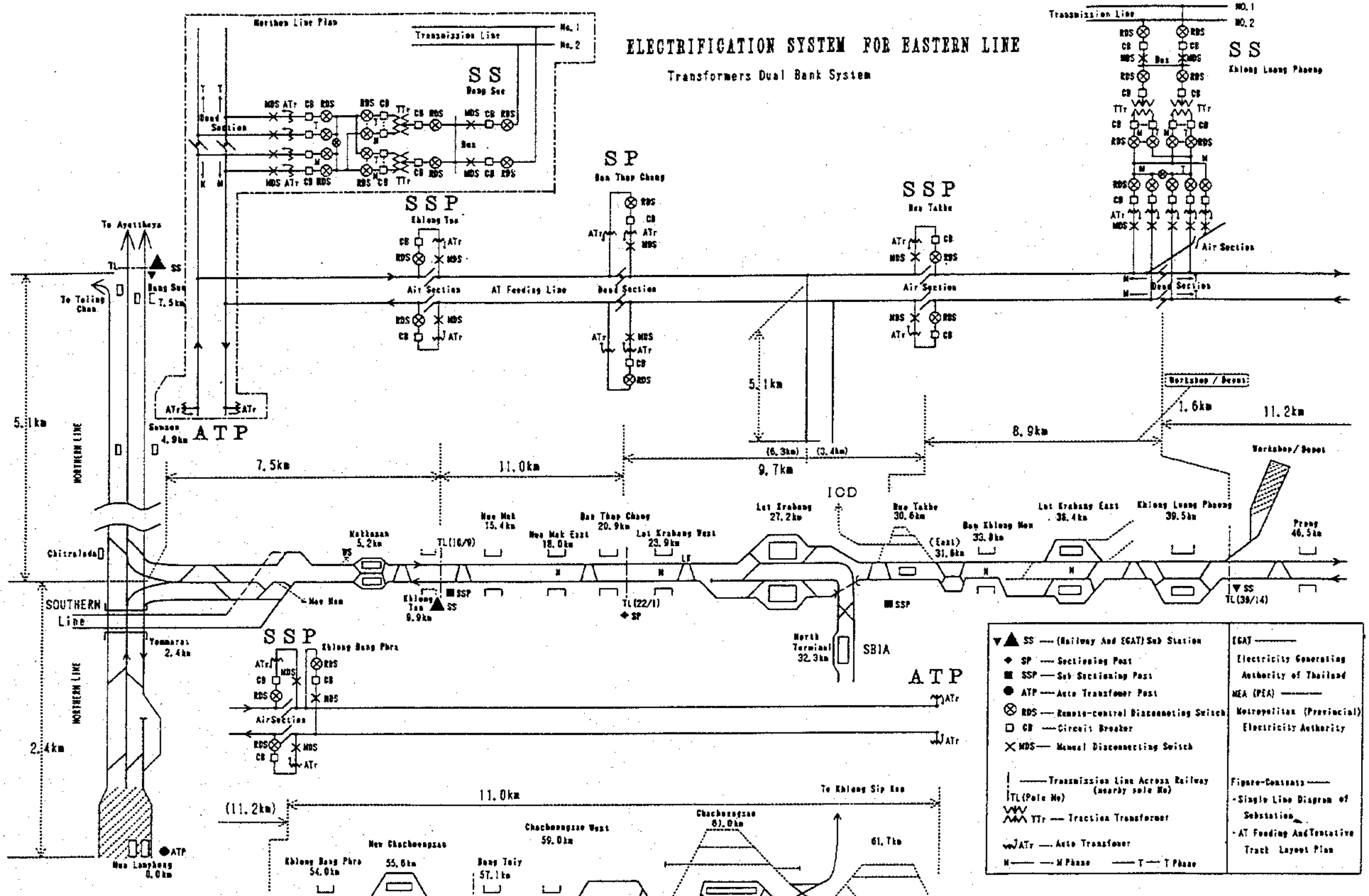


Fig.2.8.2 AT Feeding Line

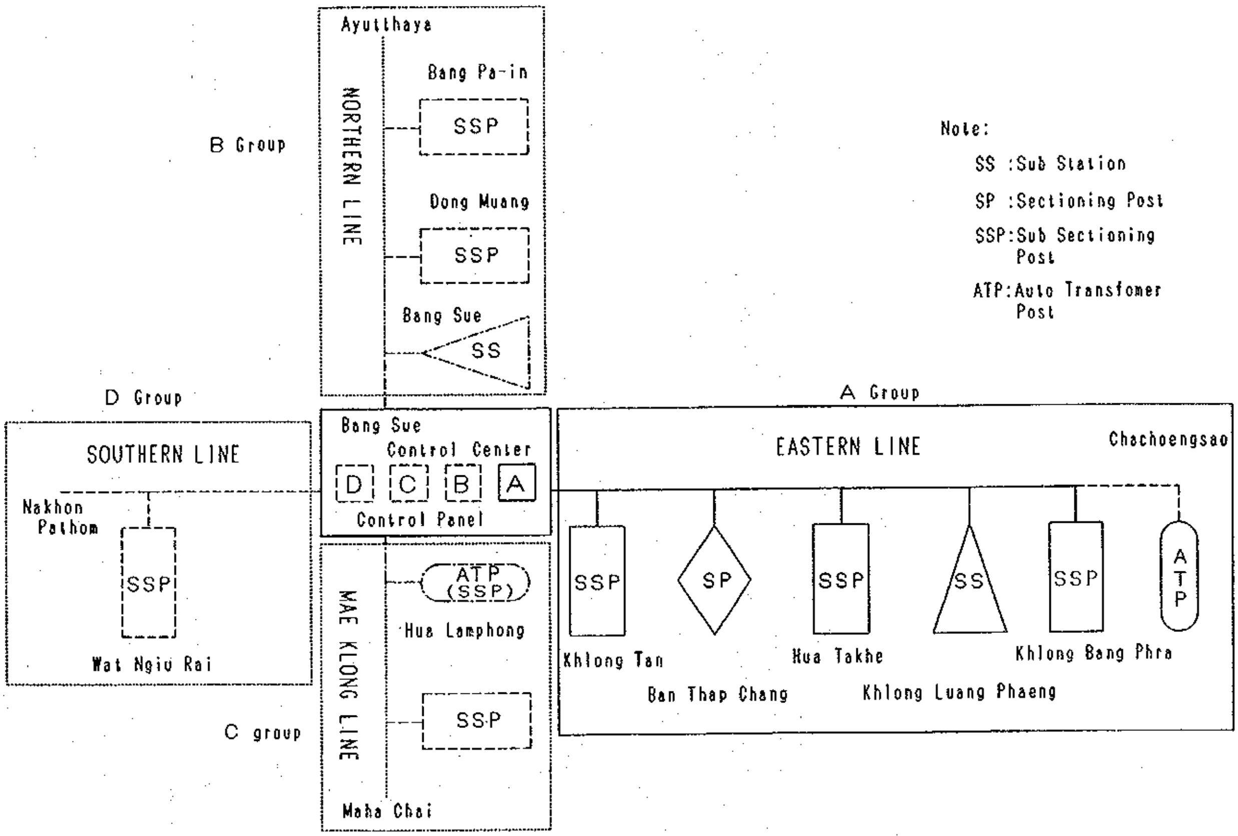


Fig.2.8.3 Central Control System

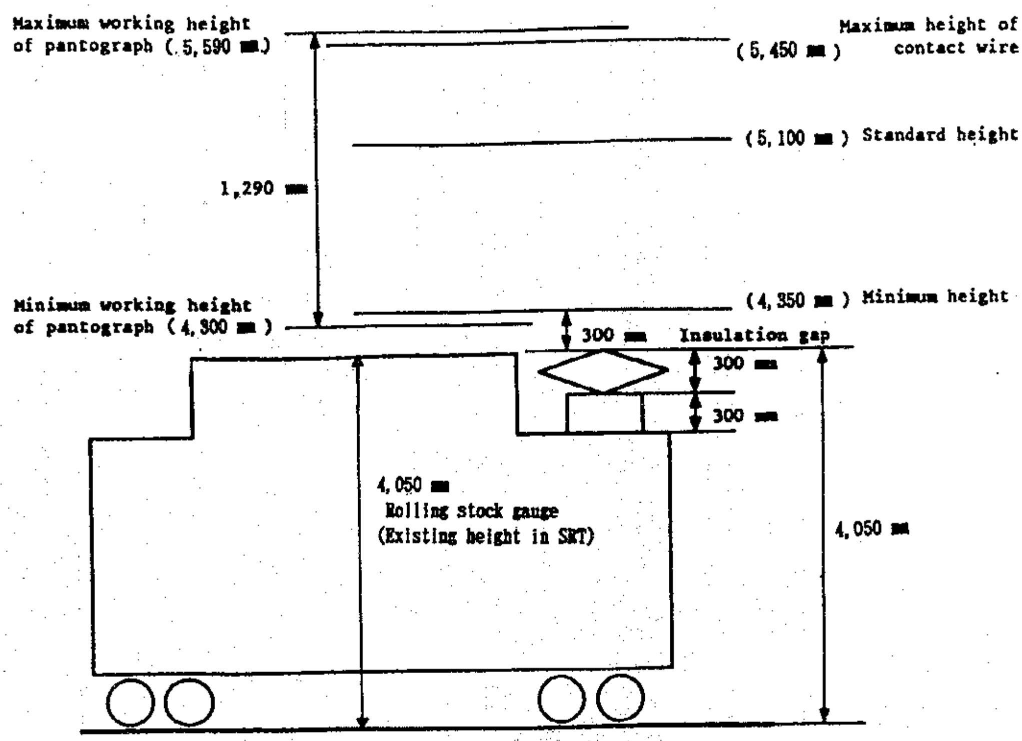


Fig. 2.8.4 Height of Contact Wire and Working Height of Pantograph

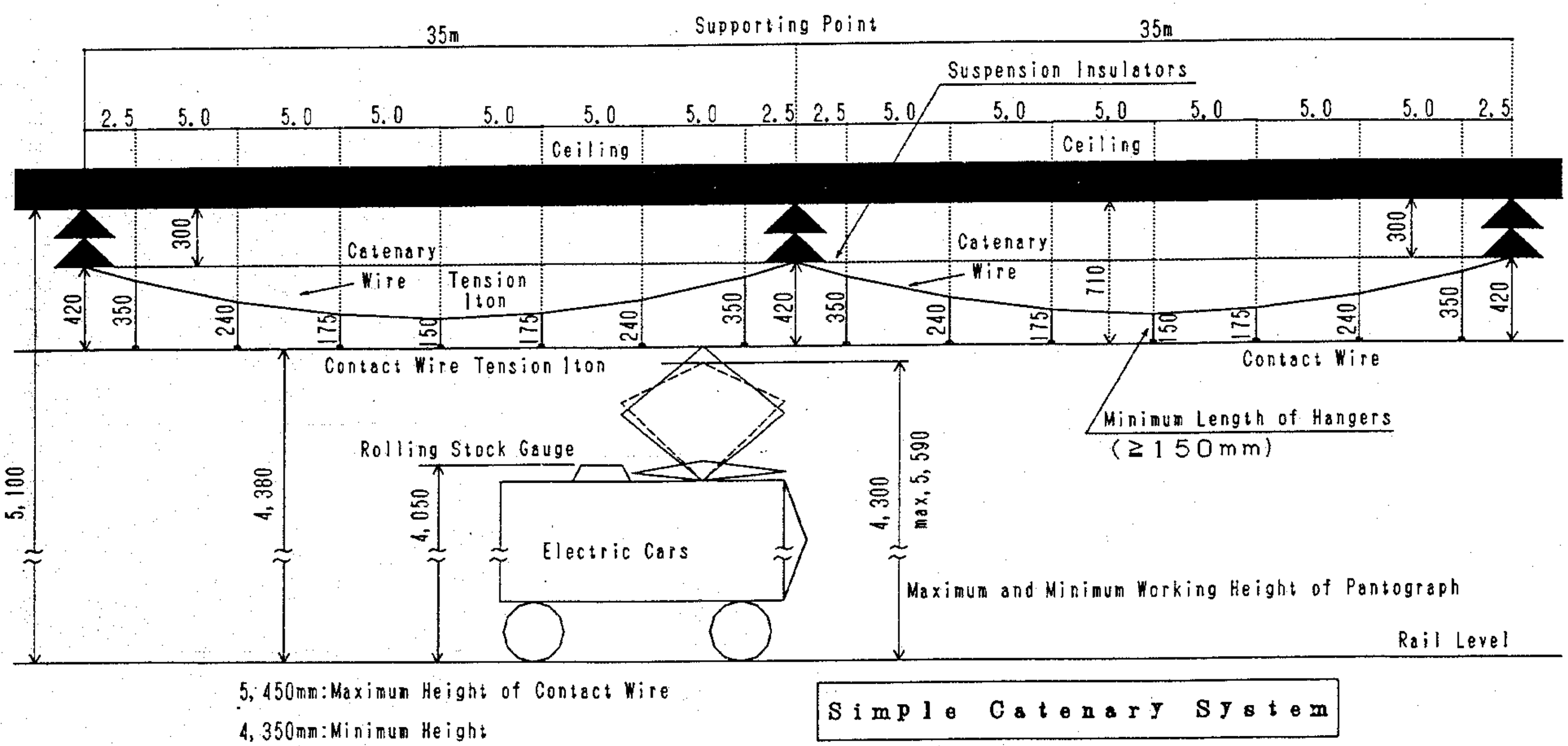


Fig.2.8.5 Contact Wire Height in Underground or Tunnel

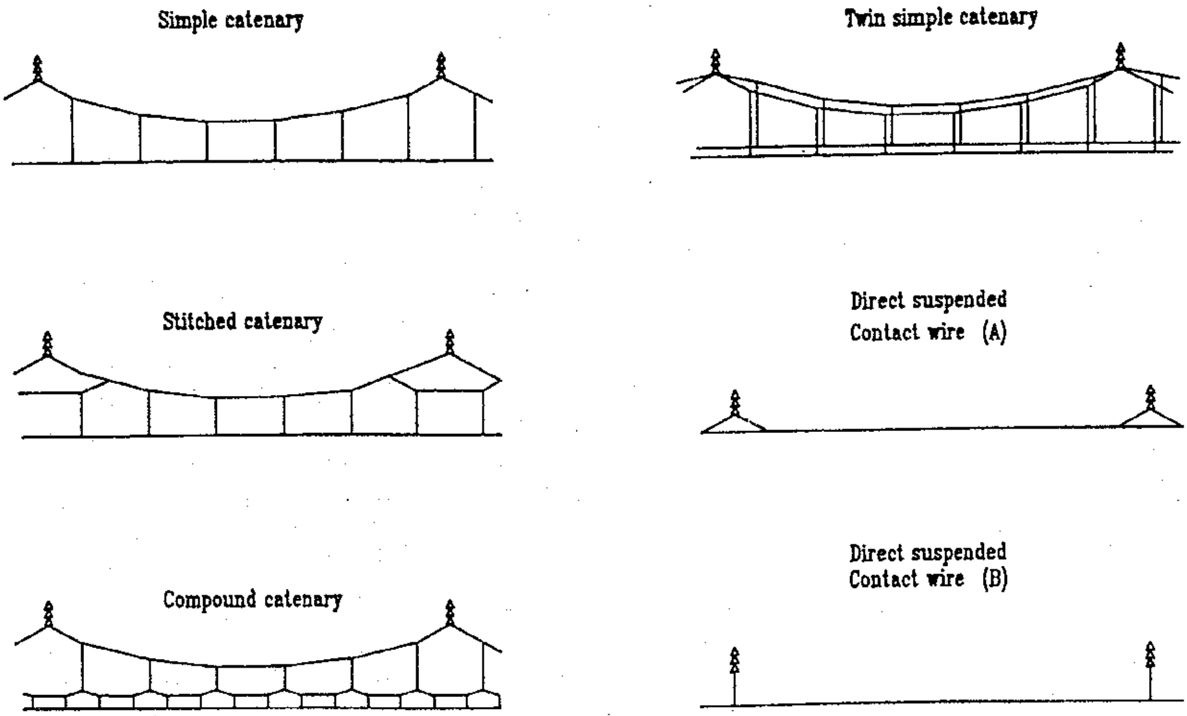


Fig.2.8.6 Type of Contact Wire Systems

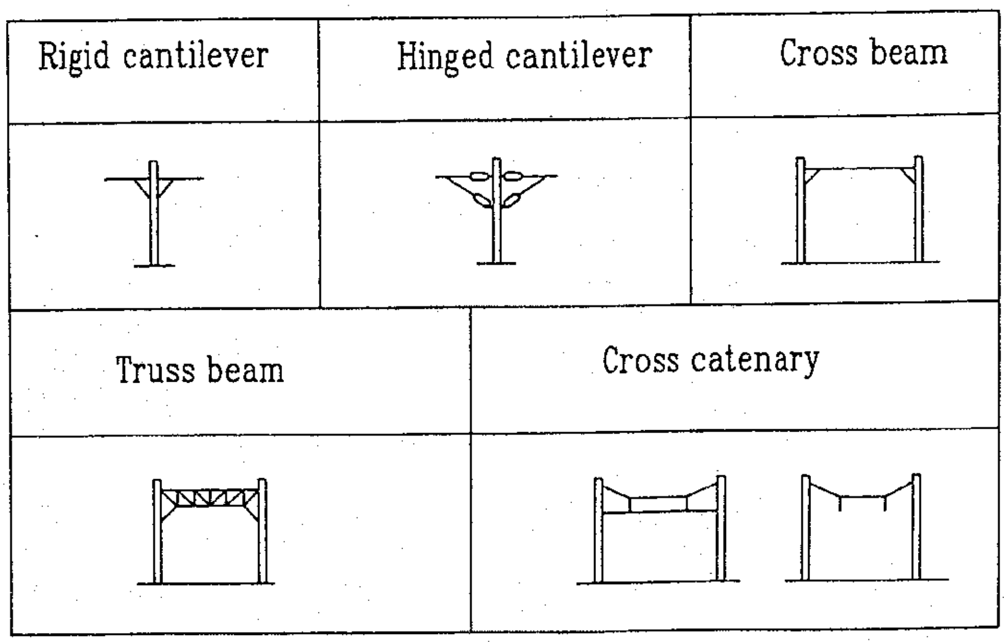


Fig.2.8.7 Type of Supports

Table 2.8.1 Overhead Contact Line System and Their Characteristics

Catenary systems	Standard of wire (mm²)			Tension (ton)	Characteristics		Notes
	Messenger wire	Auxiliary Messenger wire	Contact wire		Allow-able speed	Appli-cable load	
Simple catenary	St 90		GT 110	M:1 T:1	120 (km/h)	Middle load	Basic style
Heavy simple catenary	St 135		GT 110	M:2 T:1	140 (km/h)	Middle load	Little uplift of trolley wire
Stitched catenary	CdCu 60		GT 110	M:1 T:1	120 (km/h)	Middle load	A little uplift of trolley wire than simple catenary
Compound catenary	St 135	PH 100	GT 110	M:1 AM:1 T:1	160 (km/h)	Heavy load	Basic style, Expensive
Directly suspended contact wire			GT 110		50~80 (km/h)	Light load	For low speed train operation, Cheap

Note:
St: Galvanized steel stranded wire
PH: Power, hard drawn copper stranded wire
GT: Hard drawn copper grooved contact wire
CdCu: Cadmium-copper stranded wire
M: Catenary wire
AM: Auxiliary catenary wire
T: Contact wire

2.8.5 Inductive Interference by AC Electrification

Although the quantity of electromagnetic induction to outside facilities will be suppressed to an extent by adopting an AT feeding system as a generating-side countermeasure, some facilities in the vicinity of the electrification section will have to be improved to avoid interference affection.

(1) Measurement of earth conductivity and calculation of induction quantity

Measurement of earth conductivity at several points along the Eastern Line and calculation of induction quantity about the area within 300 meters on both sides of the railway track will be implemented in the detail-design stage. Since the induction quantity changes in accordance with the value of traction current and the location of running electric railcars as shown in Fig.2.8.8, the calculation is so complicated that it will be implemented using a computer.

The result of the calculation should be handed over to the concerned organizations at an early stage, and agreements will be concluded between the concerned organizations and the SRT.

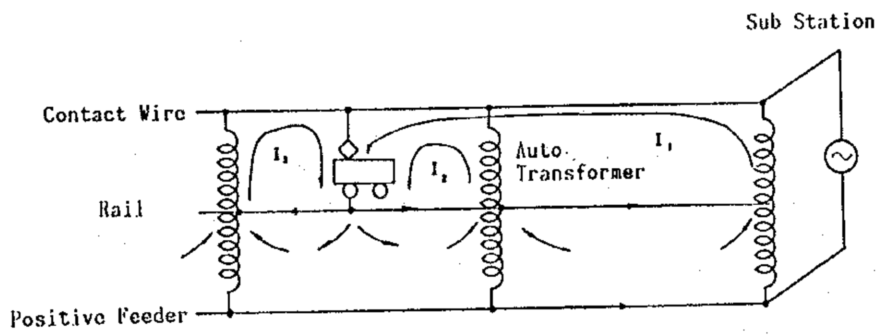


Fig.2.8.8 Traction Current in AT Feeding System

(2) Countermeasures against inductive interference

