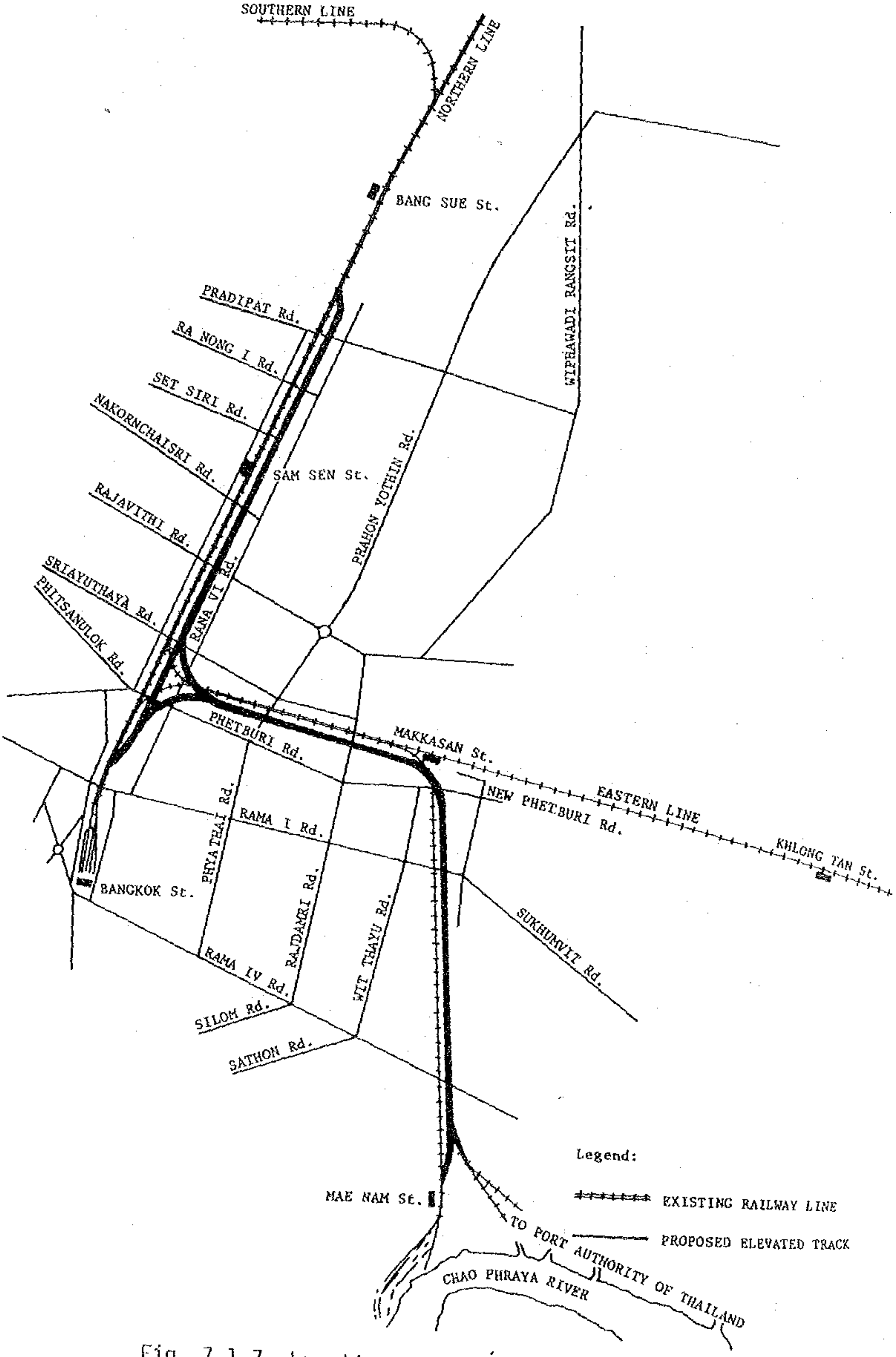


Fig. 7.1.7 Location of Proposed Elevated Track

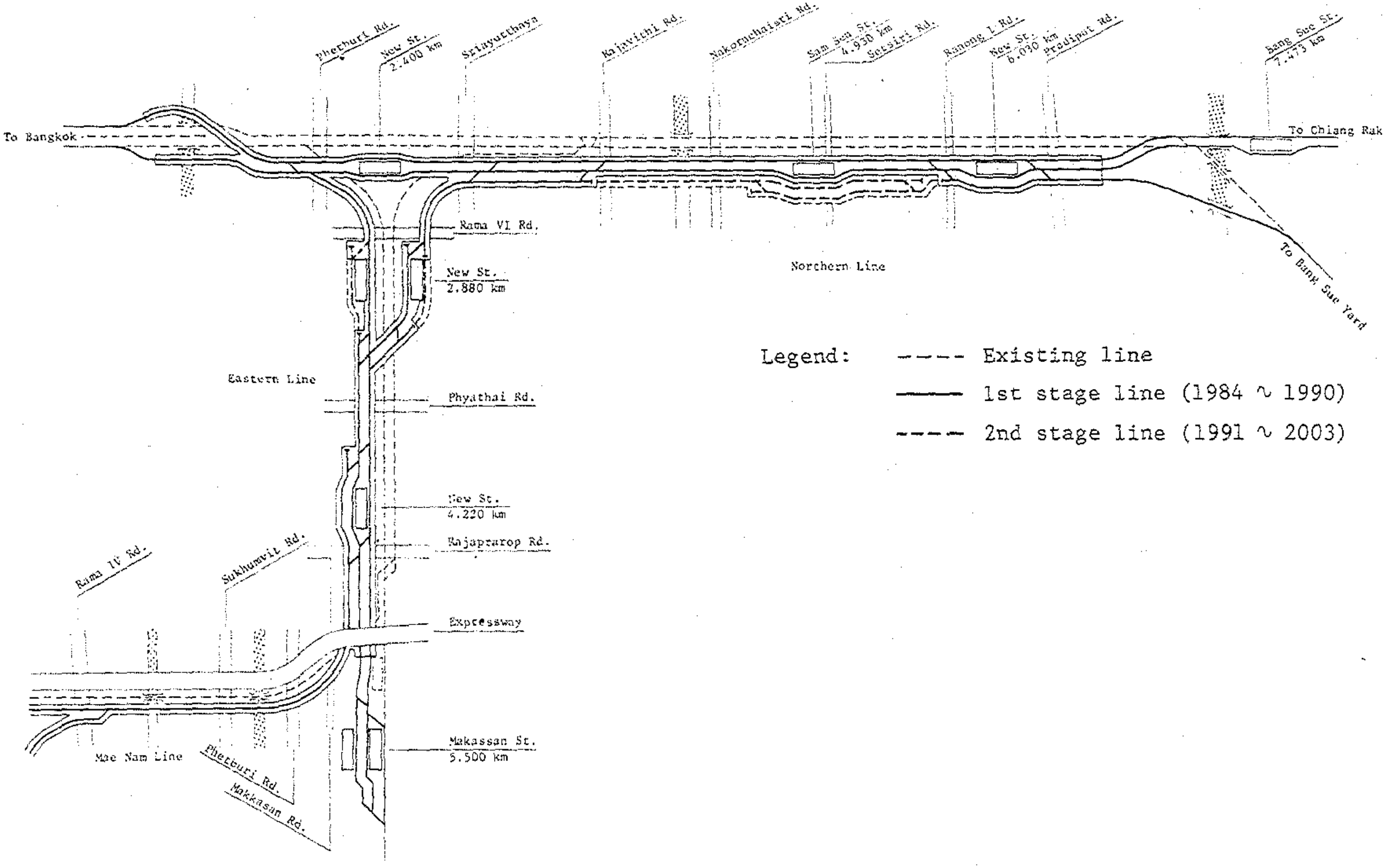
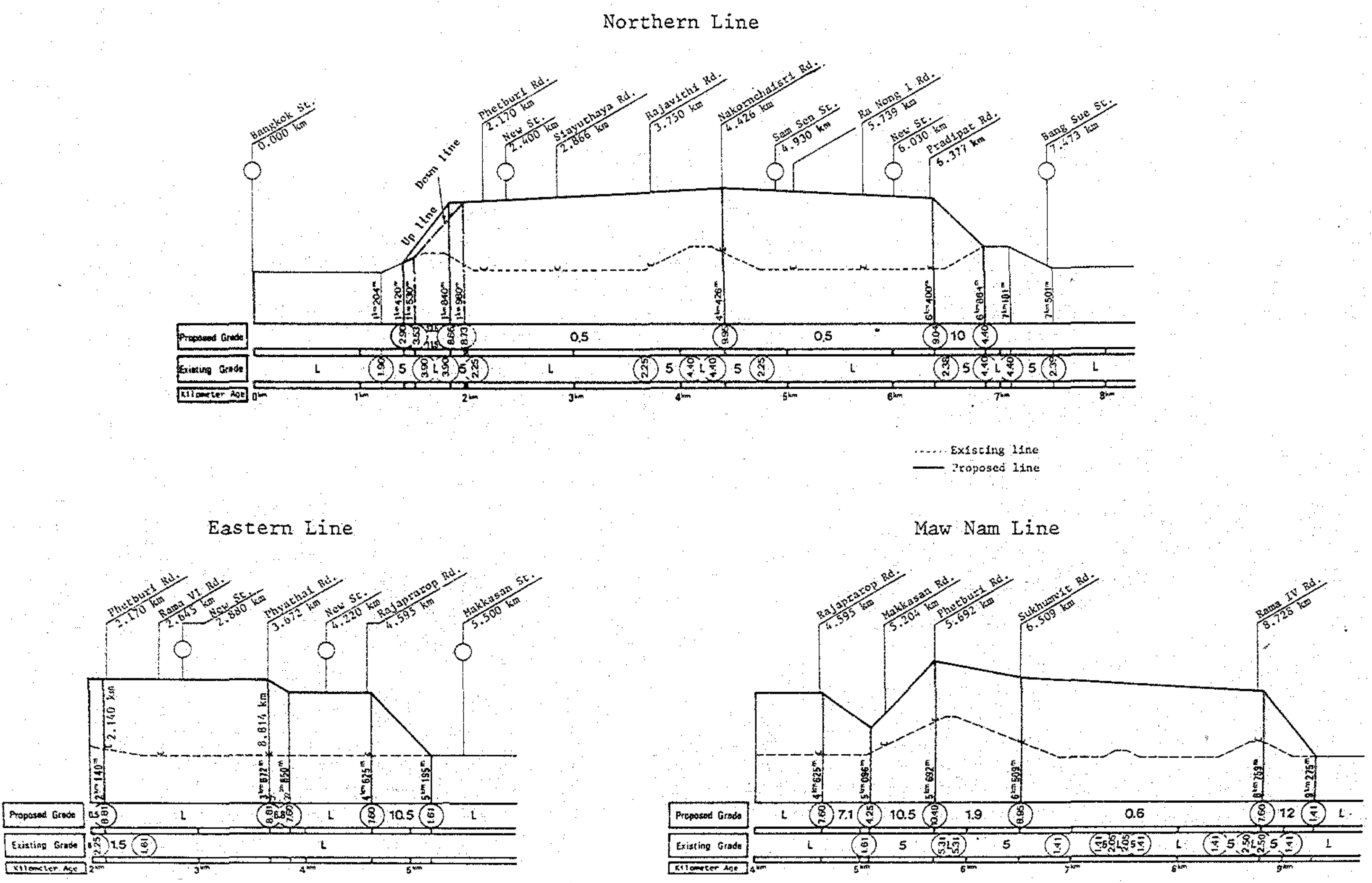


Fig. 7.1.8 Alignment of Proposed Elevated Section


Northern Line

Eastern Line

Maw Nam Line

Fig. 7.1.9 Profile Alignment

7.1.4 Elevated Structure

(1) Structure type

As the result of comparative study, as shown in Table 7.1.2, it has been decided that a rigid-frame bridge of reinforced concrete is most advantageous.

For noise prevention, a noise insulation wall will be constructed over the total length of the elevated section.

Precast piles will be used for constructing a secure foundation. However, cast-in-place piles will be used in the secondary stage to comply with increased traffic demand.

Table 7.1.2 Comparison of Viaducts by Type

Type	Economy	Execution	Environmental Preservation	Space Utilization under Viaduct	Evaluation
RC rigid frame	◎	◎	◎	◎	1
RC girder viaduct	○	◎	○	◎	2
PC girder viaduct	Δ	○	◎	◎	3

Note: ◎ Excellent degree ○ Better degree Δ Normal degree
RC Reinforced concrete
PC Prestressed concrete

(2) Standard span and section

A rough sketch of the standard spans and sections designed for the viaduct is given in Fig. 7.1.10. Rough sketches around the junction are shown in Fig. 7.1.11 and 7.1.12.

(3) Bridge

A rough sketch of the over road bridges is shown in Fig. 7.1.13. Prestressed concrete bridges will be used, in principle, for any crossings over roads. Those bridges proposed for construction over Rajaprarop Road, Phetburi Road and Rama IV Road are all designed to be steel bridges with ballast.