Generally, telecommunication bare wires/cables and commercial-frequency track circuits are the main items to be affected, however, the latter is not used at present in Thailand. The Hopewell Project will presumably adopt AF track circuits that are immune from AC induction interference. AC induction falls into normal/abnormal electromagnetic induction and static induction. Countermeasures will be executed in accordance with the limiting value of induced voltage recommended by the CCITT.

(3)TV interference

Various kinds of interference from a electrified railway can occuras shown in Fig.2.8.9. Acommon TV receiving system will be adopted if the interference is of a high level.

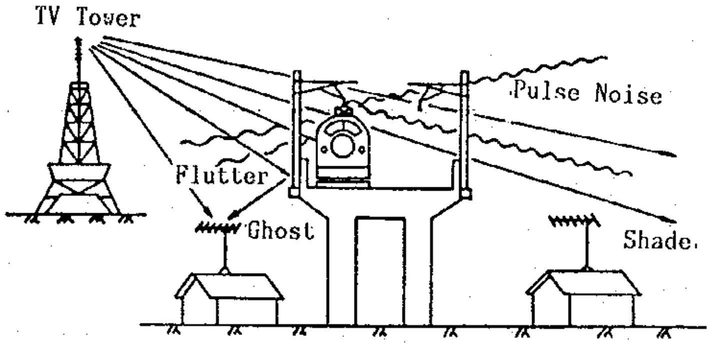


Fig. 2.8.9 TV Interferences from Electrical Railways

2.9 Crossings with Road

2.9.1 Grade Separated Crossings

At-grade crossings are dangerous both for road traffic and railway traffic, and cause the traffic volume to be restricted. It is better to sweep away all at-grade crossings. The at-grade crossings that pass automobiles should be grade-separated. In the commuting section, trains will pass frequently with high speed, so at least some safety devices should be installed.

At present, trains reduce their speed at crossings, thus affecting reliable train operation. Crossings also interrupt road traffic and cause congestion.

In the development of the Eastern Line area, not only railway operation volume but also road traffic volume will increase and the railway will operate 24 or more trains in one hour during rush hours. This will cause far more traffic interruption at the crossings. For urban development and reliable and safe train operation, grade separation of railways and main roads is required.

For grade separation, a railway or a road may be placed underground or elevated. An underground system is generally more costly in its construction and maintenance, and furthermore, dangerous in heavy squall accidents. Therefore, in general, elevation is preferable. From the view point of promoting city development and effective use of land, it is better to elevate the railway continuously in the city area. However, from the economic view, in general, to elevate roads is easier.

Comparison of an elevated road with an underground road in a typical case is as follows.

Width of road	8m
Width of right-of-way of railway	40m
Maximum gradient of road	7%
Type of structure	
Elevated road	Reinforced concrete girders and piers
Underground road	Reinforced concrete box culvert / U-type retaining wall

Construction cost		
Elevated road		120 million baht
Underground road (including pumping facilities)		150 million baht
Maintenance requirement		
Elevated road	Little	
Underground road	Examination / repair and electric charges for pumping facilities	
others		
Underground road	Risk caused by concurrence of heavy rainfall and pump trouble.	