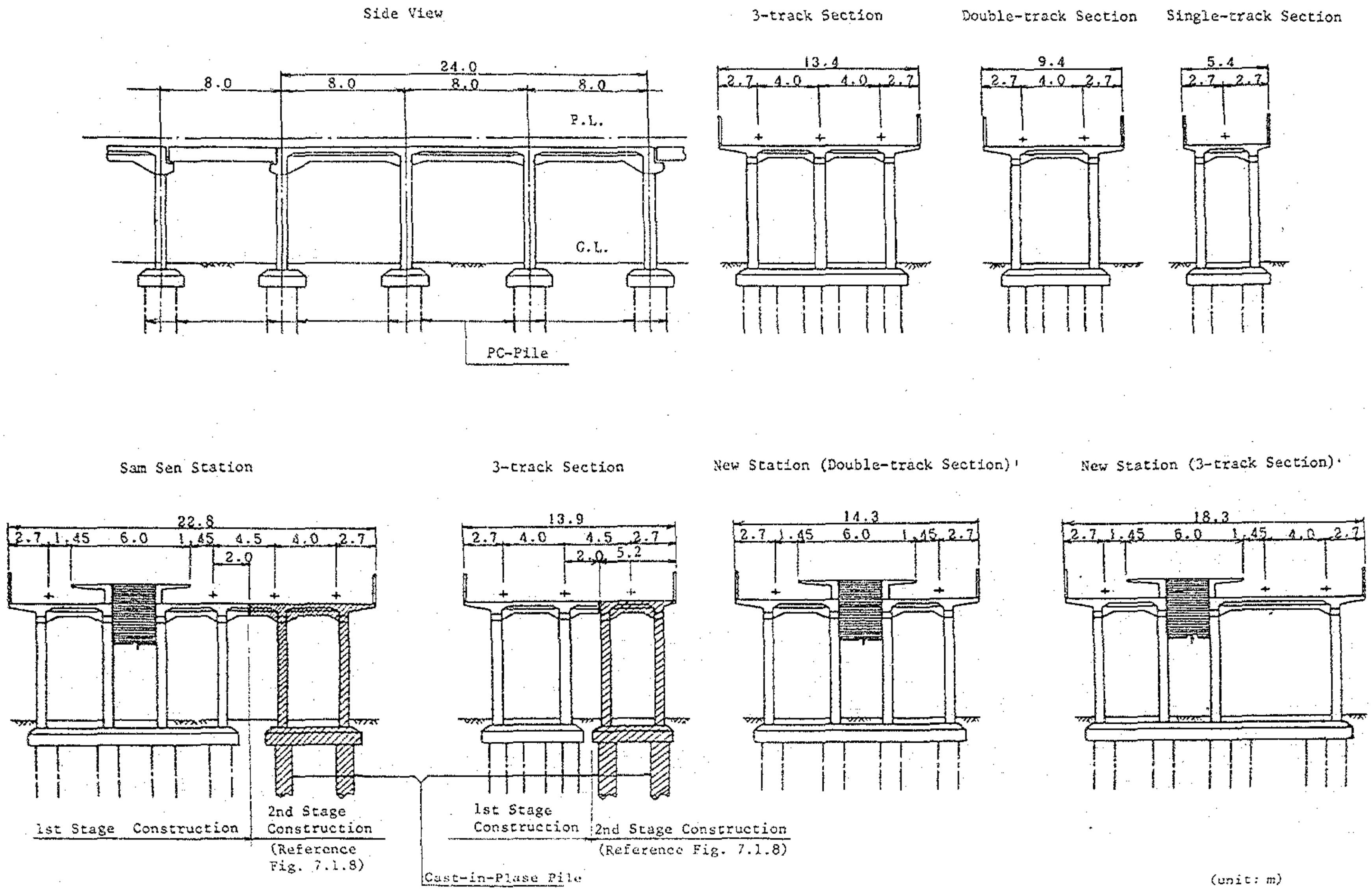


Fig. 7.1.10 Standard Spans and Sections for Elevated Structures

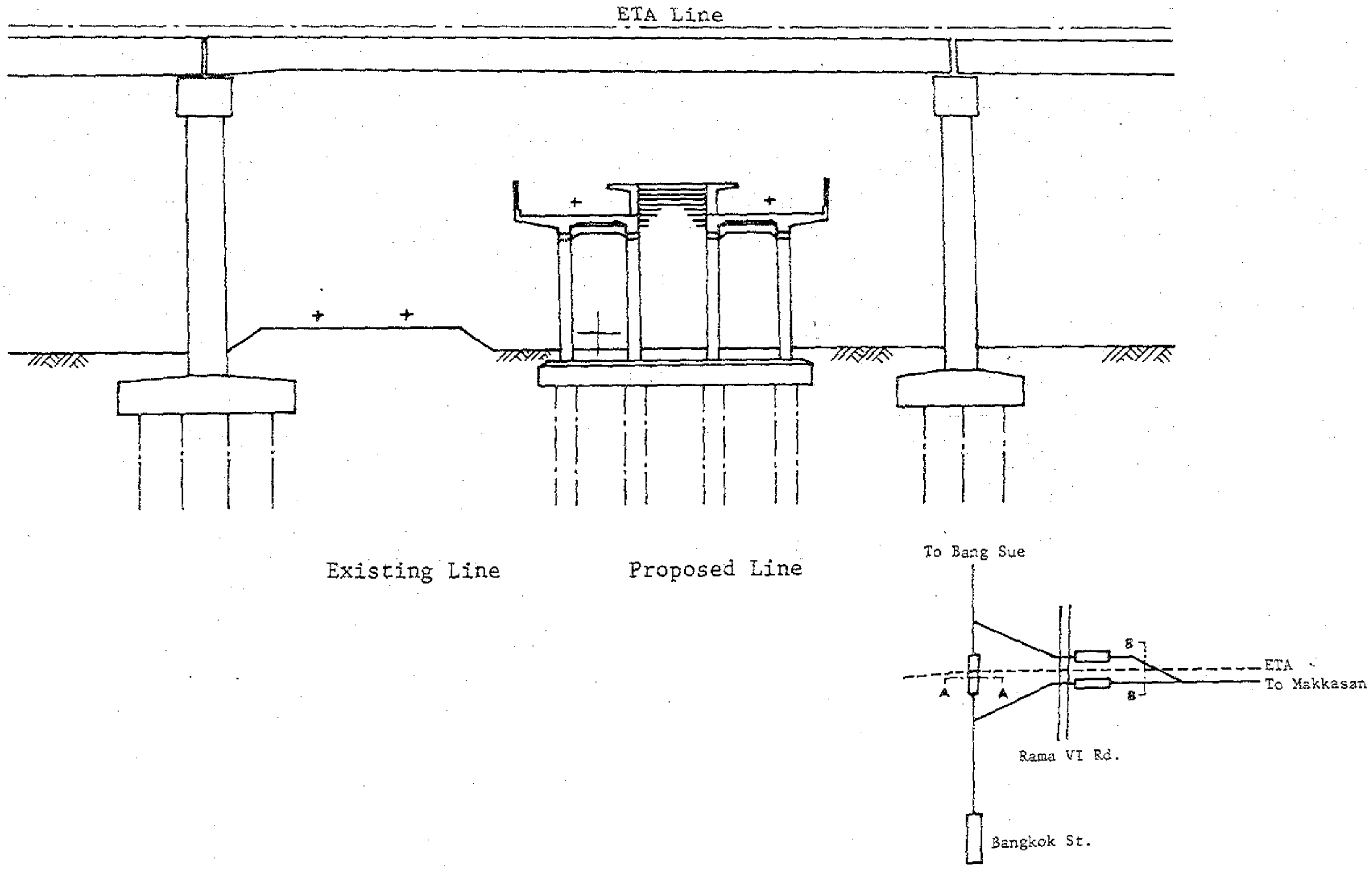


Fig. 7.1.11 Rough Sketch of Section A-A

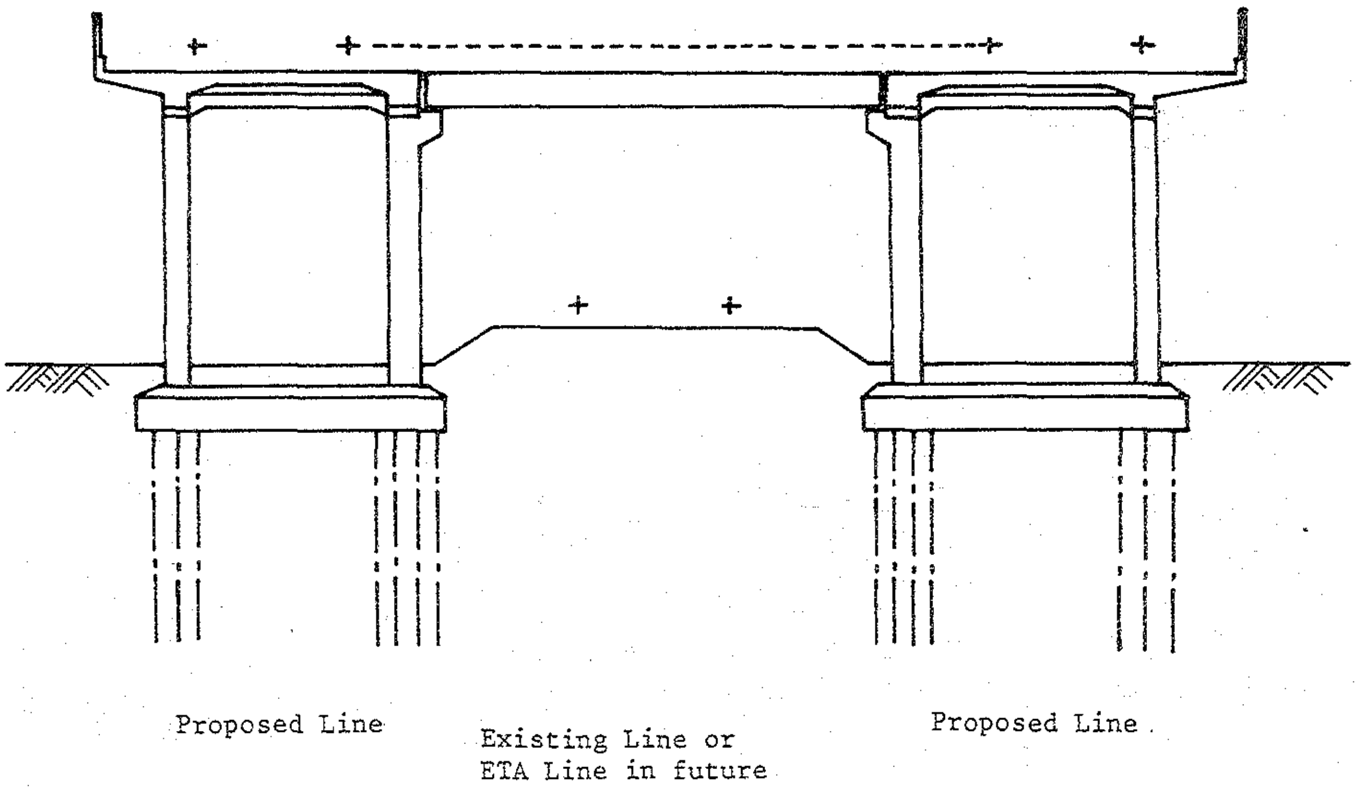
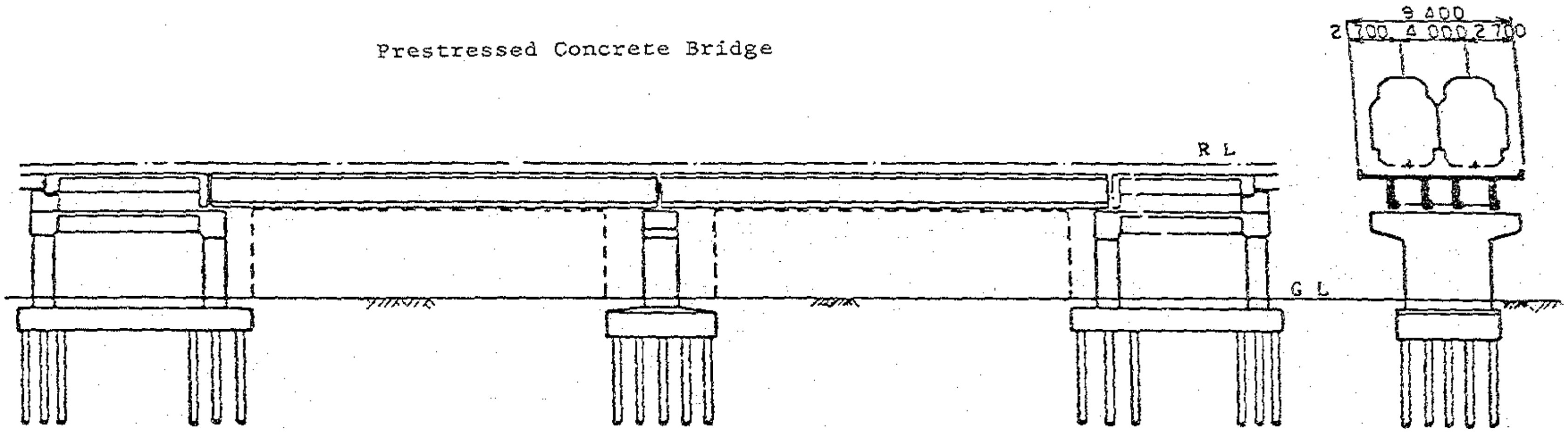
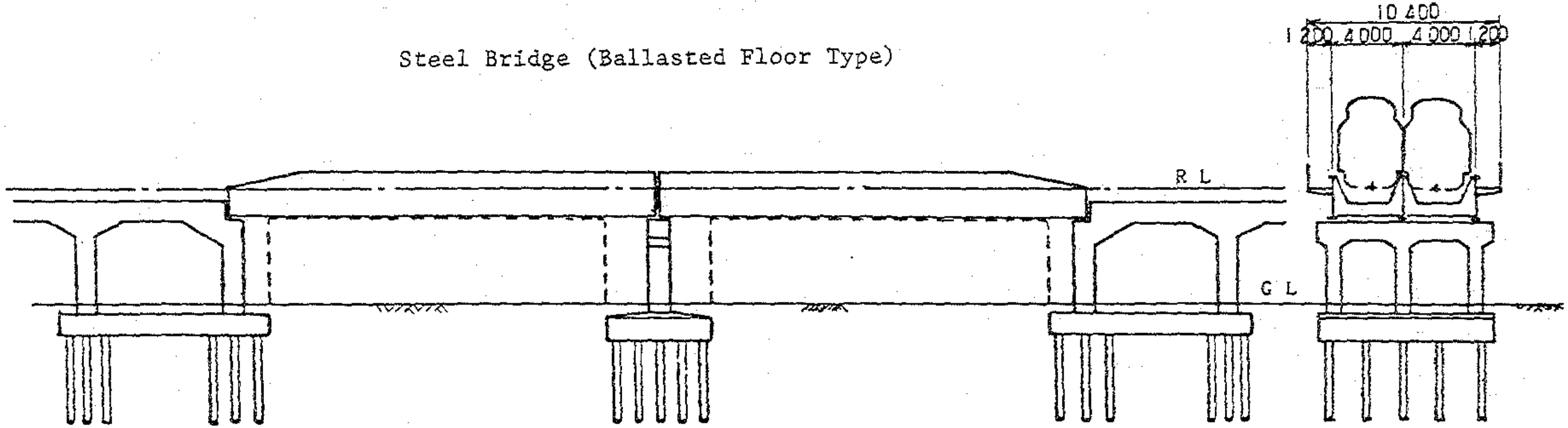


Fig. 7.1.12 Rough Sketch of Section B-B

Prestressed Concrete Bridge



Steel Bridge (Ballasted Floor Type)



(Unit: mm)

Fig. 7.1.13 Overroad Bridge

7.1.5 Station Facilities

(1) Relocation of Makkasan Station

The existing Makkasan Station will be moved to the east of the present position as shown in Fig. 7.1.14, since a part of the station will interfere with construction of the elevated track.

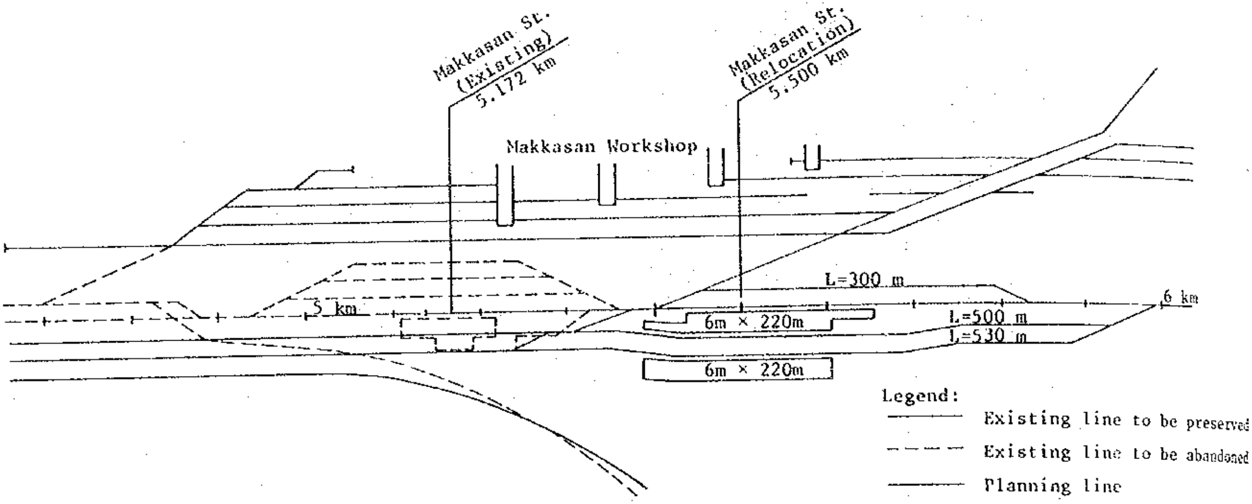


Fig. 7.1.14 Makkasan Station Layout

(2) Station main building

Each station main building in the proposed elevated section will be accommodated under the viaduct and its facilities will be arranged as shown in Fig. 7.1.15.

The scale for such station main building is classified as follows.

Medium size	Sam Sen St., Makkasan St.
Small size	New Stations

(3) Platform

a) Platform type

Island-type platforms are adopted for the following reasons:

- Track addition to the double-track viaduct on the Northern Line in accordance with the future operational plan.
- The space limitation due to the Mass Transit System by ETA and the necessity to install relief track on the Eastern Line.

b) Platform length

Platform length is determined as follows by adding a leeway of 20 m to the present maximum train length.

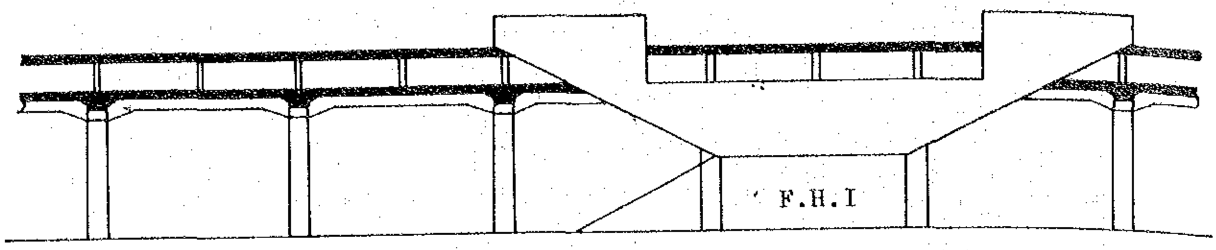
Sam Sen Station	380 m (for 18 cars)
Other Stations	220 m (for 10 cars)

c) Platform width

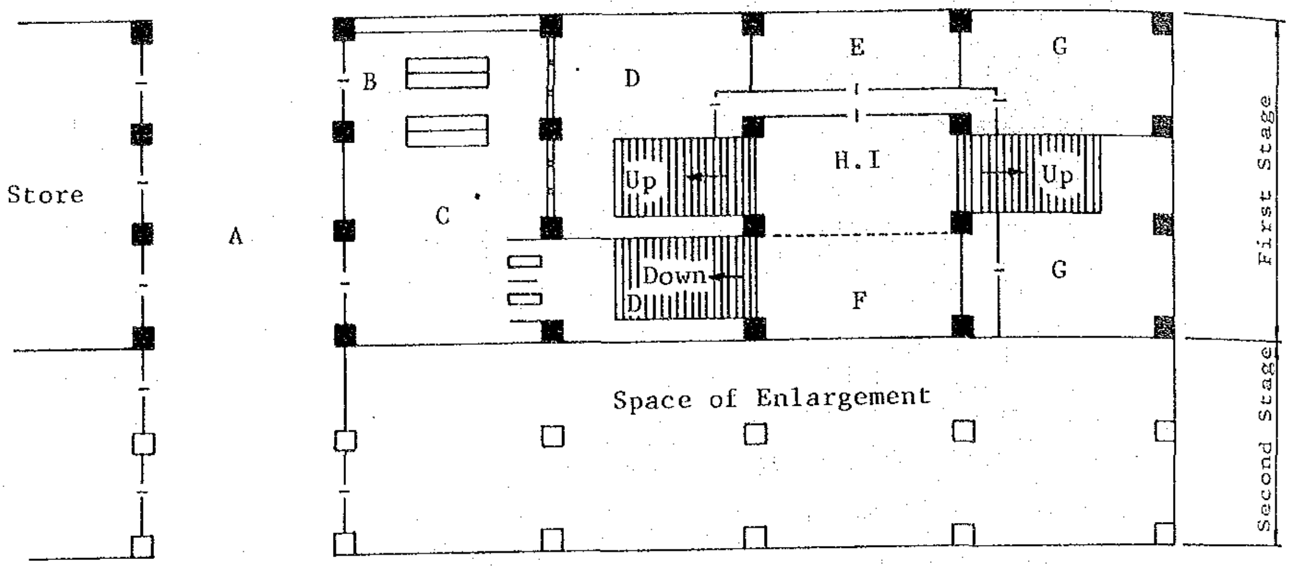
Platform width is determined to be either 6 m or 4 m considering the increased number of passengers in 2003 and the required stairway width for such an increase.
Width of each platform end is determined as follows in accordance with JNR standards.

For use of double sides	3 m
For use of single side only	2 m

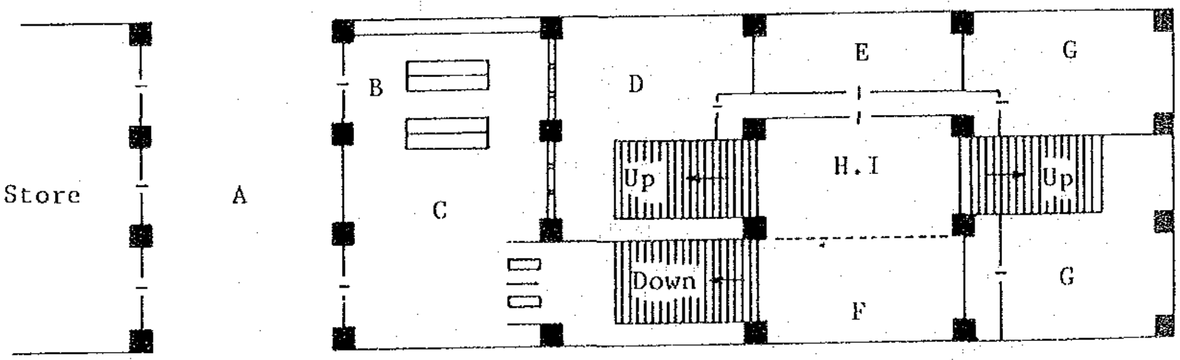
Side View



Sam Sen Station



New Station



A Free Passage
B Waiting Room
C Concourse
D Ticket Room
E Station Master
F Toilet
G Station Employee's Room
H Implement Room
I Lumber Room

Fig. 7.1.15 Station Facilities Layout

7.2 Facilities Plan for Neighboring Sections

All related facilities should be designed in order to promote effective use of the functions of the elevated structure. Therefore, the following work is examined.

7.2.1 The Terms of Planning

This plan covers about 30 km including the sections between Bang Sue and Chiang Rak on the Northern Line, between Makkasan and Hua Takhe on the Eastern Line, and between Bang Sue and Sala Ya on the Southern Line.

7.2.2 Concept of Doubling Track

Doubling of track will require widening the levee, as shown in Fig. 7.2.1. The existing station facilities will be utilized to a maximum degree, from an economic aspect.

The road bed of the Eastern Line will be raised by 1 m including existing track because some sections are still submerged.

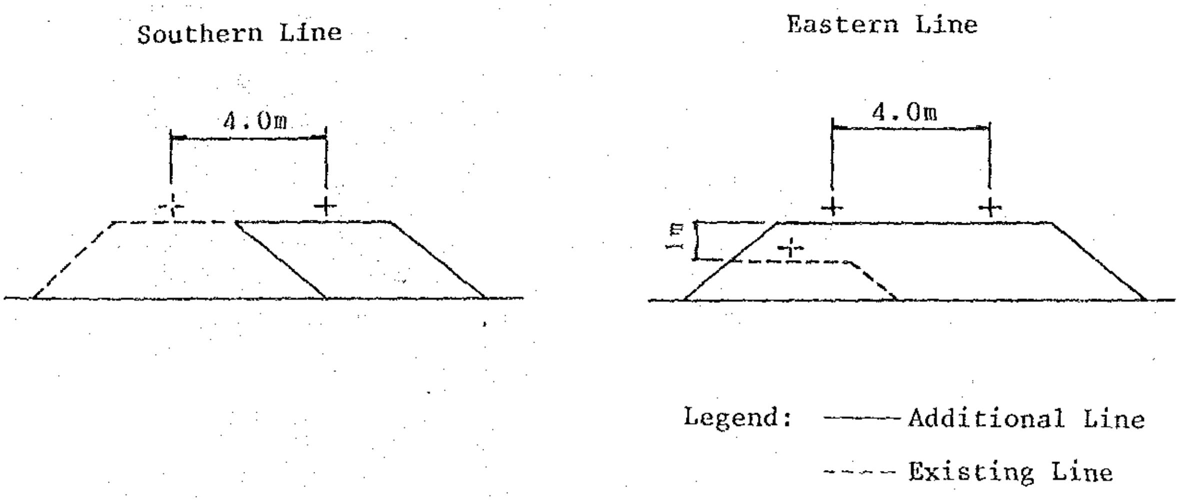
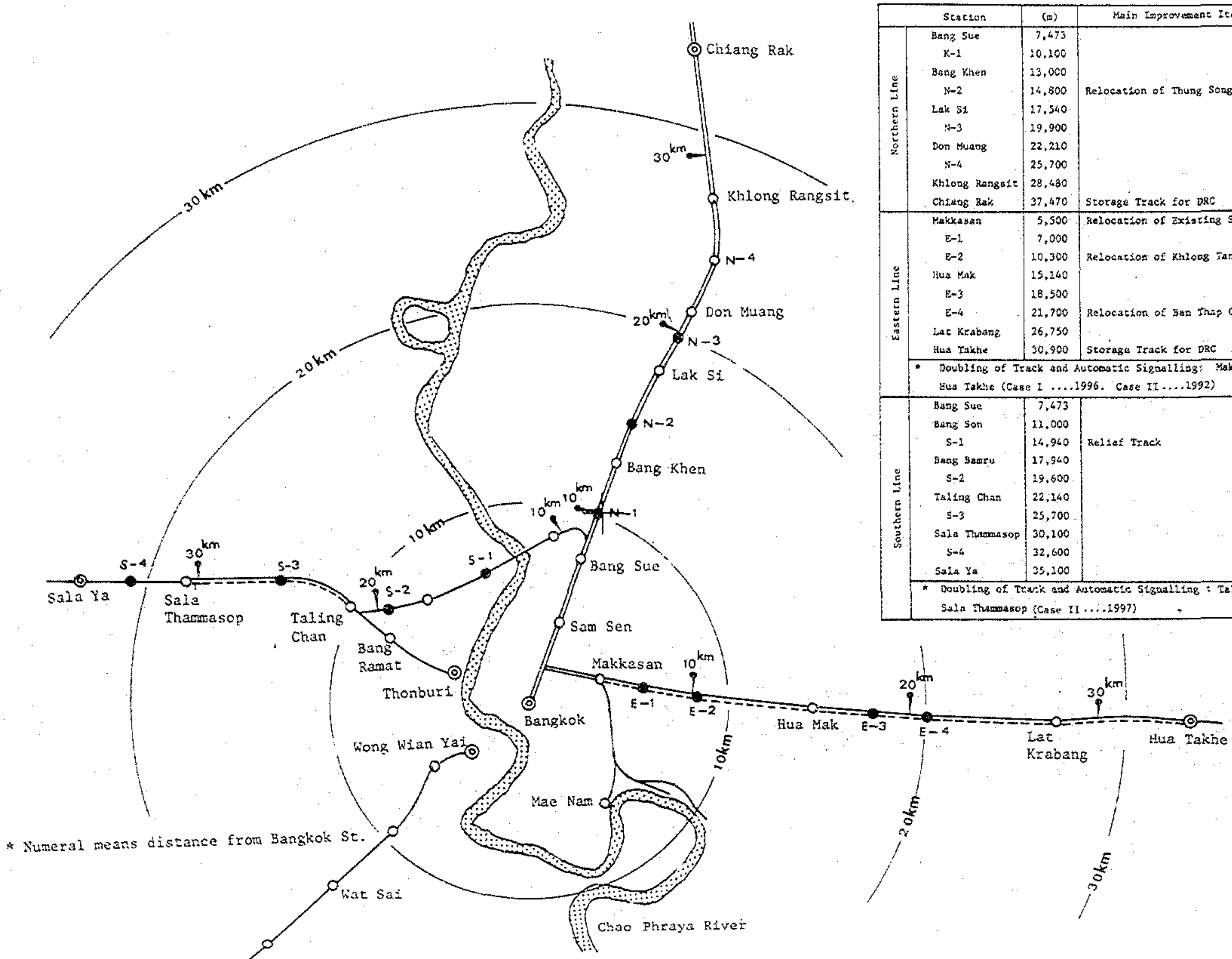


Fig. 7.2.1 Embankment of Track Addition Section

	Station	(m)	Main Improvement Items
Northern Line	Bang Sue	7,473	
	K-1	10,100	
	Bang Khen	13,000	
	N-2	14,800	Relocation of Thung Song Hong
	Lak Si	17,540	
	N-3	19,900	
	Don Muang	22,210	
	N-4	25,700	
	Khlong Rangsit	28,480	
	Chiang Rak	37,470	Storage Track for DRC
Eastern Line	Makkasan	5,500	Relocation of Existing Station
	E-1	7,000	
	E-2	10,300	Relocation of Khlong Tan
	Hua Mak	15,140	
	E-3	18,500	
	E-4	21,700	Relocation of Ban Thap Chang
	Lat Krabang	26,750	
	Hua Takhe	30,900	Storage Track for DRC
	* Doubling of Track and Automatic Signalling: Makkasan ~ Hua Takhe (Case I ....1996. Case II....1992)		
Southern Line	Bang Sue	7,473	
	Bang Son	11,000	
	S-1	14,940	Relief Track
	Bang Bamru	17,940	
	S-2	19,600	
	Taling Chan	22,140	
	S-3	25,700	
	Sala Thammasop	30,100	
	S-4	32,600	
	Sala Ya	35,100	
	* Doubling of Track and Automatic Signalling : Taling Chan ~ Sala Thammasop (Case II ....1997)		



* Numeral means distance from Bangkok St.

Fig. 7.2.2 New Stations and Relocation of the Existing Stations on Study Area

7.2.3 Establishment of New Stations

New stations will be established at the locations shown in Fig. 7.2.2 if transport service is required for the growing urban area.

7.2.4 Station Facilities

a) The existing station main buildings will remain in use, and platform height will be increased to medium height and length extended to 220 m.

b) For the time being, the new station will be provided with side platforms only.

c) Necessary repair facilities will be installed at two stations - Chiang Rak and Hua Takhe - proposed for shuttling service.

7.3 Electric Facilities Planning

In the Fifth Plan, color light signals and tokenless blocks will be installed and dispatching telephones will be replaced for electric facilities. It is assumed that the above projects are implemented and this Study is coordinated with the electrification project for the Northern Line.

Electric facilities will be installed as follows in the Study Area.

7.3.1 Signalling

A signalling system is essential to improve safety and train operation efficiency. In the Study Area, the number of trains will be increased. And so automatic block systems and three-aspect signals will be employed in double-track sections.

(i) Block system

An automatic block system will be employed on the Northern Line and Eastern Line in the proposed elevated section. Automatic block system, which automatically controls block and signal aspects as trains run on continuous track circuits, will be employed.

Automatic block signal with green normal aspect will be instaled between stations. The number of block sections and positions of block signals will be determined considering local conditions

A single-line, tokenless block system will be employed on the Mae Nam Line.

As for the unelevated section in the Study Area, the double-line automatic block system will be employed on the double-track line, and the single-line tokenless block system will be employed on single-track line.

Adaption of bidirectional type automatic block system is to be studied in the course of the engineering study on signalling systems, which covers the improvement of signalling system of double-track line section.

(ii) Signal equipment

A multiple color light signal will be employed, with three aspects as standard (consisting of green, yellow and red aspects) to allow short headway train operations.

As for the unelevated section of the Study Area, the signal equipment of the Fifth Plan will be employed on the single-track line, and the three-aspect signal equipment will be employed on the double-track line. When the single-track line is improved to the double-track line, signal equipment will be improved to the three-aspect system.

(iii) Track circuit

The track circuit is an electrical circuit which detects the existance of trains to control the safety guard system. The rails form an electric circuit which is shunted by the axles of the rolling stock. Audio frequency (AF) and direct current (DC) track circuits will be employed in consideration of alternative current (AC) electrification.

(iv) Point machines

Electric point machines with high safety will be used to suit short headway train operations.

(v) Interlocking equipment

All relay interlocking equipment will be installed at stations and signal stations equipped with points for securing safety of train operations.

(vi) Centralized traffic control system (CTC)

This allows remote control of point machines and signals, indicates the traffic situation to the control center, and dispatches the train operation. It will be installed in the proposed elevated section and controlled from the Bang Sue dispatching center.

(vii) Grade crossing equipment

Train check devices will be installed at man-operated grade crossings on the unelevated track section in the Study Area in order to warn of approaching trains.

7.3.2 Telecommunication System

A telecommunication system is essential for punctual train operation, appropriate dispatching, prompt restoration of damages after accidents and improvement of transport service.

Telecommunication system will be installed as follows in the Study Area.

(i) Telecommunication cable

Telecommunication cable will be used as much as possible to improve telecommunication quality and provide maintenance-free communication.

When AC electlrification is implemented appropriate measures should be taken to prevent induction interference to telecomminication facilities; while cables with aluminum covering outside of cable quads will be used, maximum preventive measures should be provided on the electric supply side.

Cables will be accommodated in ducts alongside the tracks in elevated section, and hung on the telecommunication poles in the unelevated section in the Study Area.

(ii) Pulse Code Modulation (PCM) equipment

PCM equipment suitable for data transmission will be installed to improve telecommunication quality and transmission efficiency.

(iii) Dispatching telephones

New dispatching telephones, considered in the Fifth Plan, will be installed in new stations.

(iv) Facsimile

This is used to promptly and accurately transmit operating information in the form of characters of figures. Central equipment and transmitter will be installed in the Bang Sue dispatching center and receivers will be installed in stations.

(v) Train radio

This facilitates direct communication between train crews and stations or the dispatching center and is used for train operating information and emergency communication in case of accident. Radio base stations will be installed at some stations.

(vi) Others

Public address equipment and electric clocks will be installed at main stations to improve passenger service.

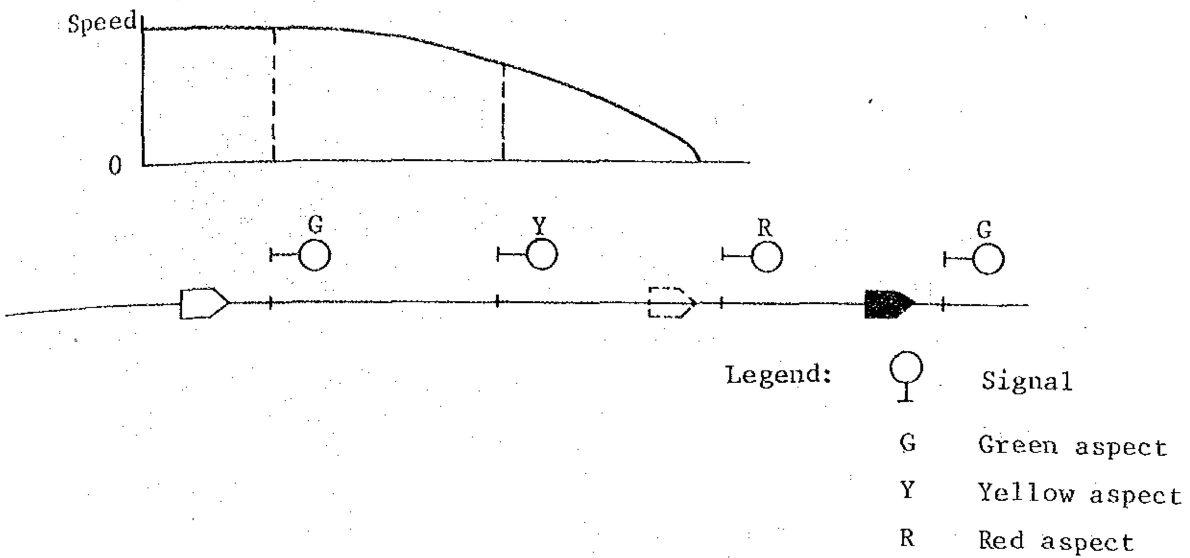


Fig. 7.3.1 Automatic Block System

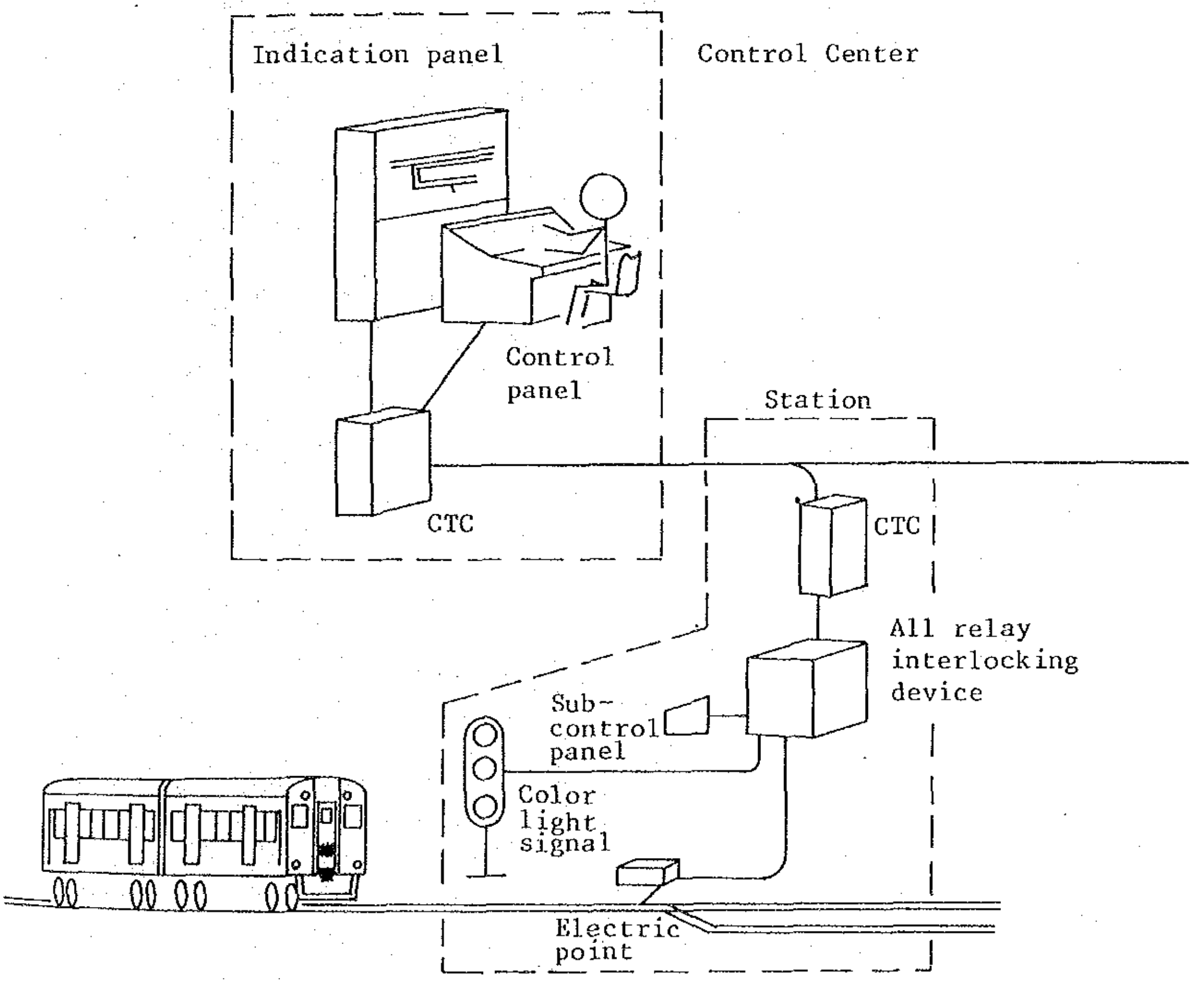


Fig. 7.3.2 CTC System

7.4 Implementation Planning

7.4.1 Implementation

The construction work requires a detailed site survey to choose the optimum construction method and the actual work will require careful field supervision because it must be done in close proximity to the existing line. Full preparation must be made by prior consultation with people concerned, considering normal train operation during construction, accident prevention, use of existing railway facilities, disposal of roads and buildings hampering construction, etc.

7.4.2 Work Schedule

The work will be.executed in stages for both the proposed elevated section and unelevated section alike. Table 7.4.1 shows the work schedule for the proposed elevated section. The first-stage work is scheduled for completion by 1990 and the second-stage work, together with the necessary work for the unelevated sections, is scheduled for completion in the target year depending upon traffic demand.

Table 7.4.1 Construction Schedule

Proposed Elevated Section (1st Stage)

Year / Type of construction	1	2	3	4	5	Remarks
Preparation	━━━					Site formation drainage
Elevated structure	━━	━━━	━━━	━━━		
Track				━━━	━━━	
Other facilities				━━━	━━━	Signalling, tele-communication

Proposed Elevated Section (2nd Stage)

Year / Type of construction	1	2	3	4	5	Remarks
Preparation	━					Site formation drainage
Elevated structure	━	━━━	━			
Track		━━	━━━	━		
Other facilities		━━	━━━	━		Signalling, tele-communication

CHAPTER 8 INVESTMENT SCALE AND SCHEDULE

CHAPTER 8 INVESTMENT SCALE AND SCHEDULE

This chapter discusses the investment scale and schedule related to arrangement of railway facilities. Both scale and schedule are based on train operation planning by the demand forecast.

8.1 Construction Cost Estimation

8.1.1 Preconditions for Calculation of Construction Cost

(1) The construction cost is calculated as of October 1983, and an escalation factor is not considered.

(2) Costs are classified as foreign currency and domestic currency costs.

(3) In the proposed elevated section, civil engineering related work is paid by international tender. For the unelevated section, civil engineering work is paid by domestic tender in Thailand. All electric related work is paid by international tender.

(4) In the construction cost calculation, construction work on Sattahib Line, road construction work in Bangkok, railway construction in Japan and sidetrack expansion work on the Eastern Line are used as reference.

(5) A value equivalent to 12% of the construction cost is allowed as investigation, design and supervision expenses. For electrical facilities, the rate is 25%.

(6) A value equivalent to 15% of the construction cost, investigation and design expenses, supervision expenses and land purchase expenses is allowed as a contingency. For electrical facilities, the rate is 5%.

(7) The foreign exchange rate is US$1 = 23 Baht = ¥230.

8.1.2 Investment Scale

Investment scales of Case I and Case II are shown in Tables 8.1.1 to 8.1.4. In those tables, Stage I is completed before 1991, and Stage II is completed depending on demand forecast.

Investment scales by five-year are shown in Appendixes 8.1.1 and 8.1.2.

8.2 Investment Schedule

Investment schedules of Case I and Case II are shown in Tables 8.2.1 and 8.2.2.

Table 8.1.1 Investment Scale (BMA) Case I

(Unit: Baht)

Classification of Work / Investment	Unit	Quantity	Unit Price x10^3	Investment ×10^6		
				Foreign Currency	Domestic Currency	Total
1. Civil Engineering, Track and Station Facilities						
Roadbed	km	30.4		102.4	152.2	254.6
Bridge structure	km	13.6		563.7	1,517.3	2,081.0
Track	km	88.5		214.9	177.4	392.3
Station facilities	Set	15		42.8	100.3	143.1
Temporary track work	Set	1		2.6	4.3	6.9
Subtotal				926.4	1,951.5	2,877.9
2. Land Purchase	Set	1	52,140	0	52.1	52.1
3. Electrical Facilities						
Electric power	Set	1	57,100	34.4	22.7	57.1
Signalling system	Set	1	464,500	274.6	189.9	464.5
Telecommunication system	Set	1	189,100	102.5	86.6	189.1
Subtotal				411.5	299.2	710.7
4. Rolling Stock						
Diesel locomotive	Car	8	36,100	236.8	52.0	288.8
Diesel rail car	Car	81	9,800	652.1	141.7	793.8
Passenger car	Car	36	6,700	198.0	43.2	241.2
Freight car	Car	254	1,000	203.2	50.8	254.0
Subtotal				1,290.1	287.7	1,577.8
5. Grand Total				2,628.0	2,590.5	5,218.5

Table 8.1.2 Investment Scale (BMA) Case II

(Unit: Baht)

Classification of Work / Investment	Unit	Quantity	Unit Price x10^3	Investment x10^6 Foreign Currency	Domestic Currency	Total
1. Civil Engineering, Track and Station Facilities						
Roadbed	km	37.3		116.5	170.9	287.4
Bridge structure	km	13.63		564.8	1,520.0	2,084.8
Track	km	96.5		250.2	196.2	446.4
Station facilities	Set	33		64.5	143.1	207.6
Temporary track work	Set	1		2.6	4.3	6.9
Subtotal				998.6	2,034.5	3,033.1
2. Land Purchase	Set	1	79,820	0	79.8	79.8
3. Electrical Facilities						
Electric power	Set	1	65,000	37.7	27.3	65.0
Signalling system	Set	1	493,400	291.5	201.9	493.4
Telecommunication system	Set	1	191,600	103.5	88.1	191.6
Subtotal				432.7	317.3	750.0
4. Rolling Stock						
Diesel locomotive	Car	8	36,100	236.8	52.0	288.8
Diesel rail car	Car	105	19,600	845.3	183.7	1,029.0
Passenger car	Car	36	9,800	198.0	43.2	241.2
Freight car	Car	254	1,000	203.2	50.8	254.0
Subtotal				1,483.3	329.7	1,813.0
5. Grand Total				2,914.6	2,761.3	5,675.9

Table 8.1.3 (1) Investment Scale Breakdown (Civil Engineering) Case I

(Unit, Baht)

Line		Item	Unit	Quantity	Unit Price $\times 10^3$	Stage I $\times 10^6$	Stage II $\times 10^6$	Foreign Currency $\times 10^6$	Domestic Currency $\times 10^6$	Total $\times 10^6$	Remarks
Northern Line	Proposed elevated section	Roadbed	km	1.2	8,780	10.5	0	3.1	7.4	10.5	Including retaining wall
		Viaduct	km	5.4	199,810	846.4	232.6	281.1	797.9	1,079.0	
		Track	km	16.4	5,880	81.8	14.7	55.0	41.5	96.5	Including removal of existing track
		Station facilities	Set	3	12,280	36.8	0	10.8	26.0	36.8	
		Temporary track	Set	1	1,400	1.4	0	0.3	1.1	1.4	Including removal of temporary track. Rails, sleepers, etc. are provided by SRT.
		Subtotal				976.9	247.3	350.3	873.9	1,224.2	
	Unelevated section	Roadbed	km	1.2	9,750	11.7	0	5.0	6.7	11.7	
		Track	km	1.7	8,300	14.1	0	8.8	5.3	14.1	
		Station facilities	Set	1	11,280	11.3	0	3.1	8.2	11.3	
		Land purchase	Set	1	26,070	26.1	0	0	26.1	26.1	
		Subtotal				63.2	0	16.9	46.3	63.2	
		Total				1,040.1	247.3	367.2	920.2	1,287.4	
Eastern Line	Proposed elevated section	Roadbed	km	0.3	40,560	12.2	0	3.1	9.1	12.2	Including retaining wall
		Viaduct	km	3.8	158,880	556.6	47.1	162.4	441.3	603.7	
		Track	km	9.0	6,490	50.6	7.8	34.0	24.4	58.4	Including removal of existing track
		Station facilities	Set	4	16,280	65.1	0	20.0	45.1	65.1	Including removal of Makkasan St
		Subtotal				684.5	54.9	219.5	519.9	739.4	
	Unelevated section	Roadbed	km	25.9	7,610	33.7	163.4	84.6	112.5	197.1	Including existing line raising
		Bridge	km	0.2	124,800	0	25.0	7.2	17.8	25.0	
		Track	km	55.2	3,290	45.4	136.2	93.0	88.6	181.6	Old rails and sleepers from existing track are used.
		Station facilities	Set	5	5,040	6.5	18.7	7.7	17.5	25.2	
		Land purchase	Set	1	26,070	26.1	0	0	26.1	26.1	
		Subtotal				111.7	343.3	192.5	262.5	455.0	
		Total				796.2	398.2	412.0	782.4	1,194.4	
Mae Nam Line	Proposed elevated section	Roadbed	km	0.5	37,300	18.7	0	4.6	14.1	18.7	Including retaining wall
		Viaduct	km	4.2	88,900	373.4	0	113.1	260.3	373.4	Including Phetburi and Rama IV Rd lowering
		Track	km	4.9	6,600	32.3	0	18.4	13.9	32.3	Including removal of existing track
		Temporary track works	Set	1	5,450	5.5	0	2.3	3.2	5.5	Including removal of temporary track. Rails, sleepers, etc. are provided by SRT.
		Subtotal				429.9	0	138.4	291.5	429.9	
Southern Line	Unelevated section	Roadbed	km	1.3	3,430	4.5	0	1.9	2.6	4.5	
		Track	km	1.3	7,220	9.4	0	5.7	3.7	9.4	
		Station facilities	Set	2	2,320	4.6	0	1.1	3.5	4.6	
		Subtotal				18.5	0	8.7	9.8	18.5	
Grand Total						2,284.7	645.5	926.3	2,003.9	2,930.2	

Table 8.1.3 (2) Investment Scale Breakdown (Electrical Facilities) Case I

(Unit: ×10^6 Baht)