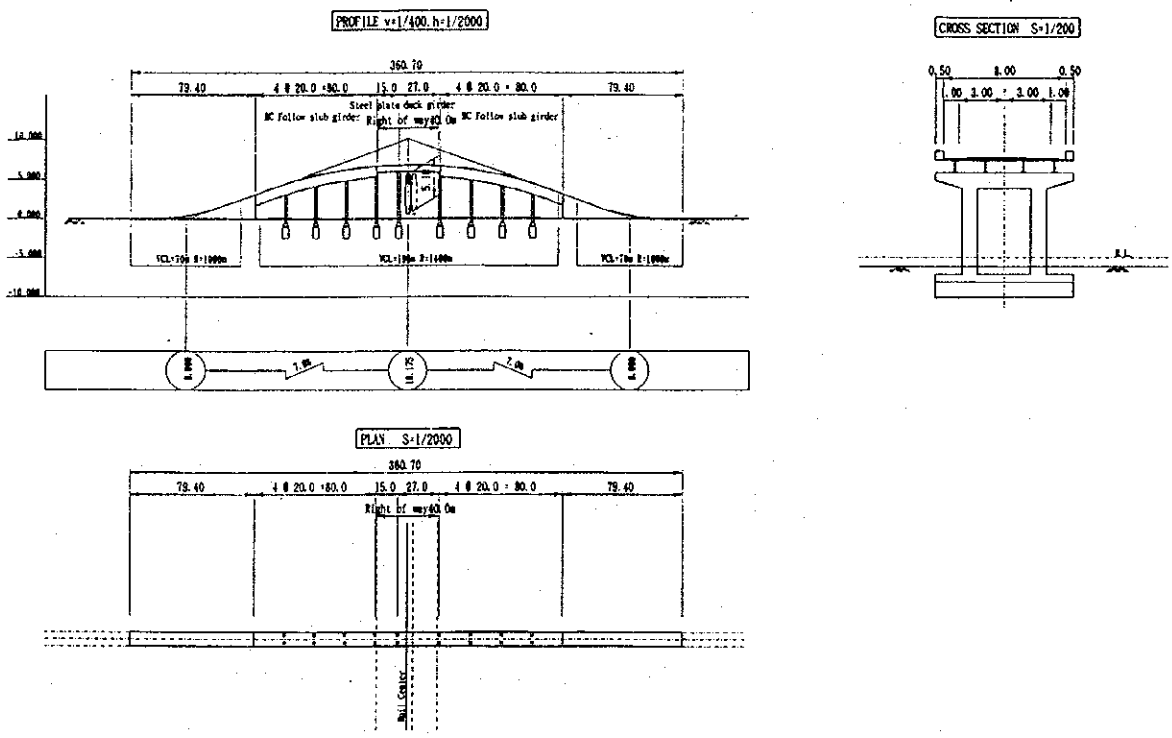
Drawing of a typical elevated road and underground road is shown in Fig. 2.9.1.

An elevated road is better than an underground road because of lower construction costs and small maintenance requirements, unless special site conditions exist.

On the Eastern Line between Hua Mak and Chachoengsao, every main road crossing should be grade separated. The crossing at 15km529m will be taken off by the Hopewell project. The crossings at 16km752m, 30km337m, 33km966m, 38km781m, 45km456m and 60km153m should be swept out by elevating roads. At the crossing at 26km931m, the DOH project plans to elevate the road. (For the estimation of project costs, the crossing at 60km153m is assumed to be improved by the road administrater because of the importance of the trunk road.)

At the crossings at 29km777m, 43km560m and 50km950m crossing alarms and barriers should be installed.

Alt-1 Over bridge



Alt-2 Under Pass

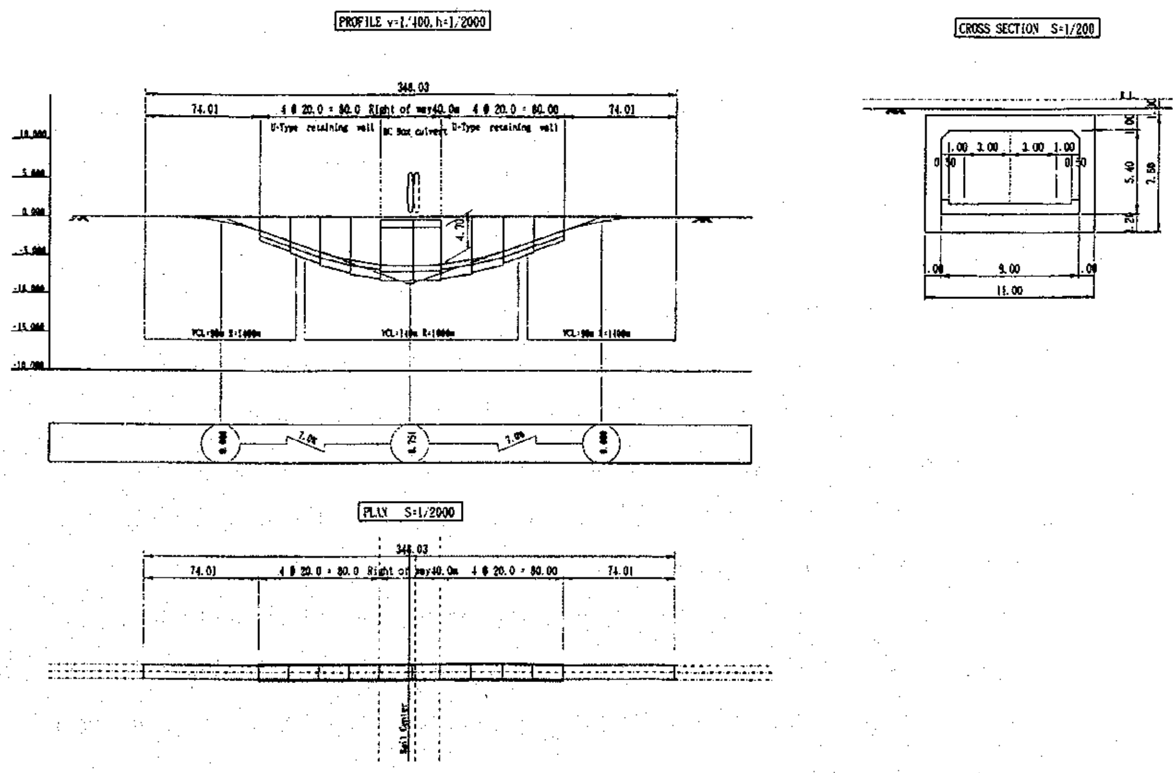


Fig. 2.9.1 Typical Elevated Road and Underground Road

2.9.2 Safety Devices for At-grade Crossings

At-grade crossing facilities fall into three classifications in the SRT as follows.

Type A : Manual operation (Controlled crossings)

A1 : Electrical full or half width lifting barrier.

A2 : Mechanical full or half width lifting barrier.

A3 : Mechanical full width hoisting barrier.

A4 : Sliding barrier (Trolley).

Type B : Automatic operation

B1 : Automatic half width lifting barrier and flashing light warning.

B2 : Open crossing with flashing light warning.

Type C : Unprotected

C : No protection except road traffic warning signs.

The SRT's criterion for construction of crossing equipment is shown below.

Traffic Moment	Type of Crossing
< 10,000	Traffic Signs
10,000 to 40,000	Automatic Level Crossing with Warning Flashing Lights
40,000 to 100,000	Electrical Full or Half Width Lifting Barriers by Manual Operation
>100,000	Overpass

Note: Traffic moment equals number of road vehicles times number of trains passing that crossing within 24 hours.

Improvement of at-grade crossing protection is one of the most important items for high speed traffic operation. Grade up of at-grade crossings protection and equalization of warning time should be implemented in this project.

(1) Grade up of at-grade crossing protection

The greater part of at-grade crossings between Yommarat and Chachoengsao will be replaced with grade separated crossings in this project and other projects. As for the remaining at-grade crossings between Yommarat and Chachoengsao, and between Chachoengsao and Map Ta Phut, improvement from C, B1 and B2 type to B1f type, i.e. with full width lifting barrier type, will be implemented in this project.

Fig.2.9.2 shows a sample of level crossing protection system with full width lifting barriers. In this figure, the left side lifting barriers shall be lowered at first, then the right side ones shall be lowered. However, if the road width is less than 4.5 meters, single barriers covering the full width of the road can be used.

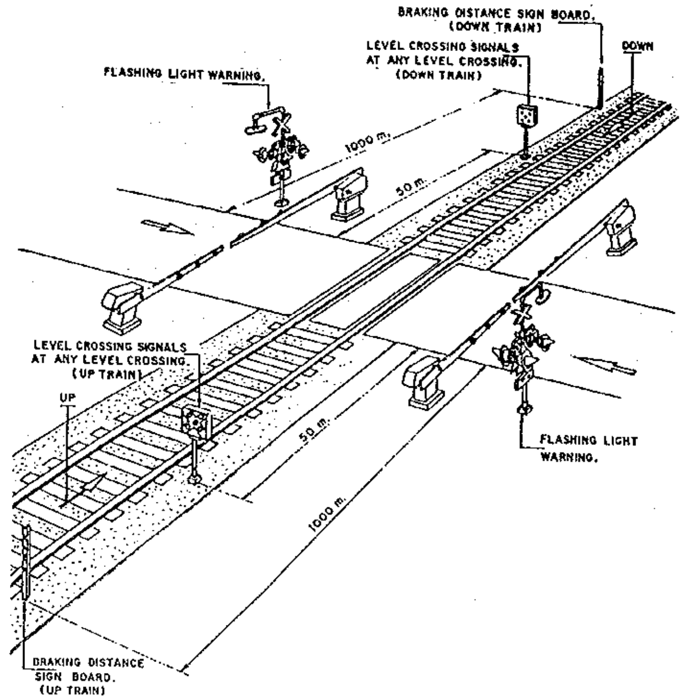


Fig.2.9.2 At-grade Crossing Protection with Full Width Lifting Barriers (B1f)

(2) Equalization of warning time

The difference between maximum speed 120km/h of electric/dieselcar and minimum speed 40km/h of existing freight trains will cause a considerable amount of warning time imbalance. For instance, B1 type protection requires a minimum warning time of 37 seconds, i.e. a warning distance of 1,233 meters at the maximum train speed of 120 km/h. On the other hand, the existing freight train running at 40 km/h will take 111 seconds for passing through this section, therefore, the warning time difference will be 74 seconds which will probably make the road-users distrustful of the level crossing protection.

Japan Railways has a criterion that makes the warning time, despite train assortment, within 20 to 60 seconds, or if it is difficult to attain, makes the difference value between maximum and minimum warning time within 40 seconds.

Generally, there are two methods for equalization of warning times as follows.

① receive train assortment from train

② detect train speed at wayside

The former method can not be adopted because the existing lower speed trains, which an at-grade crossing needs to get information from, will not carry the ATS-P cab system in this project. Therefore, the latter will be adopted.

Fig.2.9.3 shows a sample of at-grade crossing protection system using train speed detectors. The train speed detectors at points A and B detect train speed, and if the detected speeds exceed the set values then an alarm is immediately set off, or if it is lower than the set values, the start of alarm shall be reserved until the next alarm points. C point is a final alarm point. In this case, it is important to assure at least a minimum alarm time if a train accelerates at the highest acceleration rate after passing through the alarm point at a low speed.

As for reverse-direction operation in double track sections, the alarm time equalization method will not be adopted because it rarely is operated.

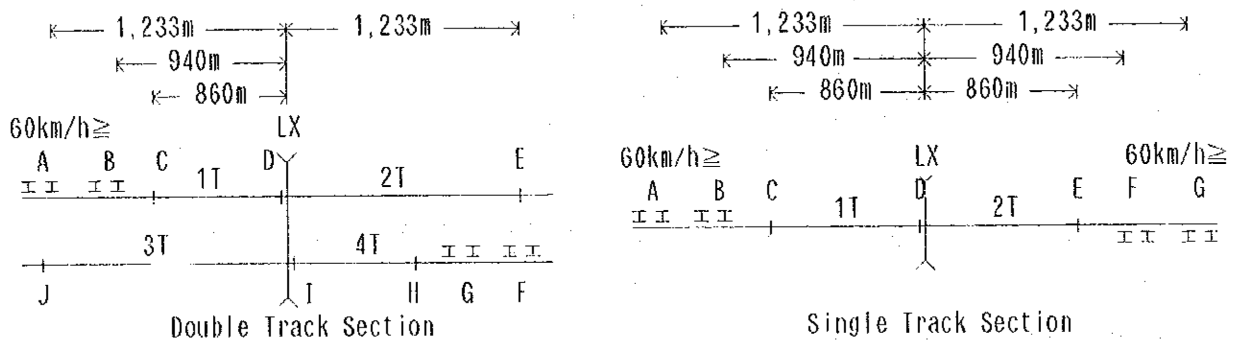


Fig.2.9.3 At-grade Crossing Protection System Using Train Detectors

A short length non-insulator-section track circuit or axle counter can be adopted for the train speed detectors. The latter type is excellent in accuracy and stability.