Line		Item	Unit	Quantity	Unit Price	Stage 1	Stage 2	Foreign Currency	Domestic Currency	Total
Northern Line	Proposed elevated section	Electric Lighting	set	1	21.2	21.2	0	12.8	8.4	21.2
		Signalling	Set	1	118.7	101.6	17.1	71.3	47.4	118.7
		Telecommunication	Set	1	65.1	65.1	0	35.3	29.8	65.1
		Subtotal			205.0	187.9	17.1	119.4	85.6	205.0
	Unelevated section	Electric Lighting	Set	1	3.2	3.2	0	1.9	1.3	3.2
		Signalling	Set	1	109.6	109.6	0	64.3	45.3	109.6
		Telecommunication	Set	1	29.8	29.8	0	16.1	13.7	29.8
		Subtotal			142.6	142.6	0	82.3	60.3	142.6
	Total				347.6	330.5	17.1	201.7	145.9	347.6
Eastern Line	proposed elevated section	Electric Lighting	Set	1	20.1	20.1	0	12.1	8.0	20.1
		Signalling	Set	1	69.7	64.9	4.8	41.7	28.0	69.7
		Telecommunication	Set	1	30.3	30.3	0	16.3	14.0	30.3
		Subtotal			120.1	115.3	4.8	70.1	50.0	120.1
	Unelevated section	Electric Lighting	Set	1	9.4	9.4	0	5.7	3.7	9.4
		Signalling	Set	1	103.2	40.6	62.6	60.8	42.4	103.2
		Telecommunication	Set	1	28.8	23.8	5.0	15.6	13.2	28.8
		Subtotal			141.4	73.8	67.6	82.1	59.3	141.4
	Total				261.5	189.1	72.4	152.2	109.3	261.5
Mae Nam Line	Proposed elevated section	Signalling	Set	1	8.7	8.7	0	4.6	4.1	8.7
		Telecommunication	Set	1	9.7	9.7	0	5.4	4.3	9.7
		Subtotal			18.4	18.4	0	10.0	8.4	18.4
Southern Line	Unelevated section	Electric lighting	Set	1	3.2	3.2	0	1.9	1.3	3.2
		Signalling	Set	1	54.6	54.6	0	31.9	22.7	54.6
		Telecommunication	Set	1	25.1	25.1	0	13.5	11.6	25.1
		Subtotal			82.9	82.9	0	47.3	35.6	82.9
Grand Total					710.4	620.9	89.5	411.2	299.2	710.4

Table 8.1.4 (1) Investment Scale Breakdown (Civil Engineering) Case II

(Unit: Baht)

Line		Item	Unit	Quantity	Unit Price $\times10^3$	Stage I $\times10^6$	Stage II $\times10^6$	Foreign Currency $\times10^6$	Domestic Currency $\times10^6$	Total $\times10^6$	Remarks
Northern Line	Proposed elevated section	Roadbed	km	1.2	8,780	10.5	0	3.1	7.4	10.5	Including retaining wall
		Viaduct	km	5.4	199,810	846.4	232.6	281.1	797.9	1,079.0	
		Track	km	16.4	5,880	81.8	14.7	55.0	41.5	96.5	Including removal of existing track
		Station facilities	Set	3	12,280	36.8	0	10.8	26.0	36.8	
		Temporary track	Set	1	1,400	1.4	0	0.3	1.1	1.4	Including removal of temporary track. Rails, sleepers, etc. are provided by SRT.
		Subtotal				976.9	247.3	350.3	873.9	1,224.2	
	Unelevated section	Roadbed	km	1.2	10,400	12.5	0	5.4	7.1	12.5	
		Track	km	2.1	8,300	17.4	0	10.9	6.5	17.4	
		Station facilities	Set	9	3,970	35.7	0	11.3	24.4	35.7	
		Land purchase	Set	1	39,910	39.9	0	0	39.9	39.9	
		Subtotal				105.5	0	27.6	77.9	105.5	
		Total				1,082.4	247.3	377.9	951.8	1,329.7	
Eastern Line	Proposed elevated section	Roadbed	km	0.3	40,560	12.2	0	3.1	9.1	12.2	Including retaining wall
		Viaduct	km	3.8	158,880	556.6	47.1	162.4	441.3	603.7	
		Track	km	9.0	6,490	50.6	7.8	34.0	24.4	58.4	Including removal of existing track
		Station facilities	Set	4	16,280	65.1	0	20.0	45.1	65.1	Including removal of Makkasan St
		Subtotal				684.5	54.9	219.5	519.9	739.4	
	Unelevated section	Roadbed	km	25.9	8,100	37.8	172.0	90.1	119.7	209.8	Including existing line raising
		Bridge	km	0.2	124,800	0	25.0	7.2	17.8	25.0	
		Track	km	55.8	3,500	58.9	136.4	106.2	89.1	195.3	Old rails and sleepers from existing track are used.
		Station facilities	Set	8	5,900	36.9	10.3	15.7	31.5	47.2	
		Land purchase	Set	1	39,910	39.9	0	0	39.9	39.9	
		Subtotal				173.5	343.7	219.2	298.0	517.2	
		Total				858.0	398.6	438.7	817.9	1,256.6	
Mae Nam Line	Proposed elevated section	Roadbed	km	0.5	37,300	18.7	0	4.6	14.1	18.7	Including retaining wall
		Viaduct	km	4.2	88,900	373.4	0	113.1	260.3	373.4	Including Phetburi and Rama IV Rd lowering
		Track	km	4.9	6,600	32.3	0	18.4	13.9	32.3	Including removal of existing track
		Temporary track work	Set	1	5,450	5.5	0	2.3	3.2	5.5	Including removal of temporary track. Rails, sleepers, etc. are provided by SRT.
		Subtotal				429.9	0	138.4	291.5	429.9	
Southern Line	Unelevated section	Roadbed	km	8.2	2,900	6.5	17.3	10.2	13.6	23.8	
		Bridge	km	0.03	124,800	0	3.7	1.1	2.6	3.7	
		Track	km	8.3	5,600	8.9	37.6	25.7	20.8	46.5	
		Station facilities	Set	9	2,530	22.8	0	6.7	16.1	22.8	
		Subtotal				38.2	58.6	43.7	53.1	96.8	
Grand Total						2,408.5	704.5	998.7	2,114.3	3,113.0	

Table 8.1.4 (2) Investment Scale Breakdown (Electrical Facilities) Case II

(Unit: ×10^6 Baht)

Line		Item	Unit	Quantity	Unit Price	Stage 1	Stage 2	Foreign Currency	Domestic Currency	Total
Northern Line	Proposed elevated section	Electric Lighting	Set	1	21.2	21.2	0	12.8	8.4	21.2
		Signalling	Set	1	118.7	101.6	17.1	71.3	47.4	118.7
		Telecommunication	Set	1	65.1	65.1	0	35.3	29.8	65.1
		Subtotal			205.0	187.9	17.1	119.4	85.6	205.0
	Unelevated section	Electric Lighting	Set	1	7.7	7.7	0	4.1	3.6	7.7
		Signalling	Set	1	109.6	109.6	0	64.3	45.3	109.6
		Telecommunication	Set	1	29.8	29.8	0	16.1	13.7	29.8
		Subtotal			147.1	147.1	0	84.5	62.6	147.1
	Total				352.1	335.0	17.1	203.9	148.2	352.1
Eastern Line	Proposed elevated section	Electric Lighting	Set	1	20.1	20.1	0	12.1	8.0	20.1
		Signalling	Set	1	69.7	64.9	4.8	41.7	28.0	69.7
		Telecommunication	Set	1	30.3	30.3	0	16.3	14.0	30.3
		Subtotal			120.1	115.3	4.8	70.1	50.0	120.1
	Unelevated section	Electric Lighting	Set	1	11.1	11.1	0	5.8	5.3	11.1
		Signalling	Set	1	103.2	40.6	62.6	60.8	42.4	103.2
		Telecommunication	Set	1	28.8	23.8	5.0	15.6	13.2	28.8
		Subtotal			143.1	75.5	67.6	82.2	60.9	143.1
	Total				263.2	190.8	72.4	152.3	110.9	263.2
Mae Nam Line	Proposed elevated section	Electric Lighting					0			
		Signalling	Set	1	8.7	8.7	0	4.6	4.1	8.7
		Telecommunication	Set	1	9.7	9.7	0	5.4	4.3	9.7
		Subtotal			18.4	18.4	0	10.0	8.4	18.4
Southern Line	Unelevated section	Electric Lighting	Set	1	4.9	4.9	0	2.9	2.0	4.9
		Signalling	Set	1	83.5	54.6	28.9	48.8	34.7	83.5
		Telecommunication	Set	1	27.9	25.1	2.8	14.8	13.1	27.9
		Subtotal			116.3	84.6	31.7	66.5	49.8	116.3
Grand Total					750.0	628.8	121.2	432.7	317.3	750.0

Table 8.2.1 Investment Schedule Case I

Line		Item / Year	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Proposed Elevated Section		Investigation, Design (Civil engineering related facilities)	■	■	■	■	■	■						■	■		
Unelevated Section			■	■					■	■							
Proposed Elevated Section		Investigation, Design (Electrical related facilities)	■	■	■	■								■	■		
Unelevated Section			■	■	■	■			■	■							
Northern Line	Proposed elevated section	Roadbed			■	■	■	■									
		Viaduct			■	■	■	■						■	■		
		Track						■	■						■	■	
		Station facilities							■								
		Temporary track work			■	■											
		Electrical facilities			■	■	■	■	■						■	■	
	Unelevated section	Roadbed					■	■									
		Track							■								
		Station facilities						■	■								
		Land purchase			■	■											
		Electrical facilities					■	■	■								
Eastern Line	Proposed elevated section	Roadbed			■	■	■	■									
		Viaduct			■	■	■	■						■	■		
		Track						■	■						■	■	
		Station facilities							■								
		Electrical facilities			■	■	■	■	■						■	■	
	Unelevated section	Roadbed				■	■	■	■	■							
		Bridge							■	■							
		Track						■	■	■	■	■	■	■			
		Station facilities						■	■	■			■	■			
		Land purchase			■	■											
		Electrical facilities					■	■	■	■	■	■	■	■			
Mae Nam Line	Proposed elevated section	Roadbed			■	■	■	■									
		Viaduct			■	■	■	■									
		Track						■	■								
		Temporary track work			■	■											
		Electrical facilities			■	■	■	■	■								
Southern Line	Unelevated section	Roadbed					■										
		Bridge							■								
		Station facilities					■		■								
		Electrical facilities					■	■	■								

Table 8.2.2 Investment Schedule Case II

Line		Year Item	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Proposed Elevated Section		Investigation, Design (Civil engineering related facilities)	━	━	━	━	━	━	━	━	━						
Unelevated Section			━	━		━	━										
Proposed Elevated Section		Investigation, Design (Electrical related facilities)	━	━	━	━	━	━	━	━	━						
Unelevated Section			━	━	━	━	━	━	━			━	━				
Northern Line	Proposed elevated section	Roadbed			━	━	━	━									
		Viaduct			━	━	━	━		━	━						
		Track						━	━		━	━					
		Station facilities							━								
		Temporary track work			━	━											
		Electrical facilities			━	━	━	━	━		━	━					
	Unelevated section	Roadbed				━	━										
		Track						━	━								
		Station facilities					━	━	━								
		Land purchase			━	━											
		Electrical facilities					━	━	━								
Eastern Line	Proposed elevated section	Roadbed			━	━	━	━									
		Viaduct			━	━	━	━		━	━						
		Track						━	━		━	━					
		Station facilities							━								
		Electrical facilities			━	━	━	━	━		━	━					
	Unelevated section	Roadbed			━	━	━		━								
		Bridge				━	━										
		Track					━	━	━	━							
		Station facilities					━		━	━							
		Land purchase			━	━											
		Electrical facilities					━	━	━	━							
Mae Nam Line	Proposed elevated section	Roadbed			━	━	━	━									
		Viaduct			━	━	━	━									
		Track						━	━								
		Temporary track work			━	━											
		Electrical facilities			━	━	━	━	━								
Southern Line	Unelevated section	Roadbed				━	━					━	━	━			
		Bridge												━			
		Track						━	━					━	━		
		Station facilities					━		━								
		Electrical facilities					━	━	━					━	━		

CHAPTER 9 UTILIZATION PLANNING UNDER ELEVATED TRACKS

CHAPTER 9 UTILIZATION PLANNING UNDER ELEVATED TRACKS

9.1 Present Land Use Situation

Present land use situation was surveyed to obtain basic information on the utilization planning under elevated tracks. The survey was conducted on both sides of the railway within a rang of 500 m. The result of the survey is shown in Table 9.1.1 (Appendix 9.1.1).

Table 9.1.1 Land Use Composition in Study Area

Section / Type of land use	Rama I to Bang Sue Stn.		Yoma Rat to Makkasan Stn.		Makkasan to Mae Nam Stn.	
	Area $(\times 10^4 m^2)$	(%)	Area $(\times 10^4 m^2)$	(%)	Area $(\times 10^4 m^2)$	(%)
Residential	244.99	40.16	110.97	43.02	175.79	42.87
Commercial	48.67	7.98	60,61	23.50	45.66	11.13
Industrial	3.35	0.55	0.16	0.06	61.02	14.88
Infrastructural	88.74	14.54	32.30	12.52	50.52	12.32
Other area	224.28	36.77	53.93	20.90	77.10	18.80
Total	610.03	100.00	257.97	100.00	410.09	100.00

General characteristics of the wayside area are as shown in Figs. 9.1.1 to 9.1.3. Wayside areas of each line are generally described as follows:

(1) Northern Line (Rama I ~ Bang Sue Station)

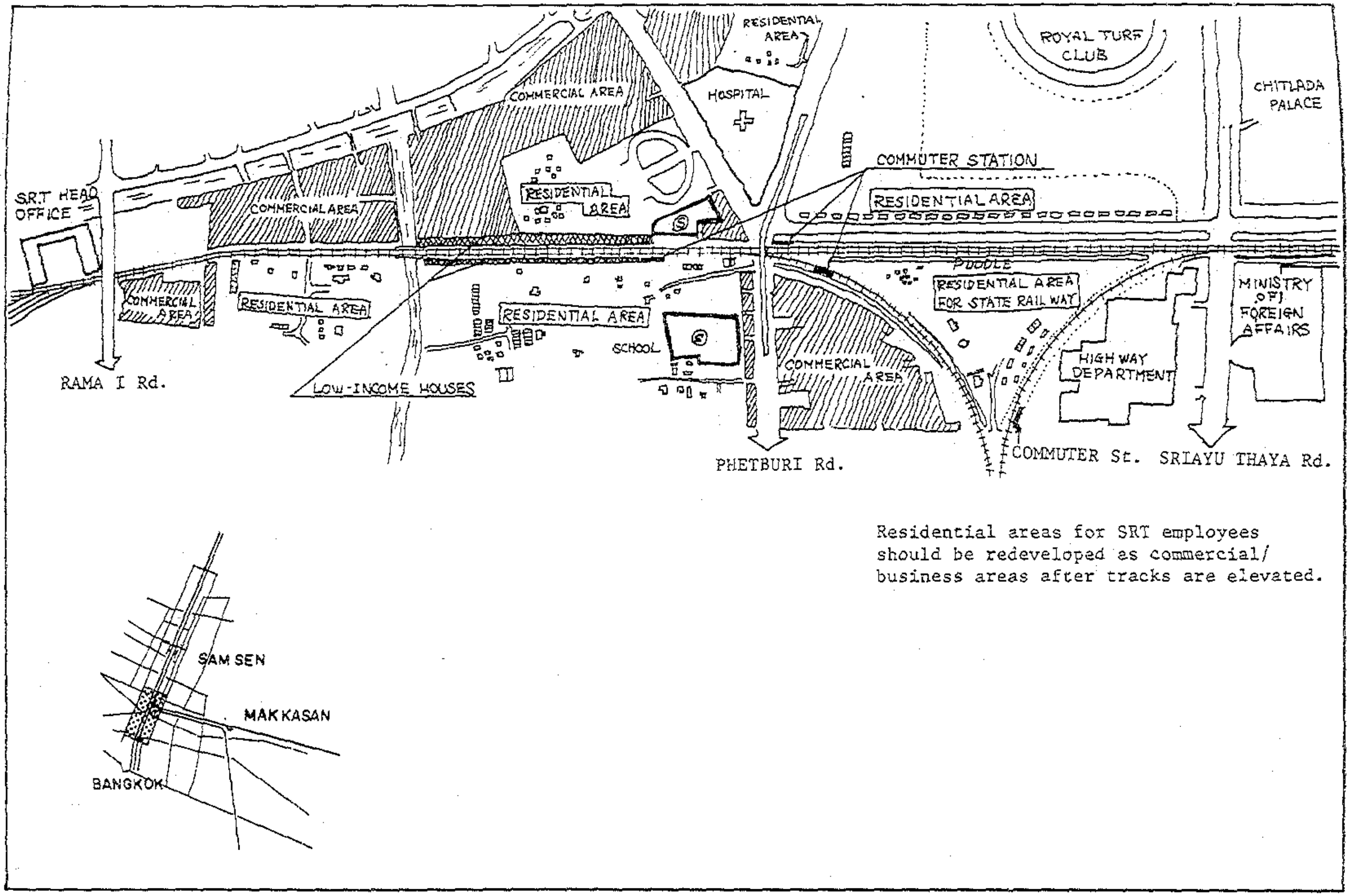
Wayside area of the proposed elevated section in this line mainly consists of residential area (40%) and public facilities (37%) such as the royal palace and hospital.
Relatively large concentration of commercial area is observed between Rama I Rd. and Sriayutthaya Rd. near Bangkok Station. However, the land use pattern varies over the railway due to frequent train operation in this section. The royal palace and hospital area are located between Sriayutthaya Rd. and Rajavithi Rd. Other areas are mostly utilized as military and residential areas.

(2) Eastern Line (Yoma Rat ~ Makkasan Station)

This section contains a relatively large amount of residential area (43%). However, the commercial area occupies 23% of the whole area along Phetburi Rd. and Sriayutthaya Rd. in parallel with the railway line. Particularly, these areas are observed on both sides of the railway between Phayathai Rd. and Makkasan Station, and a redevelopment area is located near Makkasan Station.

(3) Mae Nam Line (Makkasan Station ~ Mae Nam Station)

In this section, residential areas occupy 43% and industrial areas, 15%. The trunk roads (Phetburi Rd., Sukhumvit Rd. and Rama IV Rd.) cross the railway line, along which commercial areas are concentrated (11%).



Residential areas for SRT employees should be redeveloped as commercial/ business areas after tracks are elevated.

Fig. 9.1.1 (1) Characteristics of Existing Land Use Along the Study Area (Northern Line)

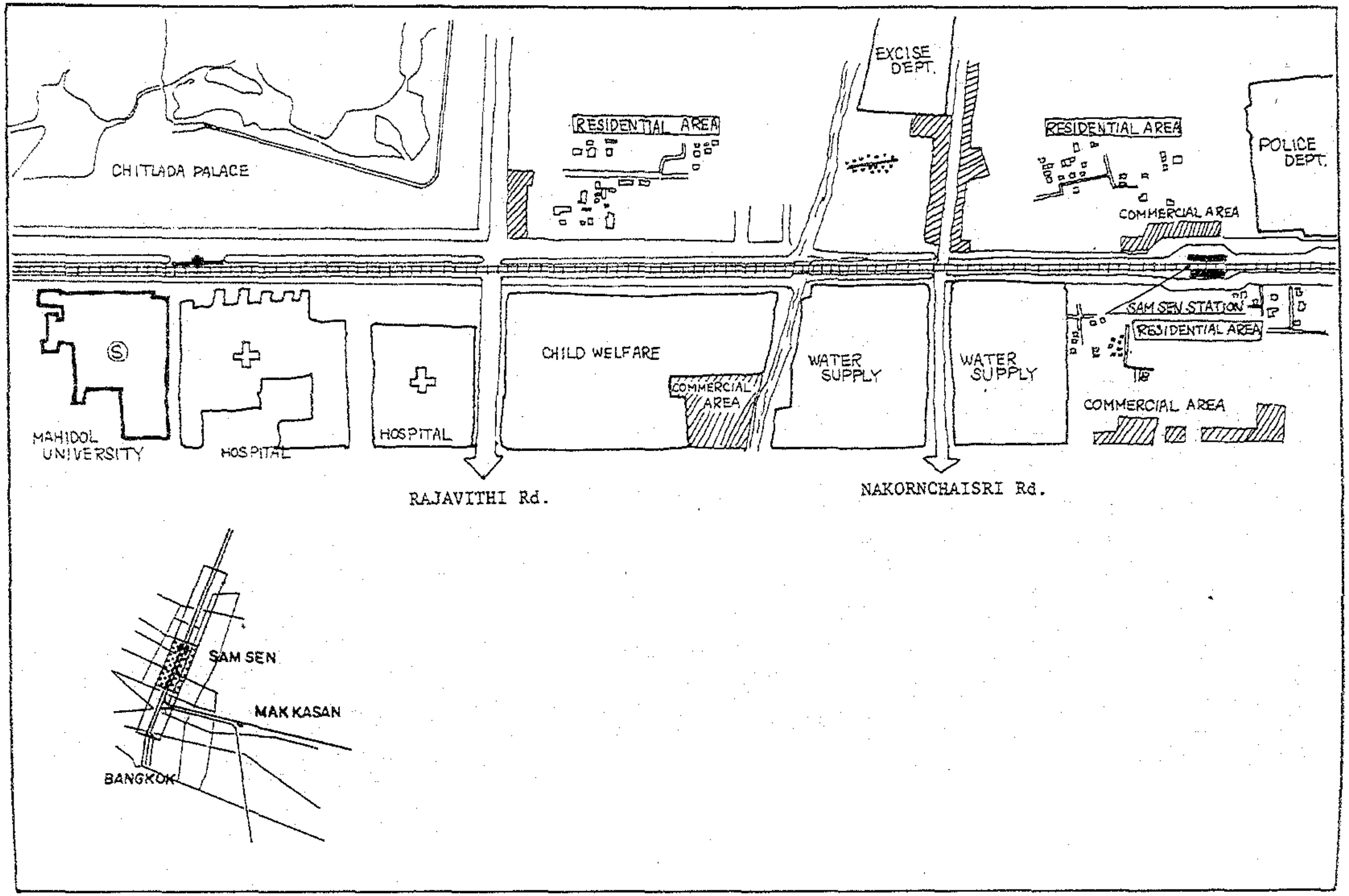


Fig. 9.1.1 (2) Characteristics of Existing Land Use Along the Study Area (Northern Line)