Fig.2.9.4 shows a sample of train speed detector using axle counters.

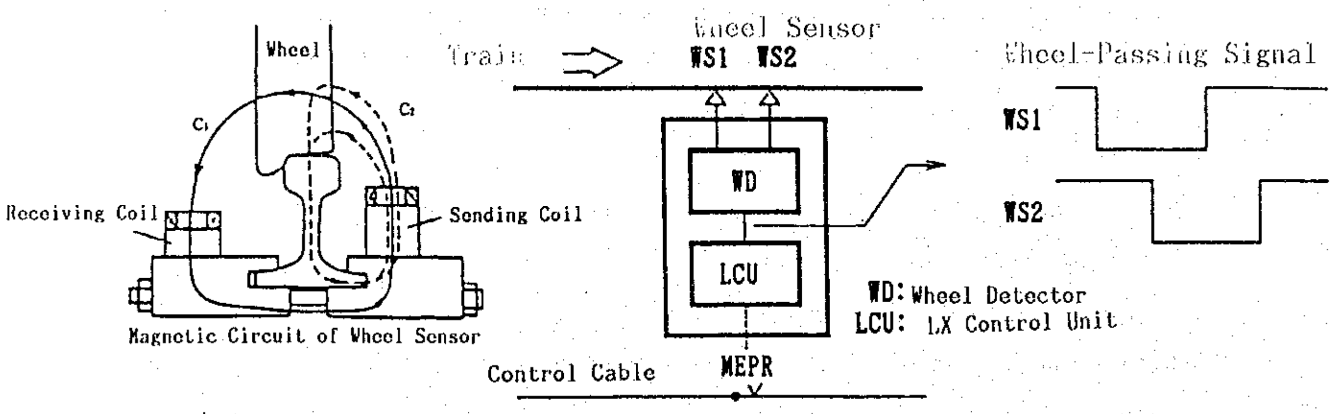


Fig.2.9.4 Train Speed Detector Using Axle Counters

Table 2.9.1 shows the at-grade crossings to be improved in this project. The total numbers of each type are as follows.

Grade separated in this project	:	7
A1 type alarm time improvement	:	31
B1 to B1f and alarm time improvement	:	57
B2 to B1f and alarm time improvement	:	13
C to B1f and alarm time improvement	:	7
Total	:	115

In fact, there are many unofficial level crossings, unprotected and of zero road width at present, which are not included in the list to be improved in this project. The SRT has to promote arrangement and integration of them so as to secure stabilized transportation.

Table 2.9.1-1 Improvement of At-grade Crossing (Hua Mak ~Chachoengsao)

No.	Location	Width	Ex. LX Type	Improvement Plan
1	15.529	24.0m	A1	(Grade separated LX by Hopewell)
2	16.752	5.5	A3	→ Grade separated LX
3	26.931	12.0	A1	(Grade separated by DOH Proj.)
4	29.777	8.0	B1 #	→ B1f and alarm time impr.
5	30.337	7.0	A1 #	→ Grade separated LX
6	33.966	8.0	A3	→ Grade separated LX
7	38.781	8.0	B1 #	→ Grade separated LX
8	43.560	3.0	C	→ B1f and alarm time impr.
9	45.456	6.0	B1 #	→ Grade separated LX
10	50.950	4.0	C	→ B1f and alarm time impr.
11	60.153	6.5	A3	→ Grade separated LX

Note ; # shows the at-grade crossing (LX) type after improvement by SRT.
; B1f shows B1 type with full width lifting barrier.

Table 2.9.1-2 Improvement of At-level Crossing (Chachoengsao~Khao Chi Chan)1/3

No.	Location	Width	Ex. LX Type	Improvement Plan
1	61.274	6.0	B1 #	→ B1f and alarm time impr.
2	62.052	4.0	B1 #	→ Grade separated LX
3	62.732	5.0	B1 #	→ B1f and alarm time impr.
4	66.143	6.0	B1 #	→ B1f and alarm time impr.
5	68.334	7.8	B2	→ B1f and alarm time impr.
6	71.038	7.2	B2	→ B1f and alarm time impr.
7	71.920	7.2	B2	→ B1f and alarm time impr.
8	73.143	8.0	C	→ B1f and alarm time impr.
9	75.654	9.0	A1	Alarm time improvement.
10	82.343	6.0	B2	→ B1f and alarm time impr.
11	83.268	12.0	B1 #	→ B1f and alarm time impr.
12	84.254	6.0	B1 #	→ B1f and alarm time impr.
13	85.315	6.0	B1 #	→ B1f and alarm time impr.
14	86.952	7.0	B1 #	→ B1f and alarm time impr.
15	88.123	14.0	B2	→ B1f and alarm time impr.
16	88.717	6.0	B1 #	→ B1f and alarm time impr.
17	90.524	6.0	B1 #	→ B1f and alarm time impr.
18	90.593	6.0	B1 #	→ B1f and alarm time impr.
19	91.208	6.0	A1	Alarm time improvement.
20	92.141	10.2	A1	Alarm time improvement.
21	92.893	6.0	B1 #	→ B1f and alarm time impr.
22	96.103	12.0	B2	→ B1f and alarm time impr.
23	97.397	6.0	B2	→ B1f and alarm time impr.
24	99.138	10.8	B1 #	→ B1f and alarm time impr.
25	99.595	6.0	B1 #	→ B1f and alarm time impr.
26	100.234	6.0	B1 #	→ B1f and alarm time impr.

Table 2.9.1-3 Improvement of At-grade Crossing (Chachoengsao~Khao Chi Chan)2/3

No.	Location	Width	Ex. LX type	Improvement Plan
27	100.816	6.0	B1 #	→ B1f and alarm time impr.
28	101.509	13.2	A1 #	Alarm time improvement.
29	103.200	6.0	B1 #	→ B1f and alarm time impr.
30	103.664	6.0	B1 #	→ B1f and alarm time impr.
31	104.162	6.0	C	→ B1f and alarm time impr.
32	107.124	9.0	A1	Alarm time improvement.
33	108.490	9.0	A1	Alarm time improvement.
34	109.319	6.0	B1 #	→ B1f and alarm time impr.
35	109.770	6.0	B1 #	→ B1f and alarm time impr.
36	111.061	6.0	B1 #	→ B1f and alarm time impr.
37	111.685	8.0	A1	Alarm time improvement.
38	112.620	6.0	B1 #	→ B1f and alarm time impr.
39	113.049	6.0	B1 #	→ B1f and alarm time impr.
40	113.954	9.0	B1 #	→ B1f and alarm time impr.
41	114.565	9.0	A1 #	Alarm time improvement.
42	115.440	6.0	B1 #	→ B1f and alarm time impr.
43	116.711	9.0	A1 #	Alarm time improvement.
44	117.179	11.4	A1 #	Alarm time improvement.
45	117.787	6.0	B1 #	→ B1f and alarm time impr.
46	118.350	6.0	B1 #	→ B1f and alarm time impr.
47	118.811	6.0	B1 #	→ B1f and alarm time impr.
48	119.680	6.0	B1 #	→ B1f and alarm time impr.
49	120.310	6.0	A1	Alarm time improvement.
50	122.700	9.0	B2	→ B1f and alarm time impr.
51	123.980	10.2	A1	Alarm time improvement.
52	125.020	9.0	A1	Alarm time improvement.
53	125.551	9.0	A1 #	Alarm time improvement.
54	126.573	6.0	B1 #	→ B1f and alarm time impr.
55	128.431	15.0	A1 #	Alarm time improvement.
56	130.178	9.0	A1	Alarm time improvement.
57	133.219	6.0	B1 #	→ B1f and alarm time impr.
58	134.270	24.0	A1	Alarm time improvement.
59	135.601	6.0	B1 #	→ B1f and alarm time impr.
60	137.139	6.0	B1 #	→ B1f and alarm time impr.
61	138.064	9.0	B2	→ B1f and alarm time impr.
62	139.938	6.0	B1 #	→ B1f and alarm time impr.
63	140.792	6.0	B1 #	→ B1f and alarm time impr.
64	141.790	7.2	A1 #	Alarm time improvement.
65	142.551	9.0	A1 #	Alarm time improvement.
66	144.418	6.0	A1	Alarm time improvement.
67	145.610	9.0	A1 #	Alarm time improvement.
68	149.520	6.0	B1 #	→ B1f and alarm time impr.
69	150.024	12.0	A1 #	Alarm time improvement.
70	151.205	6.0	B1 #	→ B1f and alarm time impr.
71	152.349	9.0	A1 #	Alarm time improvement.

Table 2.9.1-4 Improvement of At-grade Crossing (Chachoengsao~Khao Chi Chan)3/3

No.	Location	Width	Ex. LX type	Improvement Plan
72	153.238	6.0	B1 #	→ B1f and alarm time impr.
73	154.054	9.0	B1 #	→ B1f and alarm time impr.
74	155.755	15.0	A1	Alarm time improvement.
75	156.897	9.0	A1 #	Alarm time improvement.
76	157.986	9.0	B1 #	→ B1f and alarm time impr.
77	158.736	6.0	B1 #	→ B1f and alarm time impr.
78	159.783	9.0	B1 #	→ B1f and alarm time impr.
79	160.361	6.0	B1 #	→ B1f and alarm time impr.
80	160.914	6.0	B1 #	→ B1f and alarm time impr.
81	161.803	7.2	A1 #	Alarm time improvement.
82	162.301	9.0	A1 #	Alarm time improvement.
83	162.902	6.0	B1 #	→ B1f and alarm time impr.
84	163.554	6.0	B1 #	→ B1f and alarm time impr.
85	164.700	10.2	B2	→ B1f and alarm time impr.
86	165.424	6.0	B1 #	→ B1f and alarm time impr.
87	166.102	6.0	B1 #	→ B1f and alarm time impr.
88	168.797	9.0	A1	Alarm time improvement.
89	169.709	9.0	A1 #	Alarm time improvement.
90	170.232	6.0	B1 #	→ B1f and alarm time impr.
91	171.027	9.0	A1 #	Alarm time improvement.
92	172.014	10.2	B2	→ B1f and alarm time impr.
93	172.783	6.0	B1 #	→ B1f and alarm time impr.
94	172.550	6.0	B1 #	→ B1f and alarm time impr.
95	174.024	7.8	A1 #	Alarm time improvement.
96	174.069	7.2	B1 #	→ B1f and alarm time impr.
97	176.388	6.0	B1 #	→ B1f and alarm time impr.
98	177.150	6.0	B1 #	→ B1f and alarm time impr.
99	178.358	6.0	B1 #	→ B1f and alarm time impr.
100	179.314	6.0	B1 #	→ B1f and alarm time impr.

Table 2.9.1-5 Improvement of At-grade Crossing (Khao Chi Chan ~Map Ta Phut)

No.	Location	Width	Ex. LX type	Improvement Plan
1	180.650	4.0m	C	→ B1f and alarm time impr.
2	183.020	3.0	C	→ B1f and alarm time impr.
3	185.900	3.0	B1	(Grade separated by SRT)
4	191.600	5.5	B1	→ B1f and alarm time impr.
5	193.870	2.5	B2	→ B1f and alarm time impr.
6	194.420	3.0	B1	(Grade separated by SRT)
7	195.210	4.0	B2	(Grade separated by SRT)
8	196.550	4.0	C	→ B1f and alarm time impr.
9	197.550	4.0	B2	(Grade separated by SRT)
10	198.330	2.5	B2	→ B1f and alarm time impr.

2.10 Station Plaza and Interface with Access Means

2.10.1 Necessary Facilities for Station Plaza

Access to road traffic is an important subject for railway transport. Railways may transport only from station to station. Passengers require some access means. An easy transfer system between railways and road transport means or other mass rapid transit systems will be necessary. Especially at commuting stations, a large number of passengers will be required to transfer in short time.

All railway stations need station plazas for access to road transport means. For a station plaza, a bus stop, a taxi stop and pool, a private-car stop, a footpath and access pass from the main road are necessary. If there is some room around a station, it is desirable to provide a parking area for private cars also.

A station plaza connects a railway with the surrounding area and roads, and have the functions described below.

(a) Approach road and traffic

As a station plaza is provided for the transfer between railways and roads, every station plaza needs to connect to a road. The approach road should have enough width for railway passengers to pass. Only one or two entrances should be provided for a station plaza to connect with a road so as not to disturb the road traffic. Traffic in the station plaza, preferably, should be one way.

(b) Bus transfer facilities

A bus is a principal mode in the city area. A railway must connect to bus routes. Bus stops are necessary in a station plaza. A number of bus stops should be decided according to the passenger volume and frequency of buses.

For the design of bus bays, it is necessary to secure the safety of passengers by separating passenger and vehicular traffic. If construction of a station plaza is not feasible due to various constraints of land use around the station, bus stops along the road nearest to railway stations should be constructed so as to make it convenient for the transferring passengers.

(c) Taxi bays

Taxis and tuktuks are indispensable transport means for passengers. Properly controlled taxis should operate in station plazas. A station master should be responsible for controlling taxis that operate in the station plaza. Railway passengers arrive at a station intermittently, so a taxi pool is necessary to adjust to such undulation.

(d) Private-car stops and parking lots

To connect with road traffic, private-car stops are necessary. Private cars are difficult to control, so a private-car area should be separated from the bus area. If there is enough land around the station, it is desirable to prepare a car-parking area for private-car owners. The construction cost of a parking lot may be borne by car owners through a parking fee.

(e) Bicycle/motorcycle parking lots

Bicycles or motorcycles are convenient means for passengers to move from their homes to the stations. To promote using the railways, it is effective to provide some parking spaces for bicycles and motor-cycles at suburban stations.

(f) Pedestrian passages

Moving on foot is the most convenient and economic transport means. Pedestrian passages should be provided so as not to check the flow of passengers. A footpath should be provided along a short course to town.

(g) Community service facilities

Railway stations should be an important traffic center of an area. Some community service facilities or shops may be provided in a station building. It may be an amenity plaza and a town landmark.

2.10.2 Scale of Station Plaza

A formula to calculate the area of a station plaza is shown in "1.6.4".

Another way to decide the area of station plaza is to total all the necessary areas (stops and pools for bus, taxis and private cars, pedestrian space, etc.).

2.10.3 Some Examples of Station Plazas

Some considered examples of station plazas are shown in Fig. 2.10.1, Fig. 2.10.2.

(1) Hua Takhe	28,000passengers/day	Necessary scale 3,500 m^2
(2) Chachoengsao	35,000passengers/day	Necessary scale 4,500 m^2

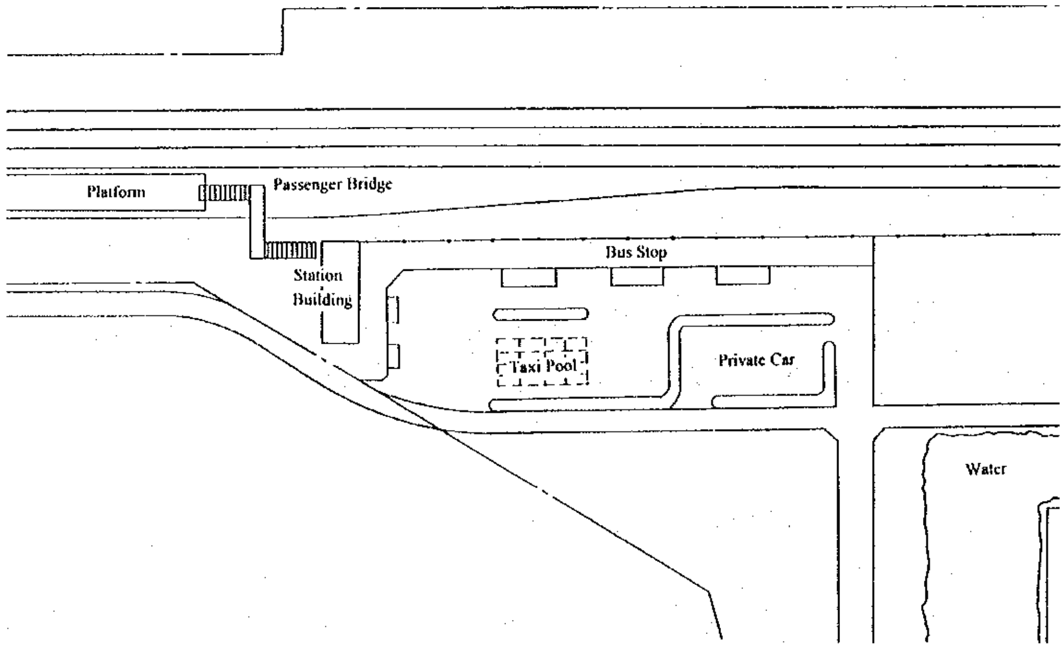


Fig. 2.10.1 An Example of Station Plaza (Hua Takhe Sta.)

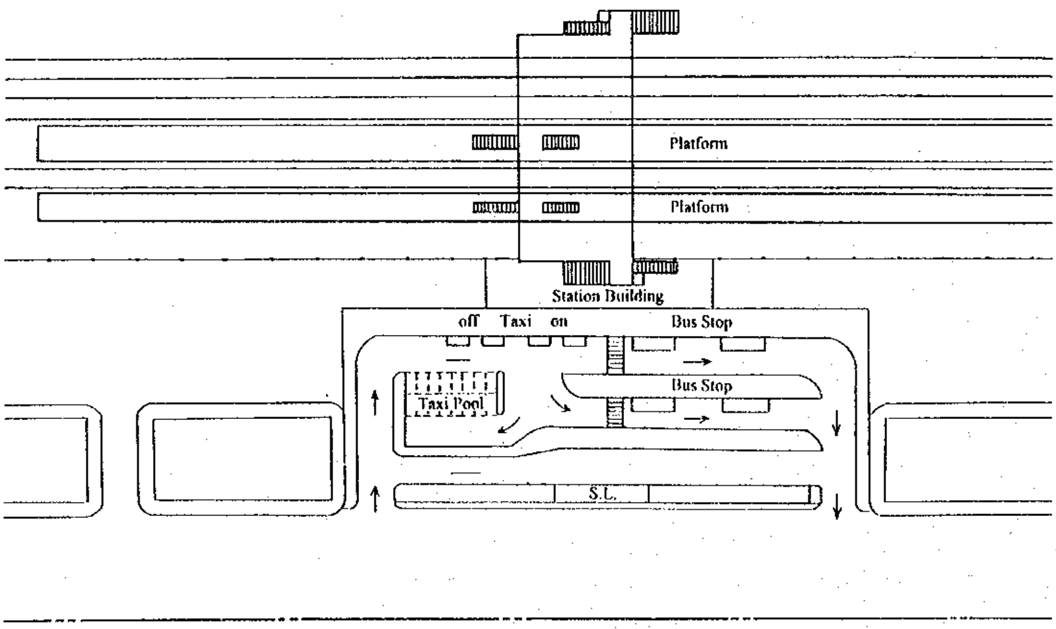


Fig. 2.10.2 An Example of Station Plaza (Chachoengsao Sta.)

2.11 Investment Cost

(1) Prerequisite for estimation of investment cost

In order to evaluate the project, investment cost is estimated first on the result of demand forecast and service/transport plan. The prerequisite for estimation of construction costs and rolling stock procurement cost is as follows.

(a) Track elevation and double-tracking between Yommarat and Hua Mak by the Hopewell Project and double-tracking between Hua Mak and Chachoengsao by the preceding project of the SRT will be completed by the year 2000. Therefore, such cost is not included in the cost estimation of this Feasibility Study Project. (The double-tracking project will only provide an additional main track, so that necessary tracks in station yards such as refuge tracks, lead tracks, etc. are included in this cost estimation.)

(b) According to the SBIA plan, railway infrastructure in the SBIA area will be provided as grand access facilities by the SBIA project. Therefore, the cost of track, electrification, signalling, telecommunication and station facilities are included in this cost estimation.

(c) The basically adopted prices are those of 1994, when the Study (F/S) in Thailand was carried out.

(d) Value-added tax (VAT) (7%) and customs for imported machinery, equipment, rolling stock, etc. are not included.

(e) Details of construction cost estimation are mentioned below.

i) Construction costs to be estimated for each item in consideration of labor cost, material cost (including machinery depreciation) and all expenses
ii) Construction costs for each item to be classified in domestic and foreign currency
iii) Imported construction materials, prices for foreign currency to be calculated on CIF (Cost including Delivery, Insurance and Freight) basis
iv) Labor costs for each construction item to be in domestic currency. Labor cost for project management to be in foreign currency

v) Construction unit cost for each item such as labor cost and material cost to be unit cost in Thailand. For construction technology which is not available the cost appropriate for construction in Japan to be referred to

vi) A 10% contingency allowance adopted in consideration of the cost of unestimated items has been included

vii) In estimation, domestic products to be used as much as possible considering availability

viii) Unit costs have been set considering the rate of domestic and foreign currency on the basis of the construction unit cost list for each kind provided from Thailand

ix) Composition of construction unit cost is shown in Fig 2.11.1.

(2) Investment cost

The estimated investment costs are shown in Table 2.11.1.

In order to make economic and financial evaluation, the following alternatives are set up.

Alternative 1:	Commuter service (Yommarat - Chachoengsao)
Alternative 2:	Commuter service (Yommarat - Chachoengsao) and SBIA access service (Lat Krabang - SBIA North Terminal)
Alternative 3:	Commuter service (Yommarat - Chachoengsao), SBIA access service (Lat Krabang - SBIA North Terminal) and intercity express service (Hua Lamphong - Map Ta Phut)

The Study proposes that the SRT should provide all the services. However, SBIA access service and intercity express service will compete with the proposed HSR project. The alternative 1 and alternative 2 are the cases in which intercity express service or both services will not be provided by the SRT. Besides, alternative 1 shows clearly the features of the commuter service project within the "50km" radius area, which is the main object of this Study.

- 1) Land cost
  - Land acquisition compensation
  - House cost compensation
- 2) Construction cost
  - Direct cost
    - Material cost
    - Construction cost
    - Machinery depreciation
    - Temporary construction cost (Temporary facility cost etc.)
  - Indirect cost
    - Construction cost for each civil works' unit
    - Management cost for each civil works unit
    - Profit
- 3) Management cost
  - Training, Trial running cost, Electric charges share [1% of 1) & 2)]
  - Contingency Allowance [10% of 1) & 2)]
  - Total expenses
    - Test, Examination, Survey, Design cost
    - Total technical expenses
    - Construction Management cost etc.(5% of total amount for above items)

Fig. 2.11.1 Composition of Construction Unit Cost

Table 2.11.1 Investment Cost

(1) Alternative 1

(million baht)

Year \ Item	F/L	Land	Civil Work	Track	Building	Electrification	Signalling/Telecom.	Machinery	Sub-total	Contingency (10%)	Total of Construction	Rolling Stock	Grand Total
1996	F			16			25		41	4	45		45
	L	88	36	8			12		144	14	158		158
	T	88	36	24			37		185	18	203		203
1997	F		8	32		26	79		145	15	160		160
	L	88	197	23		38	39		385	39	424		424
	T	88	205	55		64	118		530	54	584		584
1998	F		8	47		500	110		665	67	732		732
	L	88	170	34	32	765	55		1,144	114	1,258		1,258
	T	88	178	81	32	1,265	165		1,809	181	1,990		1,990
1999	F		8	31	6	243	180	33	501	50	551		551
	L		138	25	119	1,590	89		1,961	196	2,157		2,157
	T		146	56	125	1,833	269	33	2,462	246	2,708		2,708
2000	F			16	6	5	185	189	401	40	441	1,820	2,261
	L		16	14	119	17	96	34	296	30	326		326
	T		16	30	125	22	281	223	697	70	767	1,820	2,587
2001	F					12	15	33	60	6	66	228	294
	L				19	44	8		71	7	78		78
	T				19	56	23	33	131	13	144	228	372
2002	F			13		12	47	33	105	11	116	293	409
	L			7	19	44	25		95	10	105		105
	T			20	19	56	72	33	200	21	221	293	514
2003	F		4			2	59		65	7	72	293	365
	L		53			4	33		90	9	99		99
	T		57			6	92		155	16	171	293	464
2004	F		4	56	4	19	89		172	17	189	195	384
	L		72	34	68	42	49		265	27	292		292
	T		76	90	72	61	138		437	44	481	195	676
2005	F		4	56	4	27	92	120	303	30	333	1,073	1,406
	L		75	35	68	53	53	24	308	31	339		339
	T		79	91	72	80	145	144	611	61	672	1,073	1,745
2006	F											228	228
	L												
	T											228	228
2007	F											228	228
	L												
	T											228	228
2008	F											228	228
	L												
	T											228	228
2009	F											293	293
	L												
	T											293	293
2010	F											130	130
	L												
	T											130	130
1996-2010 (Project Cost)													
Total	F		36	267	20	846	881	408	2,458	247	2,705	5,009	7,714
	L	264	757	180	444	2,597	459	58	4,759	477	5,236		5,236
	T	264	793	447	464	3,443	1,340	466	7,217	724	7,941	5,009	12,950
2011-2025 (Additional Investment)													
Total	F							275	275	28	303	846	1,149
	L							58	58	6	64		64
	T							333	333	34	367	846	1.213
1996-2025 Grand Total	F		36	267	20	846	881	683	2,733	275	3,008	5,855	8,863
	L	264	757	180	444	2,597	459	116	4,817	483	5,300		5,300
	T	264	793	447	464	3,443	1,340	799	7,550	758	8,308	5,855	14,163