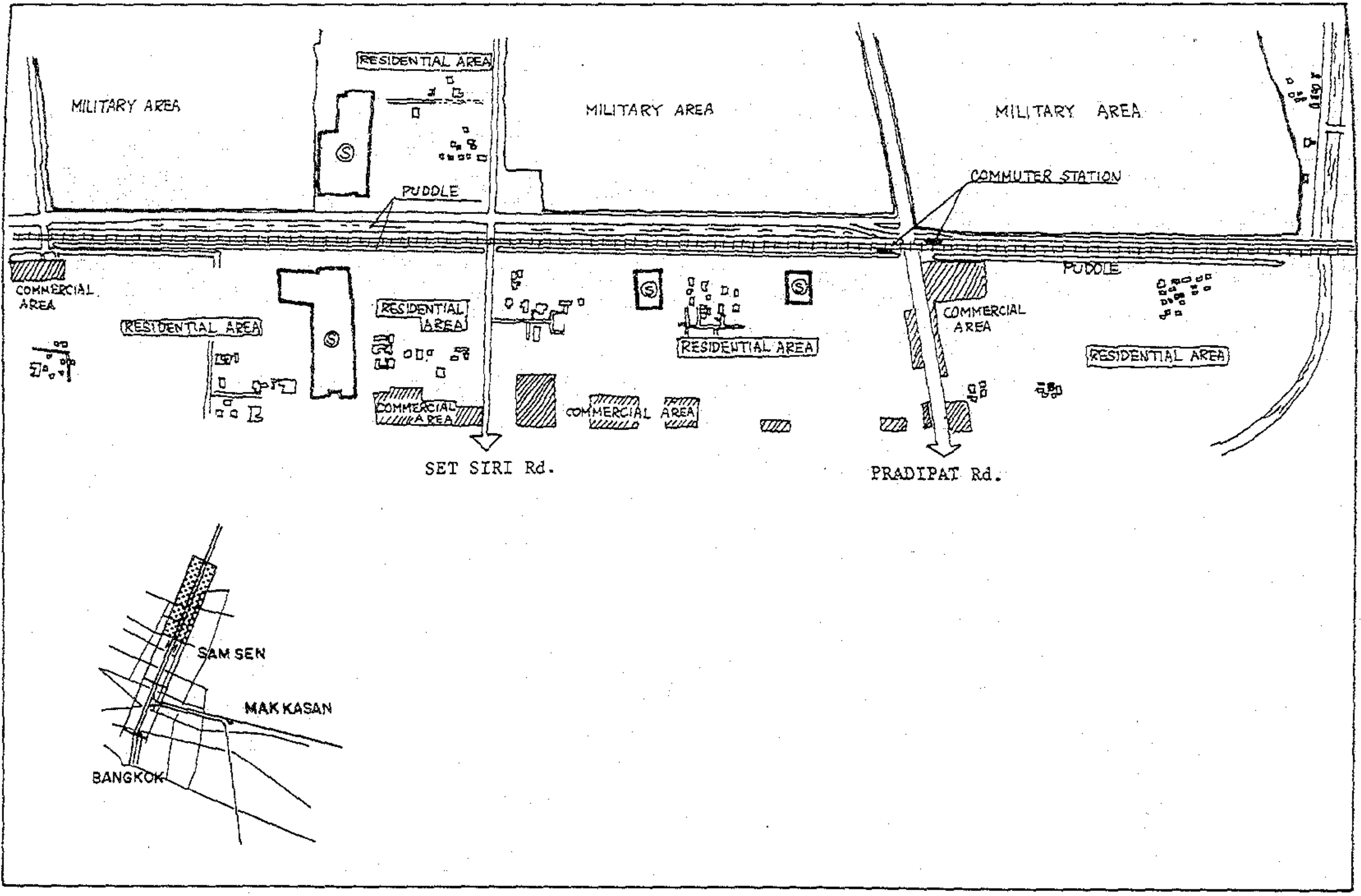


Fig. 9.1.1 (3) Characteristics of Existing Land Use Along the Study Area (Northern Line)

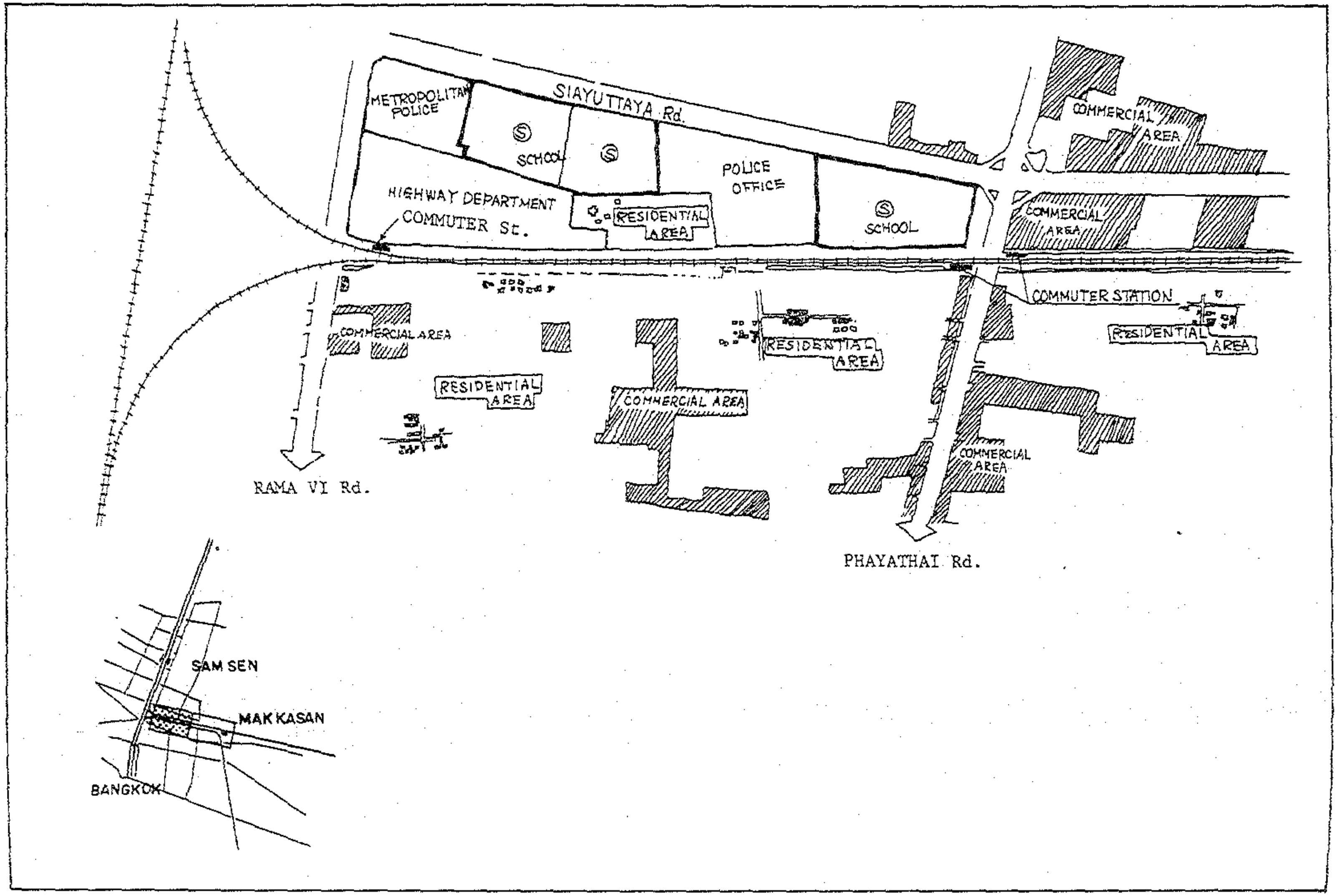
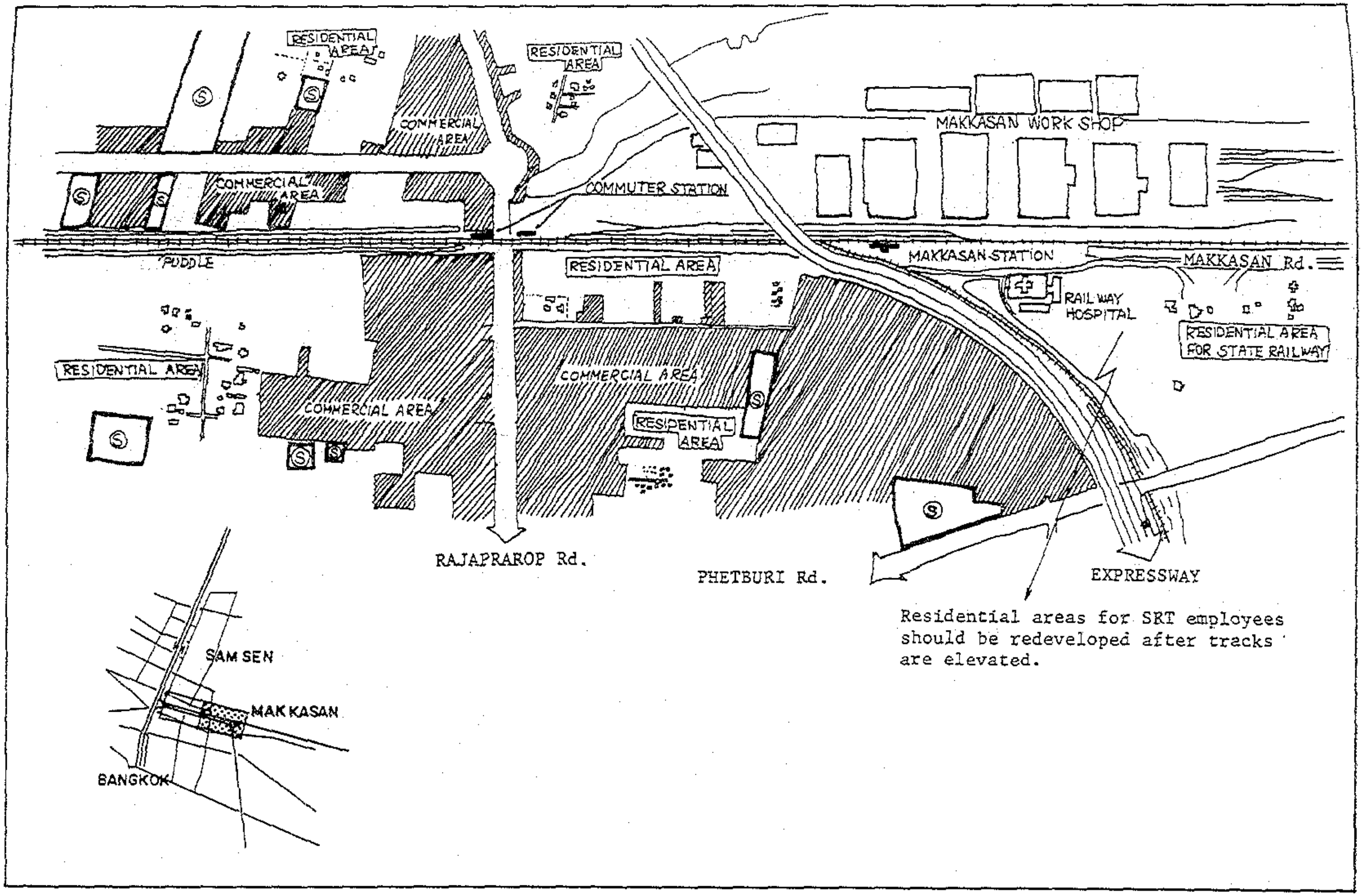


Fig. 9.1.2 (1) Characteristics of Existing Land Use Along the Study Area (Eastern Line)



Residential areas for SRT employees should be redeveloped after tracks are elevated.

Fig. 9.1.2 (2) Characteristics of Existing Land Use Along the Study Area (Eastern Line, Mae Nam Line)

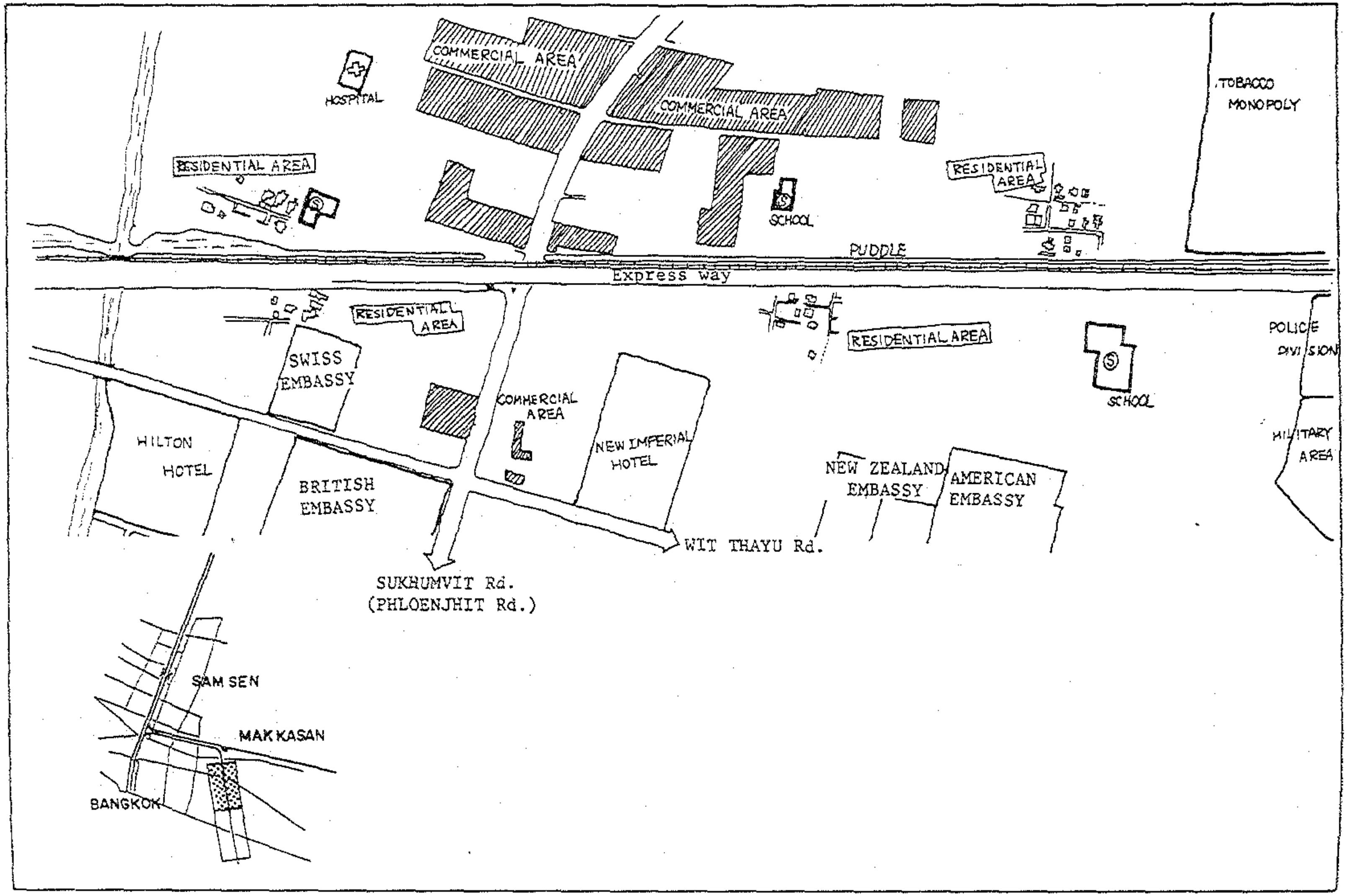


Fig. 9.1.3 (1) Characteristics of Existing Land Use Along the Study Area (Mae Nam Line)

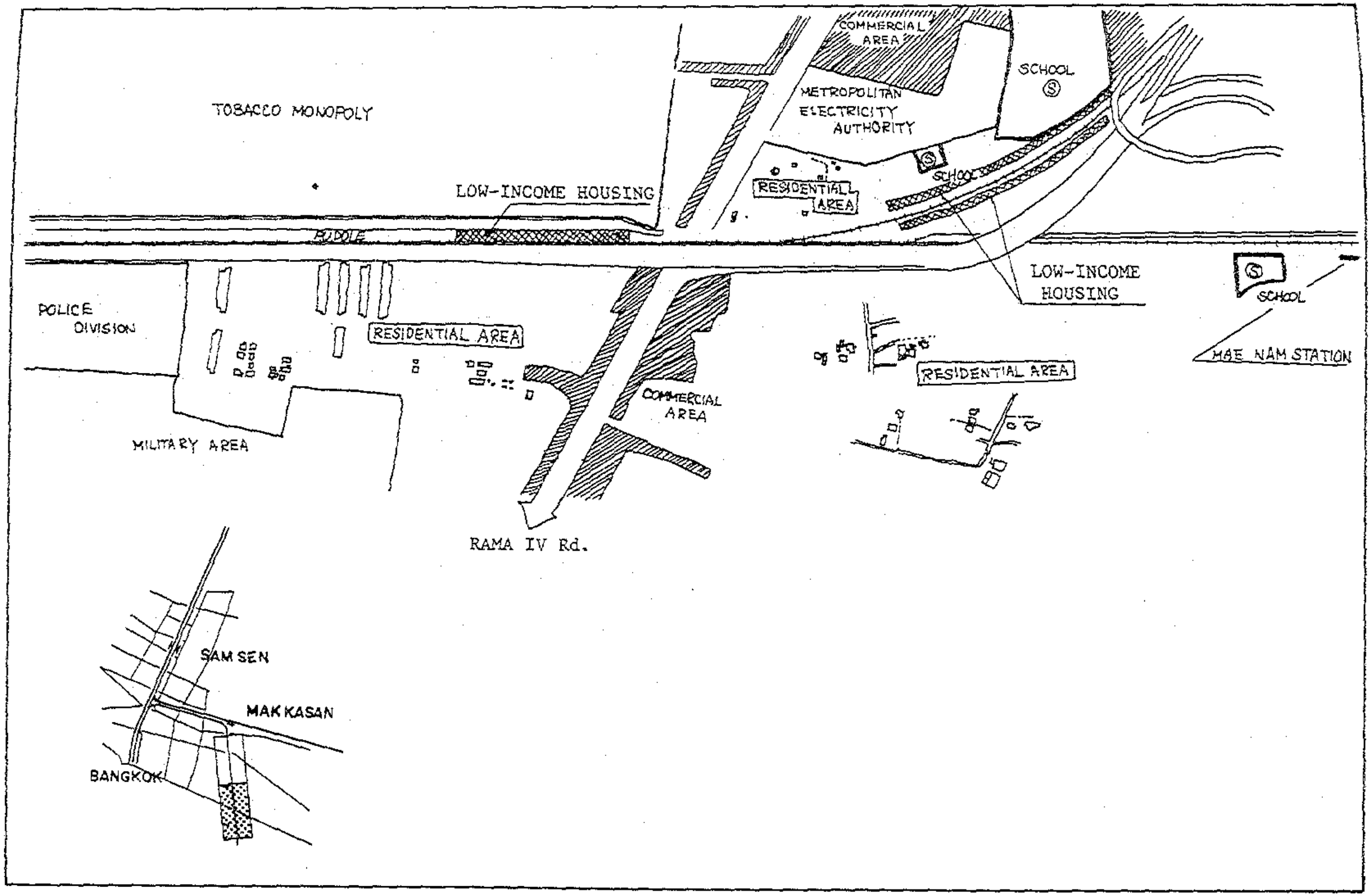


Fig. 9.1.3 (2) Characteristics of Existing Land Use Along the Study Area (Mae Mam Line)

9.2 Utilization Planning under Elevated Tracks

9.2.1 Major Facilities under Elevated Tracks

When ground-level railways are elevated, wayside areas which are separated by the railway can be integrated to facilitate the development of efficient and healthy communities.

Station facilities, commercial facilities and business facilities are planned to efficiently utilize open spaces created under elevated tracks considering land use in the vicinity.

(1) Concept of facilities

(i) Station facilities

As mentioned in Chapter 7, station facilities are an interface between railway and passengers. Stations must have a mobility function to connect the station plaza with platform and an accomodation function for passengers awaiting trains.

(ii) Commercial facilities

Commercial facilities primarily serve station users and are created as one of the new benefits from the track elevation project. At the same time, expanded consumption by local residents is expected as a result of unifying the areas which are divided by railway.

(iii) Business facilities

Business facilities are utilized for warehouses and parking lots.

(iv) Other uses

In addition, community facilities (parks and playgrounds) and buffer zones for disaster prevention could be included to make efficient use of the open spaces.

(2) Layout of facilities

(i) Northern Line

Public facilities such as the royal palace, hospitals and military areas are located in the proposed elevated section. It is desirable to introduce business facilities and community facilities, rather than emphatic introduction of commercial facilities.

A residential area between Phetburi Rd. and Sriayuthaya Rd. for SRT employees appears to be feasible for being developed as commercial and business area after railway track has been elevated, considering the surrounding land use pattern.

Also, commercial facilities are introduced near Sam Sen Station because commercial areas should be expanded after track elevation.

(ii) Eastern Line

Judging from the land use pattern, commercial areas will be expanded from now on. City structure should be changed from linear development along the roads at present to areal development centering at railway station.

As for the utilization of space under the elevated track, commercial facilities are introduced. for railway passengers and local residents in the surrounding area.

(iii) Mae Nam Line

Commercial facilities are introduced along Phetburi Rd., Sukhumvit Rd., and Rama IV Rd. Business facilities are introduced in other sections.

Judging from the land use pattern, the possibility of utilizing the space under the elevated track is shown in Table 9.2.1 and Fig. 9.2.1. Proposed redevelopment area at Yoma Rat and Makkasan is shown in Table 9.2.2.