(Remarks) F: Foreign currency L: Local carrency T: Total

(2) Alternative 2

(million baht)

Year	F/L	Land	Civil Work	Track	Building	Electrification	Signalling/Telecom.	Machinery	Sub-total	Contingency (10%)	Total of Construction	Rolling Stock	Grand Total
1996	F		6	16			25		47	5	52		52
	L	88	121	8			12		229	23	252		252
	T	88	127	24			37		276	28	304		304
1997	F		14	32		26	79		151	15	166		166
	L	88	283	23		38	39		471	47	518		518
	T	88	297	55		64	118		622	62	684		684
1998	F		14	47		500	120		681	68	749		749
	L	88	256	34	32	767	63		1,240	124	1,364		1,364
	T	88	270	81	32	1,267	183		1,921	192	2,113		2,113
1999	F		15	79	25	248	201	33	601	60	661		661
	L		227	48	143	1,605	106		2,129	213	2,342		2,342
	T		242	127	168	1,853	307	33	2,730	273	3,003		3,003
2000	F		7	64	25	10	206	189	501	50	551	2,015	2,566
	L		105	37	143	32	113	34	464	46	510		510
	T		112	101	168	42	319	223	965	96	1,061	2,015	3,076
2001	F					12	15	33	60	6	66	260	326
	L				19	44	8		71	7	78		78
	T				19	56	23	33	131	13	144	260	404
2002	F			13		12	47	33	105	11	116	325	441
	L			7	19	44	25		95	10	105		105
	T			20	19	56	72	33	200	21	221	325	546
2003	F		4			2	59		65	7	72	293	365
	L		53			4	33		90	9	99		99
	T		57			6	92		155	16	171	293	464
2004	F		4	56	4	19	89		172	17	189	195	384
	L		72	34	68	42	49		265	27	292		292
	T		76	90	72	61	138		437	44	481	195	676
2005	F		4	56	4	27	92	144	327	33	360	1,105	1,465
	L		75	35	68	53	53	46	330	33	363		363
	T		79	91	72	80	145	190	657	66	723	1,105	1,828
2006	F											260	260
	L												
	T											260	260
2007	F											293	293
	L												
	T											293	293
2008	F											228	228
	L												
	T											228	228
2009	F											228	228
	L												
	T											228	228
2010	F											130	130
	L												
	T											130	130
1996-2010 (Project Cost)													
Total	F		68	363	58	856	933	432	2,710	272	2,982	5,332	8,314
	L	264	1,192	226	492	2,629	501	80	5,384	539	5,923		5,923
	T	264	1,260	589	550	3,485	1,434	512	8,094	811	8,905	5,332	14,237
2011-2025 (Additional Investment)													
Total	F							300	300	30	330	846	1.176
	L							80	80	8	88		88
	T							380	380	38	418	846	1,264
1996-2025 Grand Total	F		68	363	58	856	933	732	3.010	302	3,312	6,178	9,490
	L	264	1,192	226	492	2,629	501	160	5,464	547	6,011		6,011
	T	264	1,260	589	550	3,485	1,434	892	8,474	849	9,323	6,178	15,501

(Remarks) F: Foreign currency L: Local carrency T: Total

(3) Alternative 3

(million baht)

Item / Year	F / L	Land	Civil Work	Track	Build-ing	Elec-trifi-cation	Signal-ling/ Tele-com.	Machin ery	Sub-total	Contin-gency (10%)	Total of Con struc-tion	Rol-ling Stock	Grand Total
1996	F		6	16			34		56	6	62		62
	L	88	121	8			21		238	24	262		262
	T	88	127	24			55		294	30	324		324
1997	F		14	32		26	125		197	20	217	800	1,017
	L	88	283	23		38	83		515	52	567		567
	T	88	297	55		64	208		712	72	784	800	1,584
1998	F		14	49		500	191		754	75	829		829
	L	88	256	35	32	767	127		1,305	131	1,436		1,436
	T	88	270	84	32	1,267	318		2,059	206	2,265		2,265
1999	F		15	101	25	248	273	33	695	70	765		765
	L		229	61	143	1,605	172		2,210	221	2,431		2,431
	T		244	162	168	1,853	445	33	2,905	291	3,196		3,196
2000	F		7	86	25	10	278	189	595	60	655	2,815	3,470
	L		108	50	143	32	179	34	546	55	601		601
	T		115	136	168	42	457	223	1,141	115	1,256	2,815	4,071
2001	F					12	15	33	60	6	66	380	446
	L				19	44	8		71	7	78		78
	T				19	56	23	33	131	13	144	380	524
2002	F			13		12	47	33	105	11	116	445	561
	L			7	19	44	25		95	10	105		105
	T			20	19	56	72	33	200	21	221	445	666
2003	F		4			2	59		65	7	72	413	485
	L		53			4	33		90	9	99		99
	T		57			6	92		155	16	171	413	584
2004	F		4	56	4	19	89		172	17	189	315	504
	L		72	34	68	42	49		265	27	292		292
	T		76	90	72	61	138		437	44	481	315	796
2005	F		4	56	4	27	92	144	327	33	360	1,265	1,625
	L		75	35	68	53	53	46	330	33	363		363
	T		79	91	72	80	145	190	657	66	723	1,265	1,988
2006	F											420	420
	L												
	T											420	420
2007	F											453	453
	L												
	T											453	453
2008	F											388	388
	L												
	T											388	388
2009	F											388	388
	L												
	T											388	388
2010	F											130	130
	L												
	T											130	130
1996-2010 (Project Cost)													
Total	F		68	409	58	856	1,203	432	3,026	305	3,331	8,212	11,543
	L	264	1,197	253	492	2,629	750	80	5,665	569	6,234		6,234
	T	264	1,265	662	550	3,485	1,953	512	8,691	874	9,565	8,212	17,777
2011-2025 (Additional Investment)													
Total	F							300	300	30	330	1,806	2,136
	L							80	80	8	88		88
	T							380	380	38	418	1,806	2,224
1996-2025 Grand Total	F		68	409	58	856	1.203	732	3,326	335	3,661	10,018	13,679
	L	264	1,197	253	492	2,629	750	160	5,745	577	6,322		6,322
	T	264	1,265	662	550	3,485	1,953	892	9,071	912	9,983	10,018	20,001

(Remarks) F: Foreign currency L: Local carrency T: Total

2.12 Management and Maintenance

2.12.1 Management and Maintenance Plan

(1) General (Fundamental figures to operate a railway)

Railway improvement requires additional expenses to maintain them. However, reexamining the maintenance work and constructing new rational maintenance systems can decrease the ordinary maintenance expenses. The railway enterprise should bear not only the large initial investment cost but also the large maintenance cost, so it is important to consider in the plan how to operate the railway economically. In the promptly developing countries, the national economy grows rapidly and the personnel expenses for enterprises will run up quickly. The maintenance system should be created with a long term view in mind. If a railway fails to catch up to the economic movement, it may fall into decay.

Taking the present labor supply of Thailand and demands of workers into consideration, it is easy to increase the employees to cope with additional maintenance requirements. However, judging from the experience of the Japanese National Railways, it may have a bad influence on the future labor and finance situation. As the national economy develops, mechanization will advance and productivity per capita will improve so that the productivity of the railway employees will be raised. Otherwise, the enterprise cannot pay a socially acceptable average salary to the employees, or the enterprise will fall into an operating deficit. In the event of expanding business operations, it is wise to carry forward streamlining and laborsaving taking into account the labor situation 10 or 20 years after. If the railway enterprise misses this timing because of the long life of railway facilities, it will be difficult for it to catch up with the expansion of social economy.

(2) Management of stations and trains

At every station, selling tickets and examining tickets at the wicket will be executed at the commuting times. It will be necessary to reinforce some station clerks. On the other hand, less conductors will be needed to examine tickets in the trains. In order to minimize increase of the station staff, introduction of an automatic ticketing system is essential.

Station masters will be expected to control the security of passengers and smooth transfer at the station plazas. For operating the highly increased numbers of trains in the proposed service, a train should be operated by at most one driver and one conductor, otherwise the improvement plan will not be manageable because of high expense for them. Therefore, train operating system should be changed as a number of trains increases.

(3) Maintenance of track and structure

With the increase of train speed and passing tonnage due to the reinforcement of train service, the amount of track destruction will be more than three times higher. In order to cope with such conditions, the track should be reinforced (making rails heavier, changing sleepers to PC, and increasing ballast thickness) and introduction of track-maintenance machinery like a multiple tie-tamper, motor-car, a ballast hopper-car and rearrangement of the maintenance system should be executed so as not to increase labor costs for maintenance. Such track maintenance with machinery should be made at night when trains are not running. The possibility of train absence time of several hours should be taken into consideration.

Furthermore to treat maintenance machinery, the training of operators and inspectors of the machinery is necessary. Manpower maintenance should be decreased and the employees who engage in manpower maintenance should be transformed into skilled workers who can operate such maintenance machinery.

(4) Electric facilities

1) Signalling and telecommunication

As mentioned in 1.6.6 (2), the number of signalling and telecommunication maintenance staff should not be increased after completion of this project.

As for color light signals, double filament type signal bulbs with concentrated monitoring systems have been adopted in the SRT's re-signalling project.

The ATS-P systems to be introduced in this project will also have monitoring systems, which usually transmit the normal/failure conditions to the maintenance depot.

Education and training programs including overseas training will be provided for newly introduced equipment, such as the ATS-P and train radio systems.

2) Electrification

a) Maintenance depot

The maintenance depot should be located in the Khlong Luang Phaeng railcar depot / workshop yard or near by the traction substation, midway in the electrified section, so as to shorten the arrival time to a trouble spot on the section. The depot building will possess an office, workshop, storehouse, bathroom and resting room; and an open space also will be required for the stock of cables, wires, and poles. A motor-car, carrier car for materials, and other tools will be necessary. Moreover, both-way cars, which are capable of operation on the rails and road, will be provided.

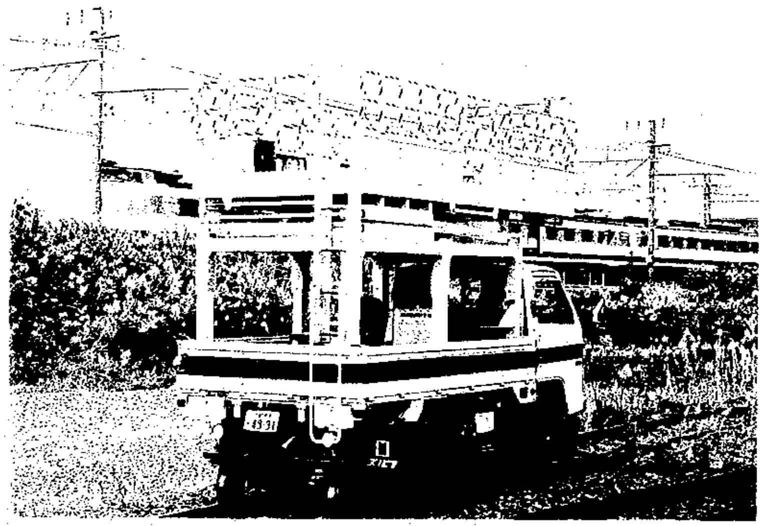


Fig. 2.12.1 Rail-road Both-way Car

b) Maintenance staff

Since the Eastern Line will be electrified at first, the electrical maintenance staff will be organized as described below.

Two power despatchers, two chief inspectors, tow assistant inspectors and two artisans will be arranged independently of other maintenance staff at the Bang Sue power despatching center to control the railway electrification system and supervise the maintenance works for both the traction substation and overhead contact facilities.

The maintenance staff will be arranged into two groups (the first and second) for each substation and overhead contact facility. Each group will consist of a chief inspector, an assistant inspector, a few artisans, semi-skilled workers and unskilled workers. The staff of the second group will be assigned at the completion of the electrification of the Eastern line including trainees.

c) Education and training

Education and training programs should be provided for the staff to acquire the maintenance techniques:

- Simulation panels for device-interlocking and remote-control / supervision systems of the traction substations will be installed at the Bang Sue substation.
- An approximately 100-meter-length counterfeit overhead contact system for training will be provided in a car depot or a railway station yard.
- Texts and training equipment such as standard maintenance manuals, instruments, etc, will be arranged.

(5) Rolling stock

1) Maintenance for electric railcars

Electric railcars for the commuter service and SBIA access service are designed to be maintenance-free, in such respects as the low ratio of motor-cars in a train utilizing induction motors for motive power and so forth. The maintenance expenses of electric railcars is only nearly half compared with that of diesel railcars, in Japan. However, the maintenance staff should have high technical skills for electric railcars to which a lot of high technology is applied.

a) Depot

The depot for the Eastern Line is constructed at Khlong Luang Phaeng. The reason to construct there is as follows. (Fig. 2.12.2)

- As the Khlong Luang Phaeng area has not yet been developed, it is easy to acquire such a vast site.

- Khlong Luang Phaeng is at the end of the Eastern Line commuter service in the Step I .
- Khlong Luang Phaeng is at a point of strategic importance for the control of train operation.

The site for the workshop and depot should be vast, in order to cope with the increase of rolling stock in future.

In Khlong Luang Phaeng depot, diesel railcars for intercity express are stored in addition to the electric railcars for the Eastern Line.

b) Workshop

The workshop is constructed in the Khlong Luang Phaeng depot/workshop yard, where the inspection work for electric railcars of all the line are conducted. Therefore, estimated investment cost is shared by the four lines. (Fig. 2.12.2)

2) Maintenance of diesel railcars for intercity express

Inspection of diesel railcars for intercity express should be performed by the existing SRT method which reflects rich experience and ability.

2.12.2 Management and Maintenance Expenses

Management and maintenance expenses for the proposed railway improvement are estimated based on the innovative systems of management and maintenance described previously. For example, a train is operated by one driver and one conductor, station staffs are arranged on condition that automatic ticketing systems are introduced, track maintenance workers are arranged based on utilizing machinery, and so on.

Estimated management and maintenance expense is shown in Table 2.12.1.

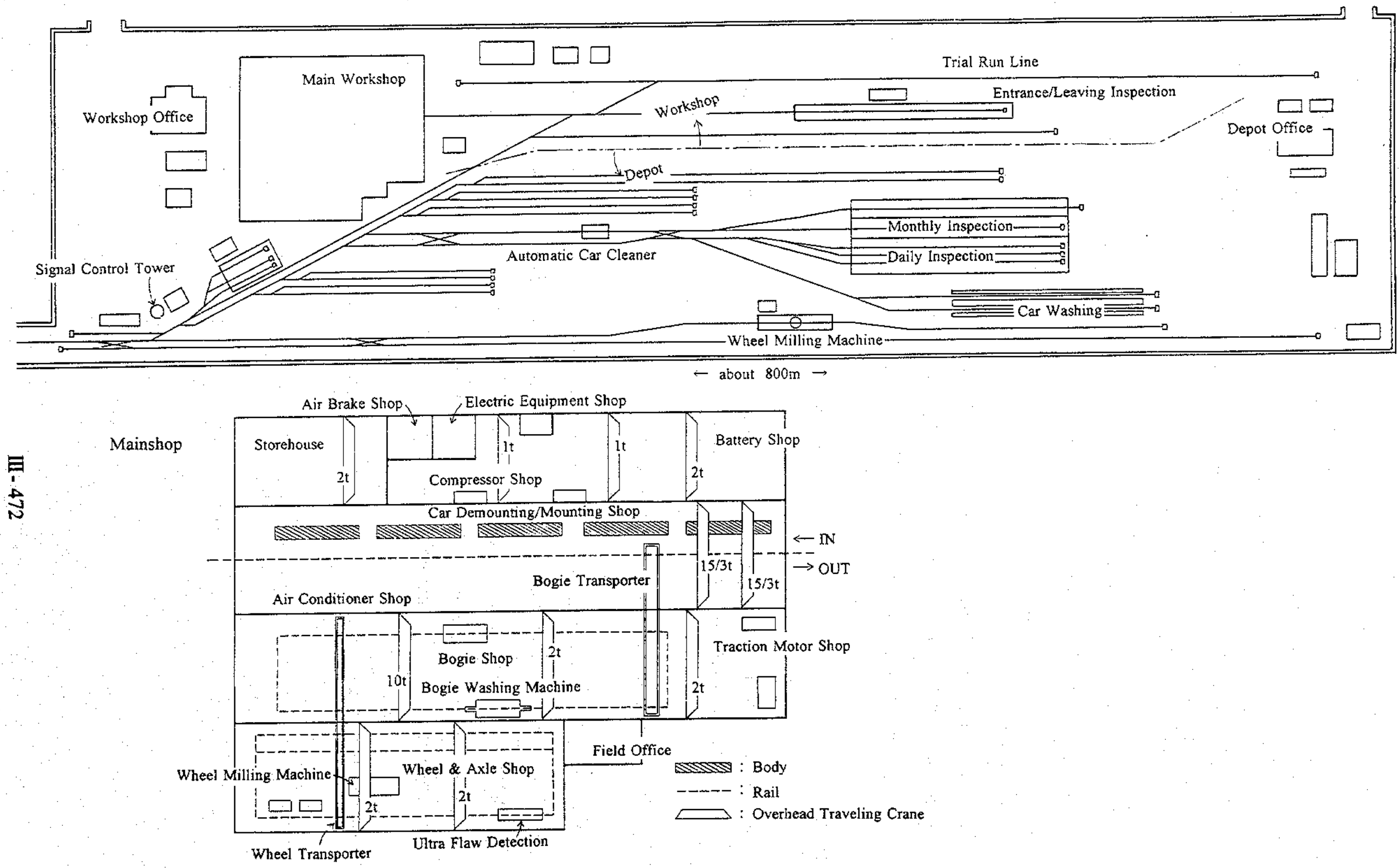


Fig. 2.12.2 Layout of Khlong Luang Phaeng Workshop and Depot

Table 2.12.1 Management/Maintenance Expenses

(1) Alternative 1

(million baht)

Year	F/L/T	Passenger-km mil.pas.km/year: Commuter	SBIA access	Ic. express	Operation of Station Train	Electricity Fuel	Facility Mainte. Exept→→	Elec. Facility Mainte.	Rolling Stock Maintenance	Total
1996	F									
	L									
	T									
1997	F					1			1	2
	L				2	2			6	10
	T	50			2	3			7	12
1998	F					2			2	4
	L				2	3			11	16
	T	150			2	5			13	20
1999	F					2			4	6
	L				2	3			16	21
	T	200			2	5			20	27
2000	F					2			4	6
	L				2	6			18	26
	T	250			2	8			22	32
2001	F					1	13	14	3	31
	L				36	8	8	16	6	74
	T	750			36	9	21	30	9	105
2002	F					1	15	14	5	35
	L				36	8	12	16	10	82
	T	880			36	9	27	30	15	117
2003	F					1	15	14	12	42
	L				37	8	12	16	14	87
	T	1,010			37	9	27	30	26	129
2004	F					2	15	14	13	44
	L				37	8	12	16	21	94
	T	1,190			37	10	27	30	34	138
2005	F					2	15	14	14	45
	L				38	8	12	16	22	96
	T	1,320			38	10	27	30	36	141
2006	F						20	32	15	67
	L				50	12	22	37	10	131
	T	1,780			50	12	42	69	25	198
2007	F						20	32	15	67
	L				50	12	22	37	10	131
	T	1,960			50	12	42	69	25	198
2008	F						20	32	18	70
	L				50	12	22	37	12	133
	T	2,150			50	12	42	69	30	203
2009	F						20	32	19	71
	L				50	12	22	37	14	135
	T	2,340			50	12	42	69	33	206
2010	F						20	32	20	72
	L				50	12	22	37	15	136
	T	2,530			50	12	42	69	35	208
1996-2010 Total	F					14	173	230	145	562
	L				442	114	166	265	185	1,172
	T	16,560			442	128	339	495	330	1,734
2011-2025 Total	F						300	480	350	1,130
	L				750	180	330	555	251	2,066
	T	46,360			750	180	630	1,035	601	3,196
1996-2025 Grand Total	F					14	473	710	495	1,692
	L				1,192	294	496	820	436	3,238
	T	62,920			1,192	308	969	1,530	931	4,930

(Remarks) "Rolling Stock Maintenance" includes cost of DC for provisional service as rent.
In the case of fare level 0.215 baht/km DC: Diesel railcars
F: Foreign currency L: Local carrency T: Total

(1) Alternative 1 (Continued)

(million baht)

Year	F/L/T	Passenger-km mil.pas.km/year Commuter	SBIA access	Ic. express	Operation Station Train	Electricity Fuel	Facility Mainte. Exept**	Elec. Facility Mainte.	Rolling Stock Maintenance	Total
2011	F						20	32	21	73
	L				50	12	22	37	15	136
	T	2,600			50	12	42	69	36	209
2012	F						20	32	22	74
	L				50	12	22	37	15	136
	T	2,680			50	12	42	69	37	210
2013	F						20	32	23	75
	L				50	12	22	37	16	137
	T	2,750			50	12	42	69	39	212
2014	F						20	32	23	75
	L				50	12	22	37	16	137
	T	2,840			50	12	42	69	39	212
2015	F						20	32	23	75
	L				50	12	22	37	16	137
	T	2,910			50	12	42	69	39	212
2016	F						20	32	23	75
	L				50	12	22	37	16	137
	T	2,970			50	12	42	69	39	212
2017	F						20	32	23	75
	L				50	12	22	37	17	138
	T	3,030			50	12	42	69	40	213
2018	F						20	32	23	75
	L				50	12	22	37	17	138
	T	3,100			50	12	42	69	40	213
2019	F						20	32	23	75
	L				50	12	22	37	17	138
	T	3,160			50	12	42	69	40	213
2020	F						20	32	23	75
	L				50	12	22	37	17	138
	T	3,230			50	12	42	69	40	213
2021	F						20	32	23	75
	L				50	12	22	37	17	138
	T	3,290			50	12	42	69	40	213
2022	F						20	32	24	76
	L				50	12	22	37	18	139
	T	3,350			50	12	42	69	42	215
2023	F						20	32	25	77
	L				50	12	22	37	18	139
	T	3,420			50	12	42	69	43	216
2024	F						20	32	25	77
	L				50	12	22	37	18	139
	T	3,480			50	12	42	69	43	216
2025	F						20	32	26	78
	L				50	12	22	37	18	139
	T	3,550			50	12	42	69	44	217
1996-2010 Total	F					14	173	230	145	562
	L				442	114	166	265	185	1,172
	T	16,560			442	128	339	495	330	1,734
2011-2025 Total	F						300	480	350	1,130
	L				750	180	330	555	251	2,066
	T	46,360			750	180	630	1,035	601	3,196
1996-2025 Grand Total	F					14	473	710	495	1,692
	L				1,192	294	496	820	436	3,238
	T	62,920			1,192	308	969	1,530	931	4,930

(Remarks) "Rolling Stock Maintenance" includes cost of DC for provisional service as rent.
In the case of fare level 0.215 baht/km DC: Diesel railcars
F: Foreign currency L: Local carrency T: Total

(2) Alternative 2

(million baht)