Table 9.2.1 Utilization Planning Under Elevated Track

(Unit: m^2)

	First Construction Period				Second Construction Period			
	Station Facilities	Commercial facilities	Business Facilities	Other Facilities	Station Facilities	Commercial facilities	Business Facilities	Other Facilities
Northern Line	1,200	10,600	7,400	24,000	0	0	1,200	0
Eastern Line	1,200	23,700	2,600	0	0	1,700	900	0
Mae Nam Line	0	1,500	12,800	0	0	0	-	0
Total	2,400	35,800	22,800	24,000	0	1,700	2,100	0

Table 9.2.2 Proposed Redevelopment Area

(Unit: m^2)

	Commercial Facilities	Business Facilities	Other Facilities
Yoma Rat Area	14,900	22,200	37,100
Makkasan Area	32,000	49,000	81,000
Total	46,900	71,200	118,000

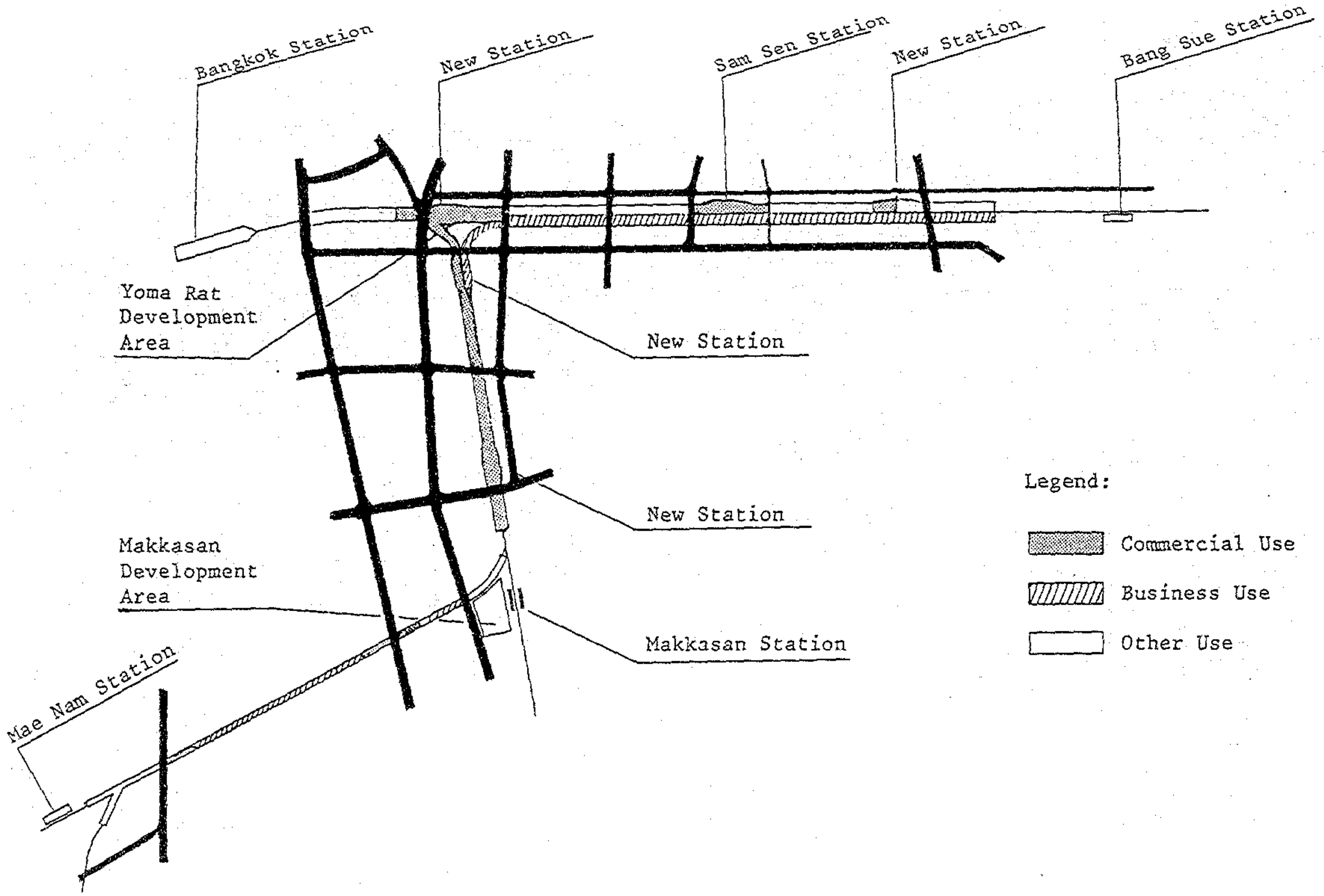


Fig. 9.2.1 Utilization Planning Under Elevated Tracks

9.2.2 Side Road Planning

(1) Effects of Side Road

Side roads are easily constructed to utilize the present railway space after tracks have been elevated. As they have a large effect on the area, it is desirable to construct of side roads.

Major effects of side roads are as follows:

(i) To facilitate community development by introducing transportation facilities.

(ii) To secure an access to transportation by using open space under the elevated tracks.

(iii) Buffer zone for such facilities as hospital and school in wayside which require environmental preservation.

(2) Planning of Side Road

The concept of side road planning for the railway line is described as follows:

(i) Northern Line

This area should be maintained as buffer zones for environmental preservation for the royal palace and hospital rather than just introducing roads.

(ii) Eastern and Mae Nam Line

Community should be actively promoted development by systematically connecting Soi and side roads and diverting automobile traffic from main roads.

Fig. 9.2.2 shows the relation between side roads and utilization planning under the elevated track.

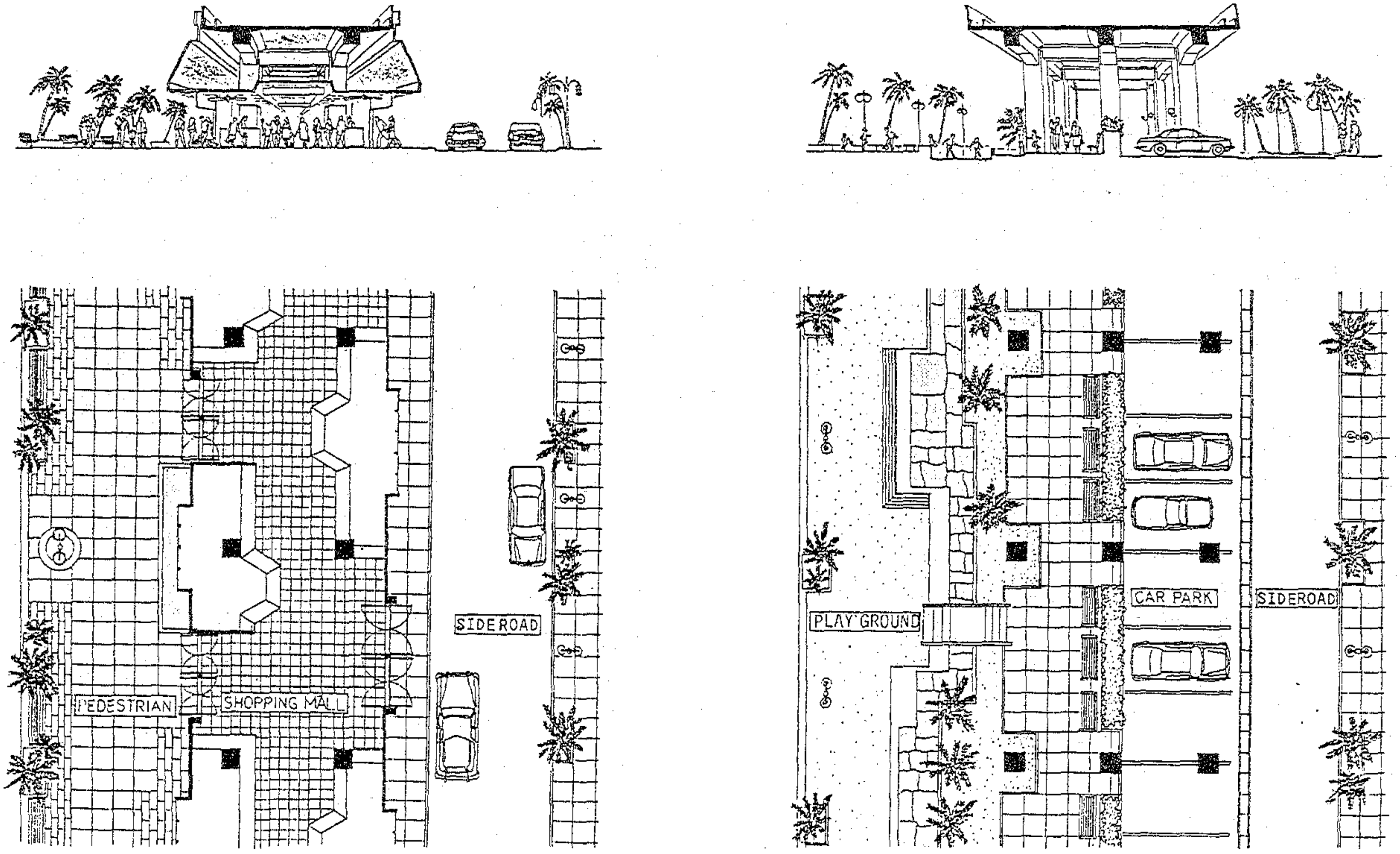


Fig. 9.2.2 Concept of Side Road and Utilization Planning Under Elevated Tracks

CHAPTER 10 GRADE SEPARATION AS ALTERNATIVE TO RAILWAY TRACK ELEVATION

CHAPTER 10 GRADE SEPARATION AS ALTERNATIVE TO RAILWAY TRACK ELEVATION

This chapter discusses the alternative of grade separation by road flyovers and/or underpasses instead of elevating the existing railway lines.

10.1 Present Condition around Grade Crossings

10.1.1 Grade Crossings

There are 14 grade crossings in the proposed elevated section, 7 on the Northern Line, 3 on the Eastern Line and 4 on the Mae Nam Line.

The location and number of each grade crossing, the traffic volume at grade crossings and related matters are shown in Table 10.1.1. (Appendixes 3.2.1 and 3.2.2.)

10.1.2 Roads around Grade Crossings

The Northern Line is parallel with and very close to Sawankaloke Road. Road intersections, which are only 30 m away from the railway, have a major impact on road traffic movements.

The Eastern Line intersects with three major north-south roads. These intersections with Sriayutthaya Road are about 120 m away from grade crossings No. 9 and No. 10.

The Mae Nam Line intersects with major east-west roads. These grade crossings are more congested, but freight train traffic on the Mae Nam Line is not frequent.

The traffic flow diagram for intersections which are close to the grade crossings of the Northern and Eastern Lines, is shown in Fig. 10.1.1.

The road traffic volume exceeds the capacity of the present traffic signals at these main intersections, and traffic congestion is due to interference with the grade crossings and insufficient capacity of the intersections and roads.

10.2 Study of Grade Separation

10.2.1 Basic Concept

Based on the information gathered through field surveys and the examination of maps, more appropriate layouts of flyovers are planned, paying special attention to the social, economic, technical and environmental aspects. The study has focused on the main items described below.

(1) Serviceability and accessibility of traffic

New facilities should not interfere with the present traffic flow as far as possible.

(2) Land purchase and compensation

The optimum grade separations with regard to land purchase and compensation were selected, with the least interference to present commercial areas and roads.

(3) Land use and environment

Due attention was paid to the impact on the present and future land use of the area and possible environmental preservation.

(4) Control points

The followings are considered as the primary control points.

- Palace and cultural assets
- Public facilities and buildings
- Military facilities
- Existing Expressway

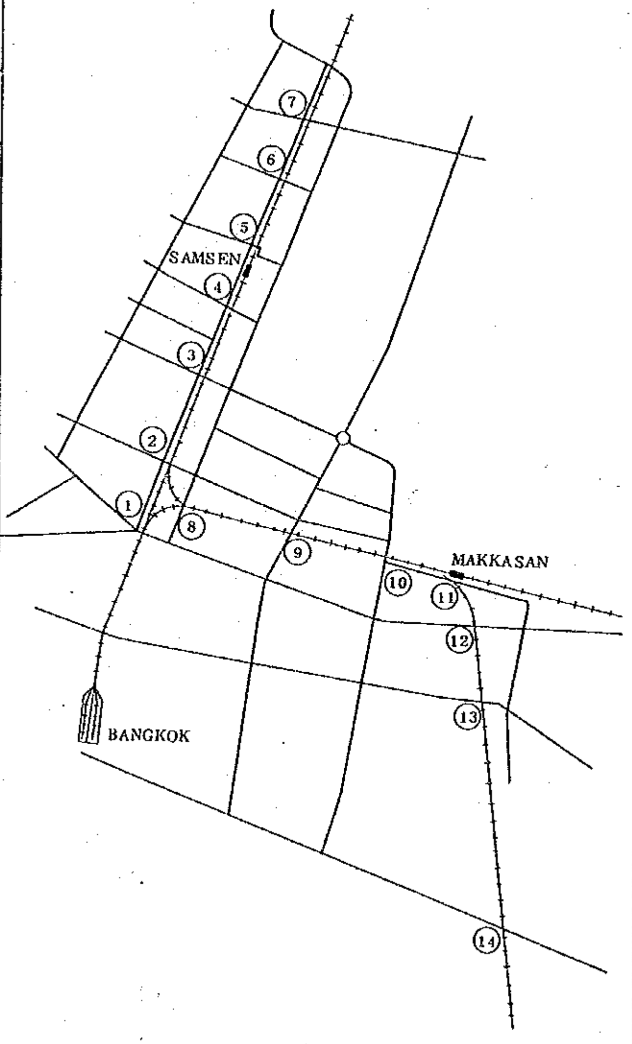
(5) The planned projects are to minimize changes to the planned Mass Transit System (MTS) and Expressway.

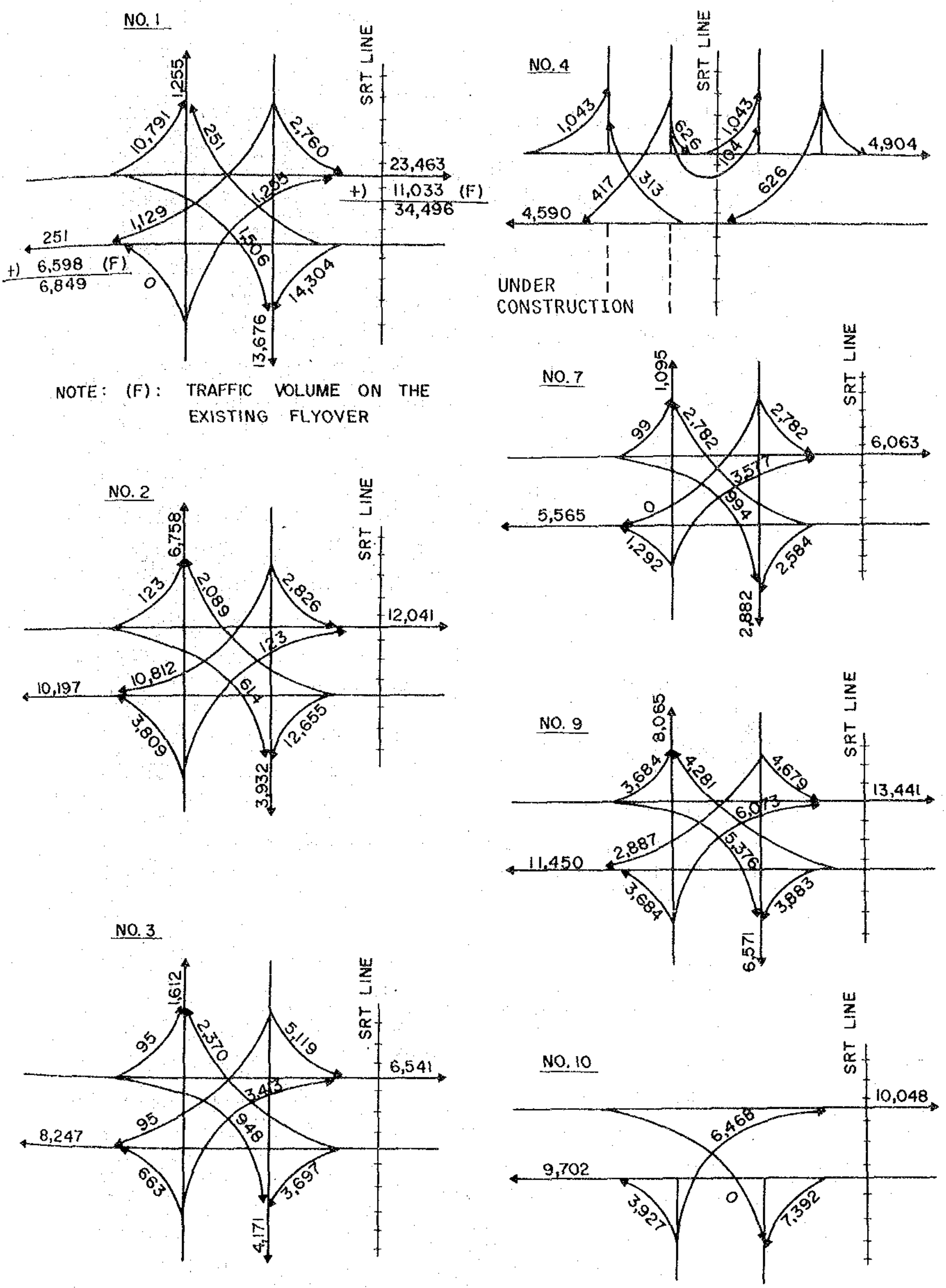
(6) Construction cost and work execution

Table 10.1.1 Present Condition of Grade Crossings

* Legend: Land use
- C Commercial area
- R Residential area
- G Government office

**(F) Traffic volume on the present flyover

Line	No.	Road	Carriageway (m)	Lane (Nos)	Traffic volume (12h)	Pedestrian (12h)	*Land use	Remarks	Location of flyover
Northern Line	1	Phetburi	21.8	6	42,284 **17,631 (F)	9,048	C. R. G. Hospital, College	A flyover (2-Lanes) exists.	
	2	Sriayutthaya	25.0	6	39,931	871	G. PALACE	On/off ramp of Expressway is being planned.	
	3	Rajavithi	19.0	6	29,387	814	- ditto -		
	4	Nakornchaisri	12.2	4	12,206	1,906	C. R. Water supply		
	5	Setsiri	8.0	2	10,259	1,059	R. Army		
	6	Ranong I	4.5	2	5,000	1,426	- ditto -		
	7	Pradipat	15.0	4	23,353	936	C. R. Army		
Eastern Line	8	Rama VI	24.0	6	26,402	4,804	C. G.	Mass Transit System and Expressway is being planned.	
	9	Phyathai	25.4	6	43,807	6,241	C. Bank	Mass Transit System is being planned along SRT line.	
	10	Rajaprarop	18.0	6	33,610	12,827	C. R.		
Mae Nam Line	11	Makkasan	6.0	2	9,881	654	(SRT)		
	12	Phetburi	18.4	6	44,362	1,110	C. R.	Expressway exists along SRT line. On/off ramps of Expressway are connected with roads.	
	13	Sukhumvit	20.5	6	35,848	6,478	- ditto -		
	14	Rama IV	24.5	6	45,377	2,477	- ditto -		



NOTE: (F): TRAFFIC VOLUME ON THE EXISTING FLYOVER

Fig. 10.1.1 Diagram of Traffic Flow at Intersections near Grade Crossings (12 hours) in Oct., 1983

10.2.2 Planning of Grade Separation

Considering the basic concept described in 10.2.1, the type of flyover, number of lanes and other items are described below.

(1) Type of grade separation

There are two types of grade separations: flyover and underpass. The underpass has several disadvantages, especially in construction, construction cost and maintenance for drainage. The appraisal is shown in Table 10.2.1. It is concluded that the flyover concept is superior to the underpass.

Table 10.2.1 Appraisal of Flyover and Underpass

Type Item	Flyover	Underpass
Flexibility for rebuilding of structure in future	–	–
Land use including community separation by the road	–	–
Environmental impact	×	O
Maintenance (drainage and water seepage)	O	×
Traffic accident	Δ	×
Construction cost	O	×
Impact during construction (traffic diversion, relocation of underground utilities and high ground water level)	Δ	×
Accessibility to/from the planned stations (MTS and SRT)	–	–

Legend:

Mark	Meaning
O	Most desirable
Δ	Desirable
×	Undesirable
–	Same level

(2) Number of lanes

The road capacity analyses are based on the "Road Design Standard, Japan" because the types and sizes of vehicles and operating conditions in Thailand and Japan resemble each other.

The flow diagram in Fig. 10.2.1 shows the procedure and the factors to be considered depending on the area, type of vehicle, quality of the traffic flow and the road cross section.

Design traffic capacity of the flyovers is calculated as shown in Table 10.2.2.

The number of flyover lanes was determined by the comparison with surveyed traffic volume and design traffic capacity, land use around the grade crossings and so on, as shown in Table 10.2.3.

Flyovers No. 2, 8 and 9 have a sufficient number of lanes for the future traffic volume.

For reference, the daily traffic volume at present on the existing two-lane flyover at Yoma Rat (grade crossing No. 1) is 24,683 vehicles per day (17,631 vehicles per 12 hours × 1.40) which greatly exceeds the design traffic capacity. This means the service level for traffic has fallen and traffic has been congested for a long time.

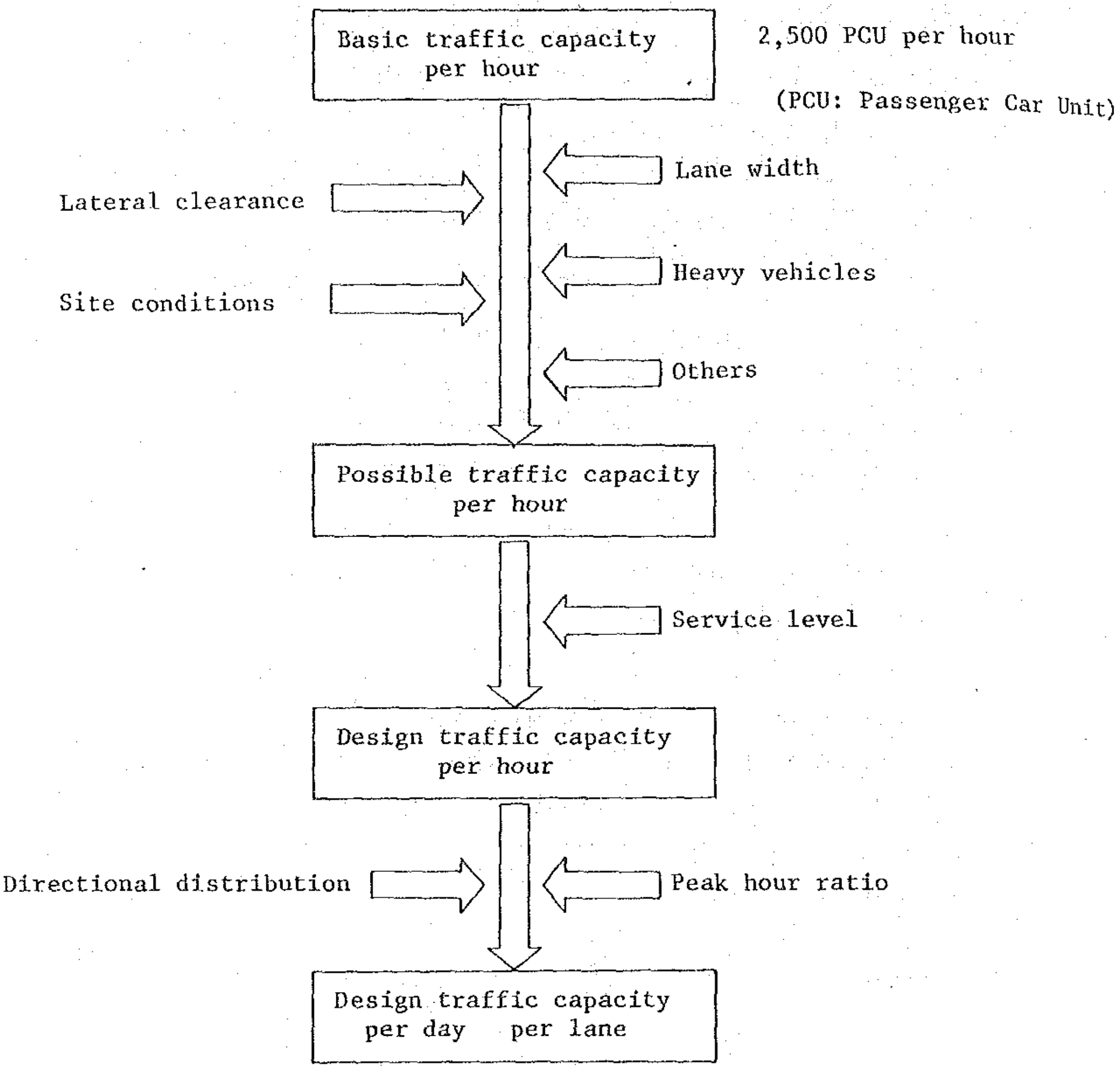


Fig. 10.2.1 Flow Diagram to Calculate Design Traffic Capacity

Table 10.2.2 Traffic Capacity Analysis (Based on "Road Design Standard, Japan")

Total number of lanes on road Item			2	4	6
Lane width		(m)	3.25	3.25	3.25
Lateral clearance	Right	(m)	0	0	0
	Left	(m)	0	0	0
Heavy vehicle	% of H.V.	Pt	10	10	10
Adjustment coefficient	Lane width	L	0.94	0.94	0.94
	Lateral clearance	c	0.70	0.81	0.81
	Heavy vehicle	T	0.90	0.93	0.93
	Site conditions	I	0.80	0.80	0.80
	Total	CE	0.474	0.566	0.566
Basic capacity (PCU per hour)		CB	2,500	2,500	2,500
Possible capacity (vehicles per hour)		C	1,190	1,420	1,420
Service level			2	2	2
Adjustment of service level			0.9	0.9	0.9
Design capacity (vehicles per hour)		CD	1,070	1,280	1,280
Peak factor (%)		K	7	7	7
Rate of direction (%)		D	—	55	55
Design capacity (vehicles per hour)		ADT	15,300	66,500	99,700

Note: $CE = L \cdot c \cdot T \cdot I$

$C = CB \cdot CE$

$$ADT = \frac{100}{K} \cdot CD \quad \text{(2-lanes)}$$

$$ADT = \frac{5000 \cdot N}{K \cdot D} \cdot CD \quad \text{(Multiple lanes)}$$

where	T	Adjustment coefficient for heavy vehicles
	Pt	Percentage of heavy vehicles (%)
	L	Adjustment coefficient for lane width
	c	Adjustment coefficient for lateral clearance
	I	Adjustment coefficient for site conditions
	K	Peak factor (%)
	D	Rate of direction (%)
	CD	Design capacity (vehicles per hour)
	CB	Basic capacity (PCU per hour)
	N	Number of lane
	DT	Design daily capacity (vehicles per day)
	CE	Total
	C	Possible capacity (vehicles per day)

The ratio of the entire day's traffic to the daytime traffic used in this Study is T24/T12 = 1.40 and is the result of a 24-hour traffic survey by "The Feasibility Study for the Second Stage Expressway System in 1983".

A part of the traffic at grade crossing No. 4 takes roundabout ways (loop roads). Therefore, the traffic volume on the flyover is 17,090 vehicles per day (Table 10.2.3) - 2,712 vehicles per 12 hours (Table 10.2.4) × 1.40 = 13,293 vehicles per day.

Table 10.2.3 Number of Flyover Lanes

No.		Road	Traffic Volume in 1983 (vehicles per day)	Number of lanes of road at present	Number of lanes of flyover
Northern Line	1	Phetburi	83,880	6	6
	2	Sriayutthaya	55,900	6	6
	3	Rajavithi	41,140	6	4
	4	Nakornchaisri	17,090	4	2
	5/6	Setsiri/Ranong I	21,360	2+2	4
	7	Pradipat	32,690	4	4
Eastern Line	8	Rama VI	36,960	6	6
	9	Phyathai	61,330	6	6
	10	Rajaprarop	47,050	6	4
Mae Nam Line	11	Makkasan	13,830	2	2
	12	Phetburi	62,110	6	6
	13	Sukhumvit	50,190	6	6
	14	Rama IV	63,530	6	6

(3) Factors in planning flyover

(i) Road intersections close to the railway

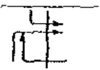
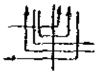
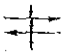
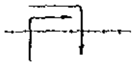
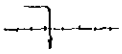
It is very important to consider the road intersections close to the grade crossings when planning the flyover. If it is not possible to manage left and right turn traffic with the flyover, loop roads are required. The flyovers which will require loop roads and the traffic volume which would pass on the loop roads are shown in Table 10.2.4.

(ii) Two-lane roads

Setsiri Road and Ranong I Road at grade crossings No. 5 and No. 6 are two-lane feeder roads and the land use around these roads is residential. Therefore, in order to avoid land purchase, an H-shaped flyover is planned between these two roads.

It is easy to make a two-lane flyover at grade crossing No. 11, Makkasan Road because the surrounding land is not built up.

Table 10.2.4 Traffic Volume Loop Roads

	No. of flyover	Traffic volume on loop roads (vehicles per 12 hours)	Direction of traffic	Remarks
Northern Line	1	4,266		New loop road
	4	2,712		Flyovers 5 and 6 and existing roads
	5	10,259		Flyovers 5 and 6
	6	5,000		Ditto
	7	11,725		Flyovers 5 and 6 and existing roads
	Total	33,962		
Eastern Line	9	10,354		New loop road
	10	6,468		Ditto
	Total	16,822		

(iii) Considerations due to planned Mass Transit System

The Mass Transit System plan for an elevated track should be modified to a ground level track at grade crossings No. 8, 9 and 10 as shown in Fig. 10.2.2 so as not to interfere with the proposed flyovers.

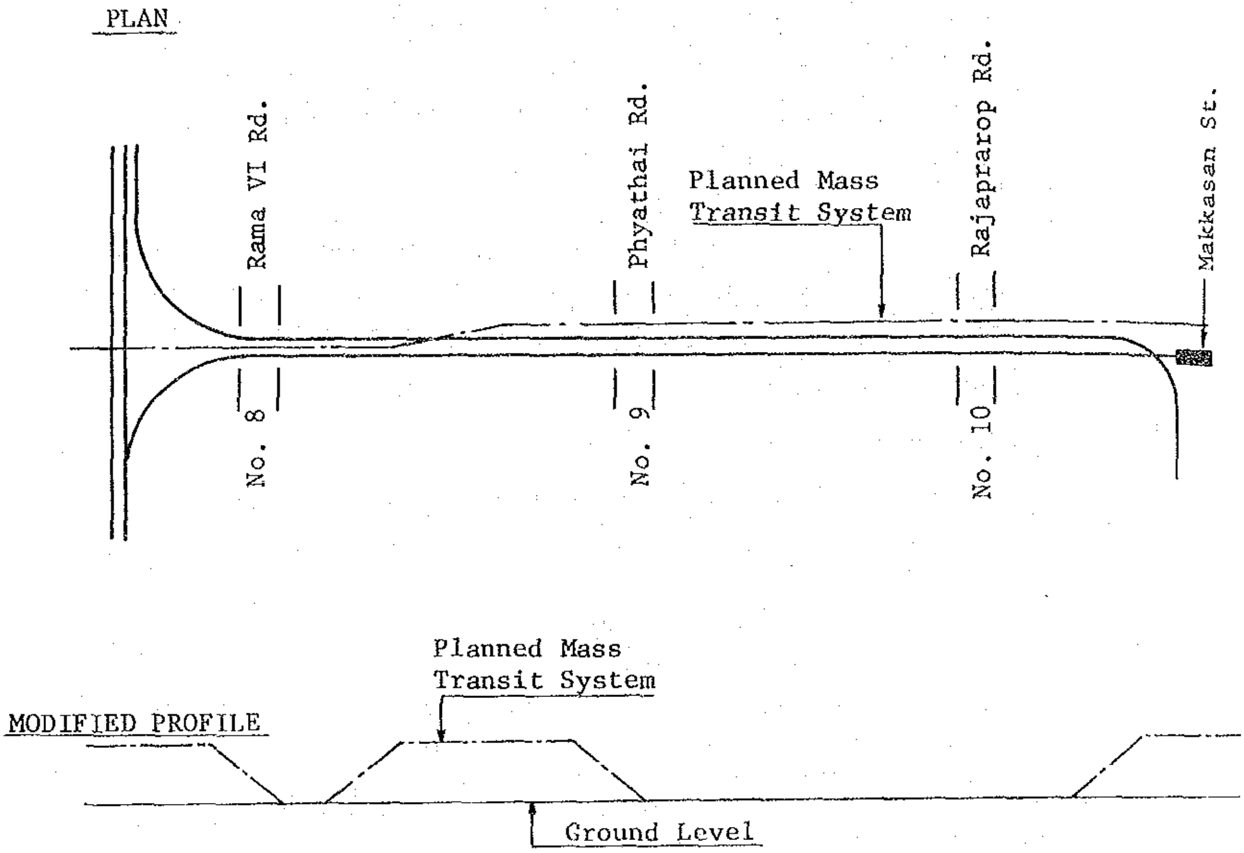


Fig. 10.2.2 Modified Profile of Mass Transit System Line

(iv) Service road and sidewalk width

The 4.5 m wide service road consists of 3.0 m for one-way traffic and 1.5 m for roadside parking lot. At least 3.0 m of width for a sidewalk is desirable, however, land purchase in densely built-up commercial and residential areas is very difficult. In order to avoid land purchase, a 2 m wide sidewalk was adopted for some flyovers.

10.2.3 Design Standard

The road and bridge design standards are based on the general standard of the BMA and these standards are determined to meet the requirements of this Project.

Design standards are shown in Table 10.2.5, and a general view of the flyover is shown in Fig. 10.2.3.

Table 10.2.5 Design Standards

Element	Unit	Standard
Design speed		
Flyover	km/h	50
Ramp way	km/h	30
Lane width	m	3.25
Median width	m	1.0 to 1.5
Crossfall of carriageway	%	2.0
Max. gradient	%	4.0
Min. vertical clearance		
- Above the road surface	m	5.0
- Above the rail of railway	m	5.1
- Above the rail of MTS	m	4.37
Design load criteria for structure		AASHTO (HS20-44)
Width of one-way service road	m	4.5
Width of sidewalk	m	2.0 to 3.0

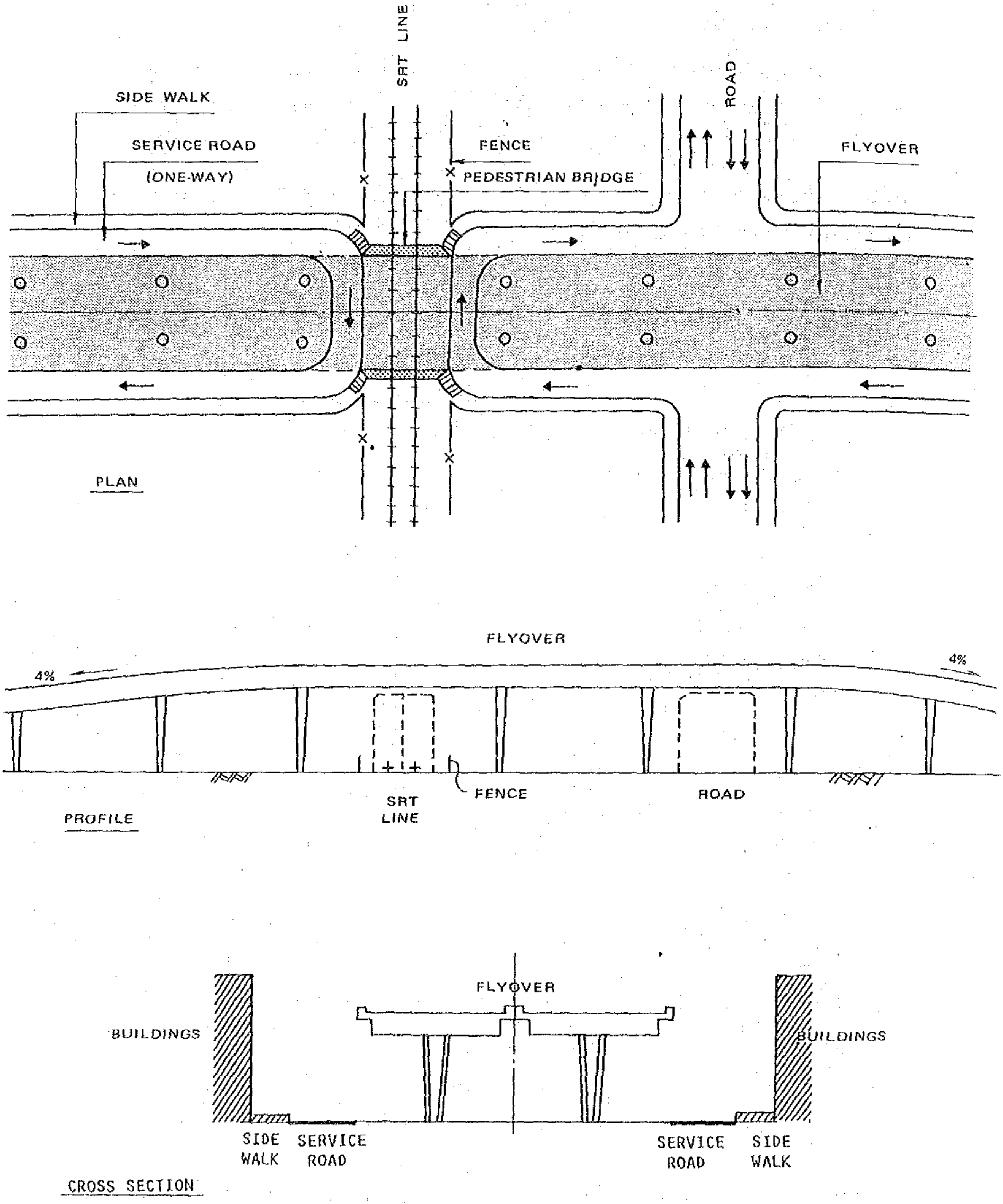


Fig. 10.2.3 General View of Flyover

10.2.4 Type of Structure

Structure types are determined by considering work execution, economics, maintenance and environmental aspects.

(1) Superstructure

It is difficult to adopt full staging on roads with heavy traffic flow, therefore, a precast method is most suitable for the construction of the superstructure.

A length of 25 m is adopted as the standard span, with 20 m of precast prestressed concrete beam and 5 m of in situ cantilever slab.

It is also possible to make the span 20 m to 35 m by changing the length of the in situ cantilever slab.

Standard span arrangement is shown in Fig. 10.2.4.

(2) Substructure

Column-type piers are adopted because these are superior to the T-section type for creating space under the flyover and from an environmental point of view. Based on the subsoil survey, the bearing piles should be driven into the stiff clay layer or sand layer, to a depth of at least 25 m below the ground surface.

(3) Approach bearing unit

Road embankment construction on soft Bangkok clays may settle considerably. Differential settlements are most likely to occur at points where the ground has been previously consolidated or where the embankment connects to a rigid structure with the consequence that the pavement may be seriously damaged.

For differential settlement control, the approach sections must be provided with piled foundations as shown in Fig. 10.2.5.

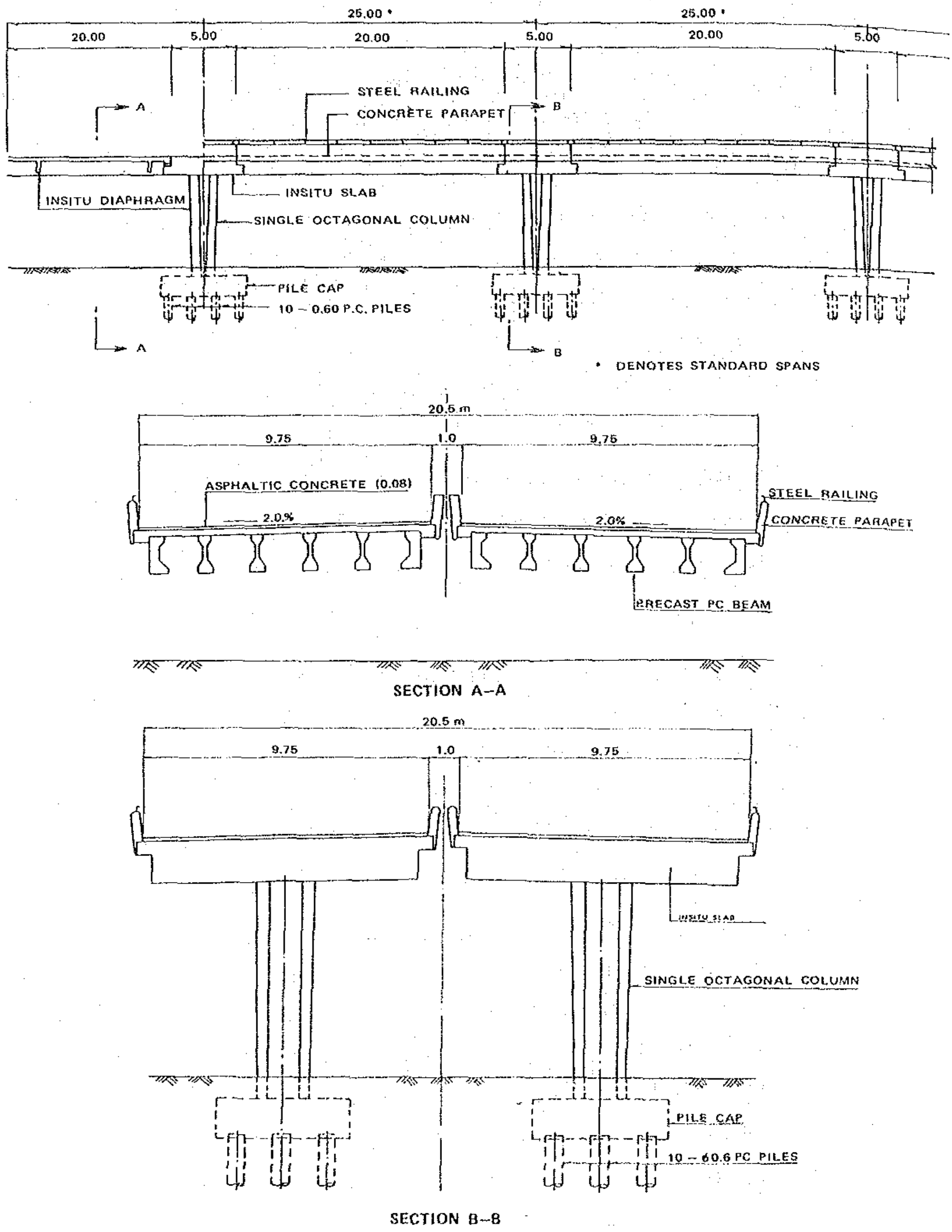
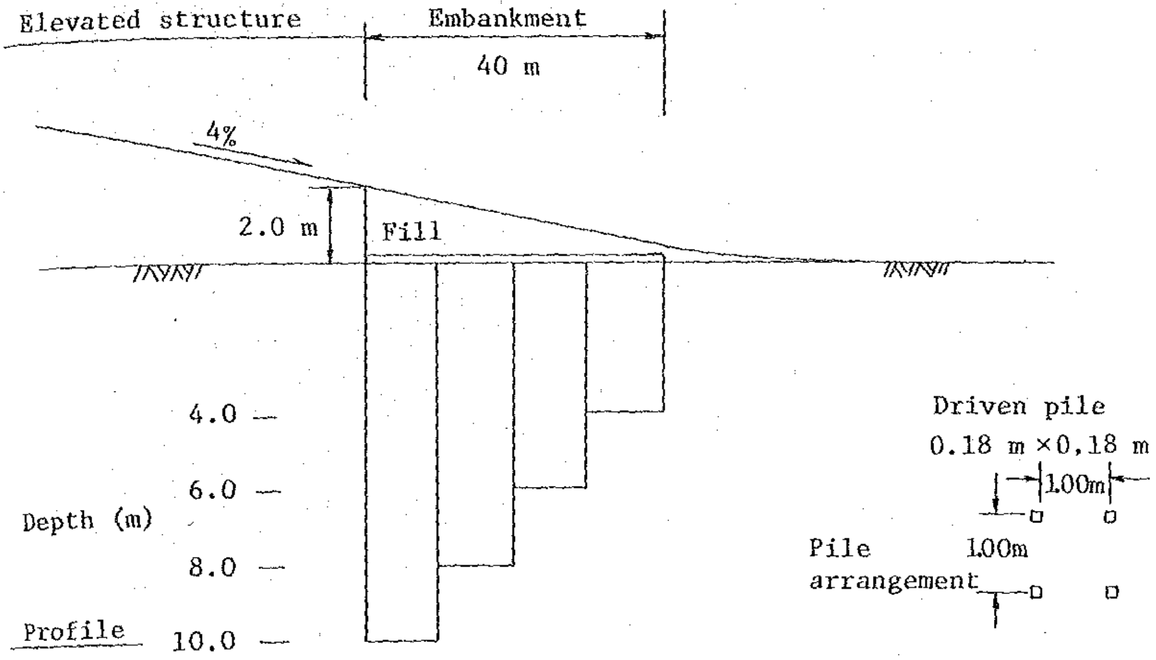
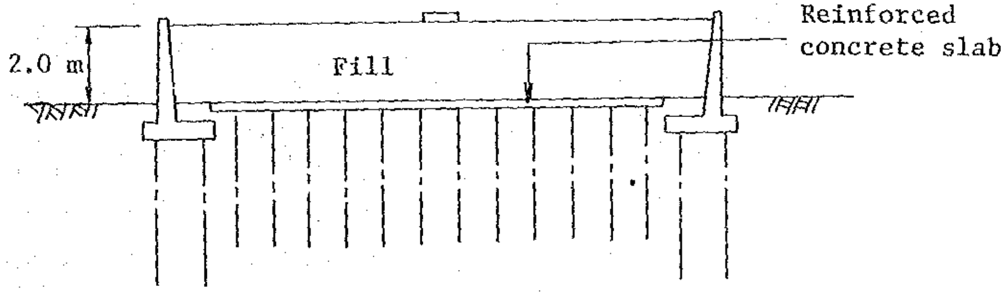