Year	F/L/T	Passenger-km mil.pas.km/year: Commuter	SBIA access	Ic. express	Operation Station Train	Electricity Fuel	Facility Mainte. Exept→	Elec. Facility Mainte.	Rolling Stock Maintenance	Total
1996	F									
	L									
	T									
1997	F					1			1	2
	L				2	2			6	10
	T	50			2	3			7	12
1998	F					2			2	4
	L				2	3			11	16
	T	150			2	5			13	20
1999	F					2			4	6
	L				2	3			16	21
	T	200			2	5			20	27
2000	F					2			4	6
	L				3	6			18	27
	T	250			3	8			22	33
2001	F					1	14	17	3	35
	L				39	10	8	19	7	83
	T	940	40		39	11	22	36	10	118
2002	F					1	16	17	5	39
	L				39	10	12	19	10	90
	T	1,080	50		39	11	28	36	15	129
2003	F					1	16	17	12	46
	L				42	10	12	19	17	100
	T	1,220	50		42	11	28	36	29	146
2004	F					1	16	17	15	49
	L				42	11	12	19	21	105
	T	1,410	50		42	12	28	36	36	154
2005	F					1	16	17	16	50
	L				43	11	12	19	22	107
	T	1,550	50		43	12	28	36	38	157
2006	F						21	35	15	71
	L				55	14	24	40	11	144
	T	2,030	50		55	14	45	75	26	215
2007	F						21	35	16	72
	L				55	14	24	40	11	144
	T	2,230	50		55	14	45	75	27	216
2008	F						21	35	19	75
	L				55	14	24	40	14	147
	T	2,430	60		55	14	45	75	33	222
2009	F						21	35	20	76
	L				55	14	24	40	15	148
	T	2,630	60		55	14	45	75	35	224
2010	F						21	35	21	77
	L				55	14	24	40	16	149
	T	2,840	60		55	14	45	75	37	226
1996-2010 Total	F					12	183	260	153	608
	L				489	136	176	295	195	1,291
	T	19,010	520		489	148	359	555	348	1,899
2011-2025 Total	F						315	525	364	1,204
	L				825	210	360	600	260	2,255
	T	51,840	1,090		825	210	675	1,125	624	3,459
1996-2025 Grand Total	F					12	498	785	517	1,812
	L				1,314	346	536	895	455	3,546
	T	70,850	1,610		1,314	358	1,034	1,680	972	5,358

(Remarks) "Rolling Stock Maintenance" includes cost of DC for provisional service as rent.
In the case of fare level 0.215 baht/km DC: Diesel railcars
F: Foreign currency L: Local carrency T: Total

(2) Alternative 2 (Continued)

(million baht)

Year	Item (F/L)	Passenger-km mil.pas.km/year Commuter	SBIA access	Ic. express	Operation Station Train	Electricity Fuel	Facility Mainte. Exept→	Elec. Facility Mainte.	Rolling Stock Maintenance	Total
2011	F						21	35	21	77
	L				55	14	24	40	17	150
	T	2,920	60		55	14	45	75	38	227
2012	F						21	35	22	78
	L				55	14	24	40	17	150
	T	2,990	60		55	14	45	75	39	228
2013	F						21	35	23	79
	L				55	14	24	40	17	150
	T	3,070	60		55	14	45	75	40	229
2014	F						21	35	23	79
	L				55	14	24	40	17	150
	T	3,150	70		55	14	45	75	40	229
2015	F						21	35	24	80
	L				55	14	24	40	17	150
	T	3,250	70		55	14	45	75	41	230
2016	F						21	35	24	80
	L				55	14	24	40	17	150
	T	3,320	70		55	14	45	75	41	230
2017	F						21	35	25	81
	L				55	14	24	40	17	150
	T	3,390	70		55	14	45	75	42	231
2018	F						21	35	25	81
	L				55	14	24	40	17	150
	T	3,470	70		55	14	45	75	42	231
2019	F						21	35	25	81
	L				55	14	24	40	17	150
	T	3,540	80		55	14	45	75	42	231
2020	F						21	35	25	81
	L				55	14	24	40	17	150
	T	3,610	80		55	14	45	75	42	231
2021	F						21	35	25	81
	L				55	14	24	40	18	151
	T	3,680	80		55	14	45	75	43	232
2022	F						21	35	25	81
	L				55	14	24	40	18	151
	T	3,750	80		55	14	45	75	43	232
2023	F						21	35	25	81
	L				55	14	24	40	18	151
	T	3,830	80		55	14	45	75	43	232
2024	F						21	35	26	82
	L				55	14	24	40	18	151
	T	3,900	80		55	14	45	75	44	233
2025	F						21	35	26	82
	L				55	14	24	40	18	151
	T	3,970	80		55	14	45	75	44	233
1996-2010 Total	F					12	183	260	153	608
	L				489	136	176	295	195	1,291
	T	19,010	520		489	148	359	555	348	1,899
2011-2025 Total	F						315	525	364	1,204
	L				825	210	360	600	260	2,255
	T	51,840	1,090		825	210	675	1,125	624	3,459
1996-2025 Grand Total	F					12	498	785	517	1,812
	L				1,314	346	536	895	455	3,546
	T	70,850	1,610		1,314	358	1,034	1,680	972	5,358

(Remarks) "Rolling Stock Maintenance" includes cost of DC for provisional service as rent.
In the case of fare level 0.215 baht/km DC: Diesel railcars
F: Foreign currency L: Local carrency T: Total

(3) Alternative 3

(million baht)

Year	F/L/T	Passenger-km mil.pas.km/year: Commuter	SBIA access	Ic. express	Operation Station Train	Electricity Fuel	Facility Mainte. Exept→	Elec. Facility Mainte.	Rolling Stock Maintenance	Total
1996	F									
	L									
	T									
1997	F					1			1	2
	L				2	2			6	10
	T	50			2	3			7	12
1998	F					4			4	8
	L				5	14			13	32
	T	150		220	5	18			17	40
1999	F					4			6	10
	L				5	14			18	37
	T	200		220	5	18			24	47
2000	F					3			10	13
	L				6	24			21	51
	T	250		220	6	27			31	64
2001	F					3	17	22	12	54
	L				47	48	11	23	12	141
	T	940	40	590	47	51	28	45	24	195
2002	F					5	18	22	14	59
	L				47	50	16	23	16	152
	T	1,080	50	630	47	55	34	45	30	211
2003	F					7	18	22	25	72
	L				51	52	16	23	25	167
	T	1,220	50	670	51	59	34	45	50	239
2004	F					8	18	22	28	76
	L				51	56	16	23	30	176
	T	1,410	50	720	51	64	34	45	58	252
2005	F					9	18	22	30	79
	L				51	58	16	23	32	180
	T	1,550	50	770	51	67	34	45	62	259
2006	F					8	23	40	30	101
	L				66	64	30	44	22	226
	T	2,030	50	840	66	72	53	84	52	327
2007	F					9	23	40	31	103
	L				66	70	30	44	23	233
	T	2,230	50	910	66	79	53	84	54	336
2008	F					9	23	40	36	108
	L				66	73	30	44	26	239
	T	2,430	60	980	66	82	53	84	62	347
2009	F					10	23	40	38	111
	L				66	75	30	44	27	242
	T	2,630	60	1,040	66	85	53	84	65	353
2010	F					10	23	40	41	114
	L				66	82	30	44	28	250
	T	2,840	60	1,100	66	92	53	84	69	364
1996-2010 Total	F					90	204	310	306	910
	L				595	682	225	335	299	2,136
	T	19,010	520	8,910	595	772	429	645	605	3,046
2011-2025 Total	F					187	345	600	707	1,839
	L				990	1,359	450	660	506	3,965
	T	51,840	1,090	19,380	990	1,546	795	1,260	1,213	5,804
1996-2025 Grand Total	F					277	549	910	1,013	2,749
	L				1,585	2,041	675	995	805	6,101
	T	70,850	1,610	28,290	1,585	2,318	1,224	1,905	1,818	8,850

(Remarks) "Rolling Stock Maintenance" includes cost of DC for provisional service as rent.
In the case of fare level 0.215 baht/km DC: Diesel railcars
F: Foreign currency L: Local carrency T: Total

(3) Alternative 3 (Continued)

(million baht)

Year	Item F L	Passenger-km mil.pas.km/year Commuter	SBIA access	Ic. express	Operation Station Train	Electricity Fuel	Facility Mainte. Exept→	Elec. Facility Mainte.	Rolling Stock Maintenance	Total
2011	F					11	23	40	41	115
	L				66	81	30	44	30	251
	T	2,920	60	1,120	66	92	53	84	71	366
2012	F					11	23	40	44	118
	L				66	84	30	44	31	255
	T	2,990	60	1,140	66	95	53	84	75	373
2013	F					11	23	40	44	118
	L				66	84	30	44	31	255
	T	3,070	60	1,160	66	95	53	84	75	373
2014	F					12	23	40	45	120
	L				66	84	30	44	31	255
	T	3,150	70	1,180	66	96	53	84	76	375
2015	F					12	23	40	46	121
	L				66	86	30	44	33	259
	T	3,250	70	1,200	66	98	53	84	79	380
2016	F					12	23	40	46	121
	L				66	86	30	44	33	259
	T	3,320	70	1,230	66	98	53	84	79	380
2017	F					12	23	40	47	122
	L				66	89	30	44	34	263
	T	3,390	70	1,260	66	101	53	84	81	385
2018	F					12	23	40	47	122
	L				66	89	30	44	34	263
	T	3,470	70	1,290	66	101	53	84	81	385
2019	F					12	23	40	48	123
	L				66	89	30	44	34	263
	T	3,540	80	1,320	66	101	53	84	82	386
2020	F					13	23	40	48	124
	L				66	95	30	44	35	270
	T	3,610	80	1,340	66	108	53	84	83	394
2021	F					13	23	40	48	124
	L				66	95	30	44	35	270
	T	3,680	80	1,370	66	108	53	84	83	394
2022	F					14	23	40	50	127
	L				66	97	30	44	36	273
	T	3,750	80	1,400	66	111	53	84	86	400
2023	F					14	23	40	50	127
	L				66	98	30	44	36	274
	T	3,830	80	1,430	66	112	53	84	86	401
2024	F					14	23	40	51	128
	L				66	98	30	44	36	274
	T	3,900	80	1,460	66	112	53	84	87	402
2025	F					14	23	40	52	129
	L				66	104	30	44	37	281
	T	3,970	80	1,480	66	118	53	84	89	410
1996-2010 Total	F					90	204	310	306	910
	L				595	682	225	335	299	2,136
	T	19,010	520	8,910	595	772	429	645	605	3,046
2011-2025 Total	F					187	345	600	707	1,839
	L				990	1,359	450	660	506	3,965
	T	51,840	1,090	19,380	990	1,546	795	1,260	1,213	5,804
1996-2025 Grand Total	F					277	549	910	1,013	2,749
	L				1,585	2,041	675	995	805	6,101
	T	70,850	1,610	28,290	1,585	2,318	1,224	1,905	1,818	8,850

(Remarks) "Rolling Stock Maintenance" includes cost of DC for provisional service as rent.
In the case of fare level 0.215 baht/km DC: Diesel railcars
F: Foreign currency L: Local carrency T: Total

2.13 Implementation Program

The proposed railway improvement plans consist of three projects phased into three steps, targeting the year of 2010.

These projects are for improvement and reinforcement of the existing Eastern Line of the SRT. They are expected to be executed by the SRT, supported by the government of Thailand. However, in order to execute these projects, innovative management and maintenance systems not based on the extension of the existing line, which holds various vested rights, should be established.

Implementation period of the projects are as follows.

Commuter service between Yommarat and Chachoengsao

Step I	Yommarat - Khlong Luang Phaeng	1996 - 2000
	(Yommarat - Hua Mak [Hopewell Project area]: Electrification only)	
Step II	Khlong Luang Phaeng - Chachoengsao	2001 - 2005
Additional electric railcar procurement		2006 - 2010

SBIA access service

Lat Krabang - SBIA North Terminal (Branch Line)	1996 - 2000
Additional electric railcar procurement	2001 - 2010

Intercity express service

Hua Lamphong - Map Ta Phut	1996 - 2000
Additional diesel railcar procurement	2001 - 2010

Times to commence the service are as follows.

Commuter service

Step I	The end of 2000
Step II	The end of 2005

SBIA access service	The end of 2000
Intercity express service	
(Provisionally)	The end of 1997
(Fully)	The end of 2000

Classified annual investment cost and summed up project cost are shown in Table 2.11.1. The project cost is summed up into the following three alternatives in order to carry out the project evaluation.

Alternative 1	Commuter service only
Alternative 2	Commuter service and SBIA access service
Alternative 3	Commuter service, SBIA access service and Intercity express service