Fig. 10.2.4 Standard Span Arrangement



Profile



Cross section

Fig. 10.2.5 Embankment with Bearing Unit and Retaining Wall

10.2.5 General Description of Flyovers

As the result of the study on each grade separation, a general layout for flyovers as shown in Fig. 10.2.7 and Fig. 10.2.8, and typical cross sections of flyovers, as shown in Figs. 10.2.9 to 10.2.11, are established. Some grade crossings are mentioned in particular below.

(1) Flyover No. 2

The planned Expressway ON/OFF ramps are located on Sriayuthaya Road. Considering the increase in traffic volume after completion of the Expressway, a six-lane flyover is required as shown in Fig. 10.2.7 and Fig. 10.2.9.

The service roads for cars which go in and out of the Palace are provided under the flyover.

(2) Flyover No. 8

The jointly planned Mass Transit System and Expressway intersection at grade crossing No. 8 should provide flyovers for both the planned Expressway and proposed Rama VI Road as shown in Fig. 10.2.12.

(3) Flyover No. 10

Makkasan Road crosses over the Eastern Line with a separate flyover because the T-intersection of Makksan Road and Rajaprarop Road which interferes very much with the road traffic is very close to grade crossing No. 10.

(4) Flyover No. 11

In this location, Makkasan Road crosses over the Mae Nam Line under the existing Expressway, therefore vehicle clearance is limited to 3.5 m and high vehicles must be restricted.

(5) Flyovers No. 12, No. 13, No. 14

The Expressway, with formation level (FL) of about 8.0 m from ground level, exists along the Mae Nam Line.

Therefore, length of flyovers is about 800 m, and the connection of the on/off ramps of the Expressway is shown in Fig. 10.2.6.

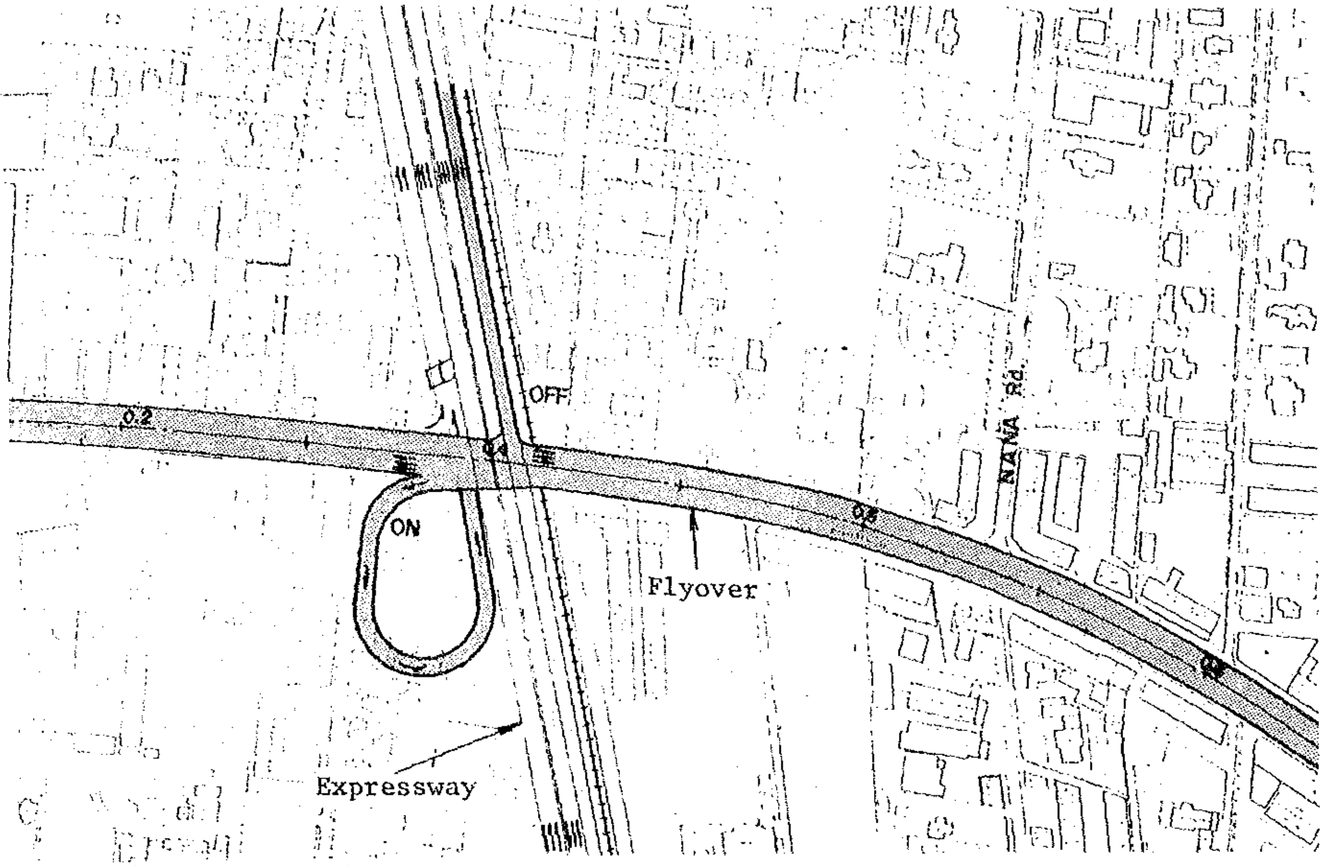


Fig. 10.2.6 Connection of Expressway Ramps

In order to make a six-lane flyover at crossings No. 12 and No. 13, large-scale demolition of a number of multistory buildings is necessary in these densely built-up commercial and residential areas. Hence, large-scale land purchase is unavoidable.

A six-lane flyover is possible without land purchase for grade crossing No. 14.

For the these three grade crossings, the flyovers are superior to the underpasses as described in 10.2.2. But in this case, there are several additional points concerning the underpass alternative that must be considered.

- The length of an underpass is half that of a flyover.
- The construction of an underpass is very close to the footing of the substructure of the Expressway, especially at grade crossing No. 14. Underpass construction is hardly possible due to the present pier in the center of Rama IV Road.

- Connection of the on/off ramps of the Expressway with the underpass is very difficult.
- It is very difficult to manage traffic and prevent traffic congestion during construction.

Therefore, the flyover is superior to the underpass due to the construction problems mentioned above.

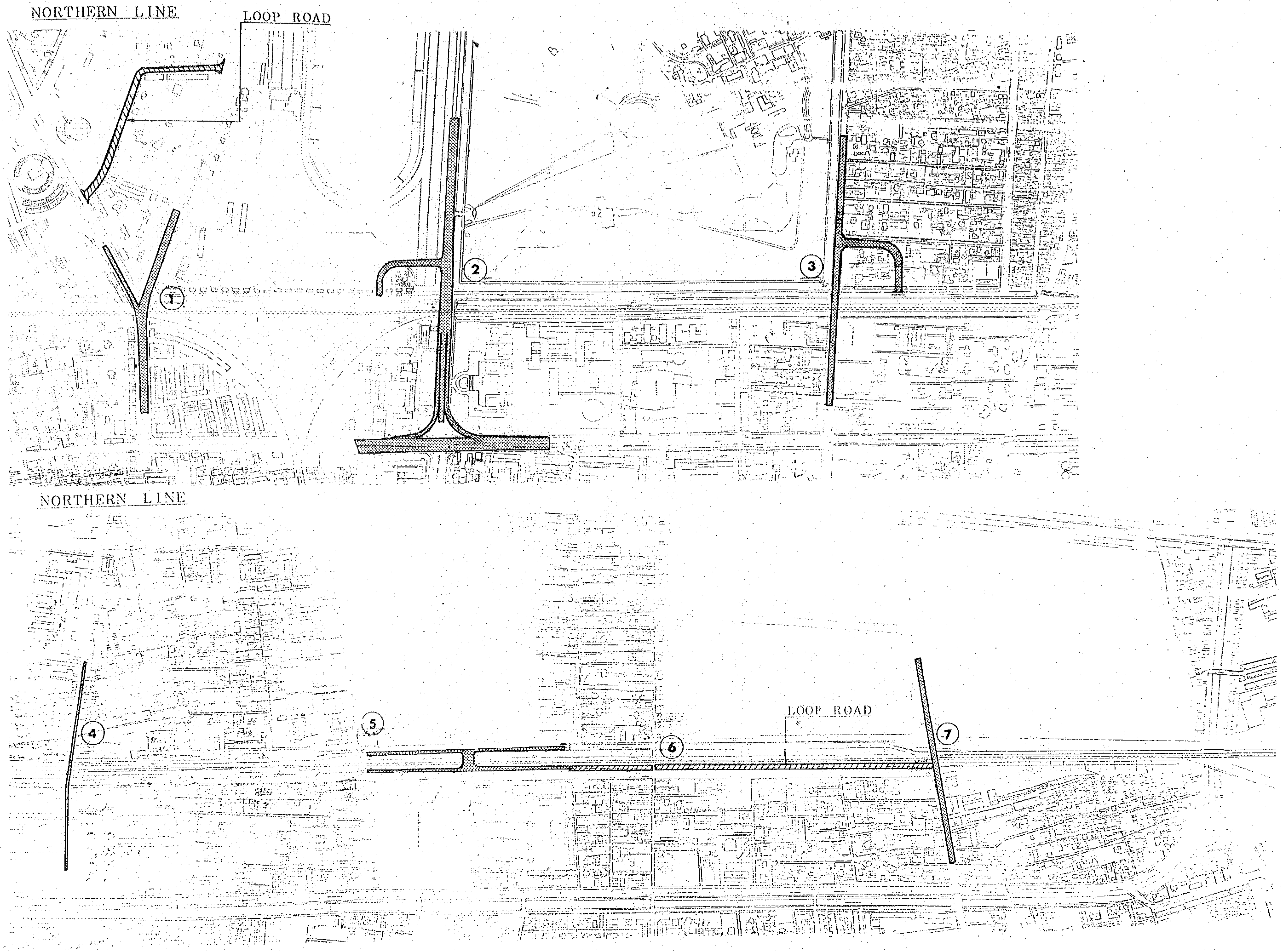
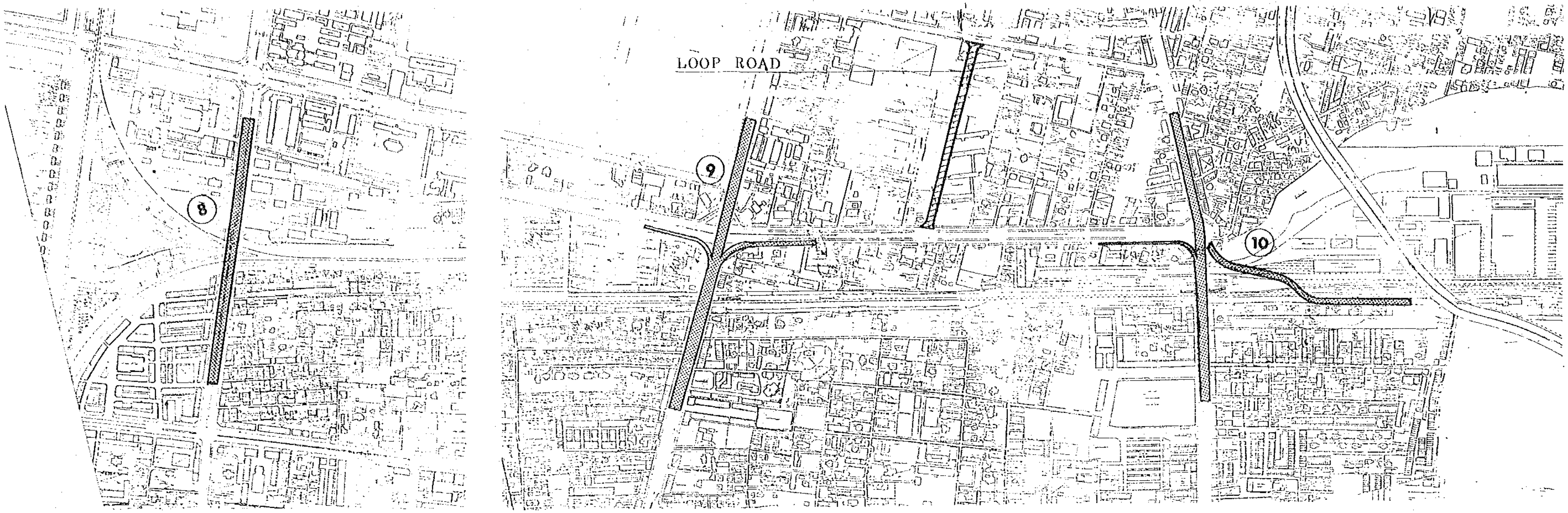


Fig. 10.2.7 General Plan of Flyover

EASTERN LINE



MAE NAM LINE

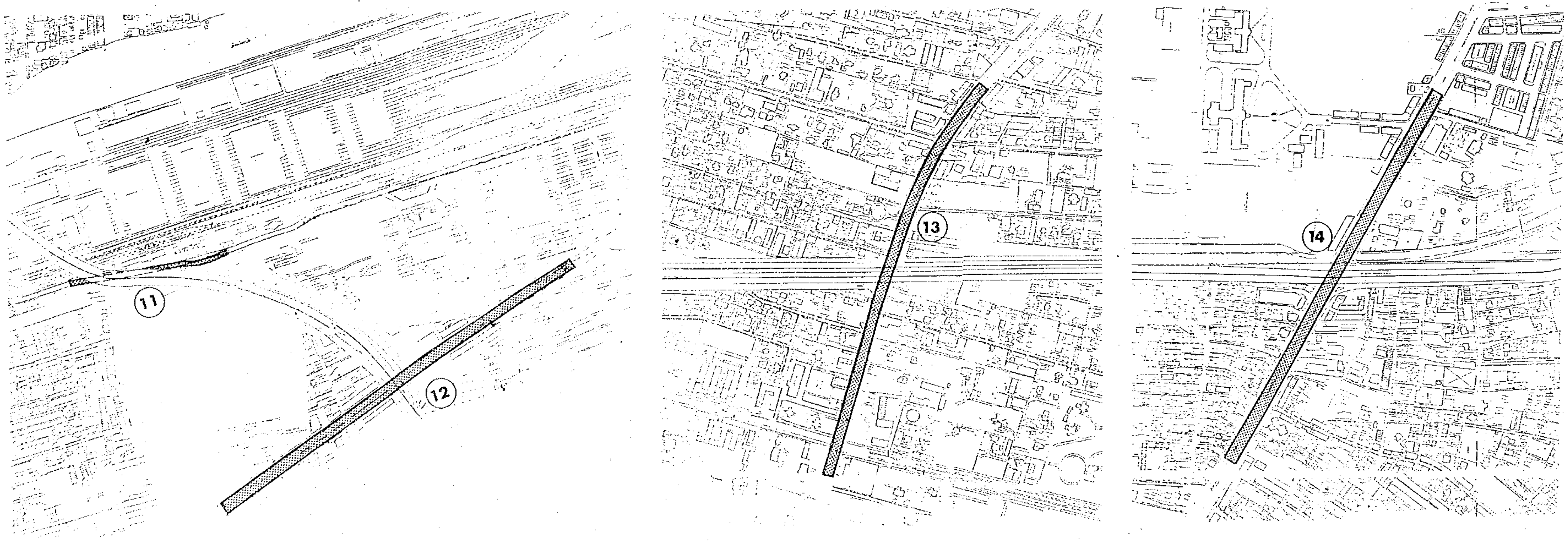
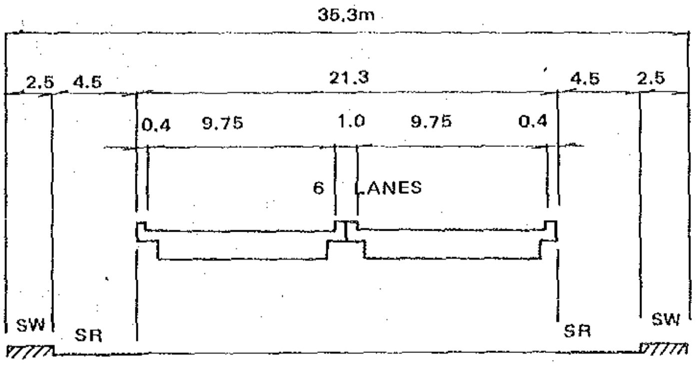
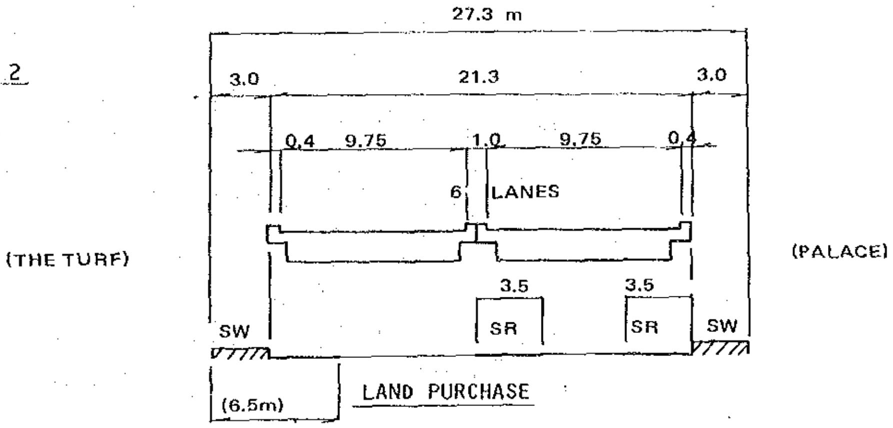


Fig. 10.2.8 General Plan of Flyover

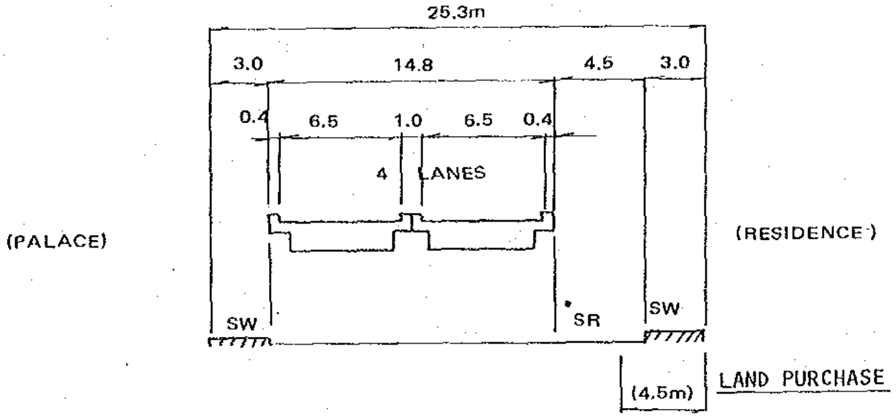
FLYOVER NO. 1



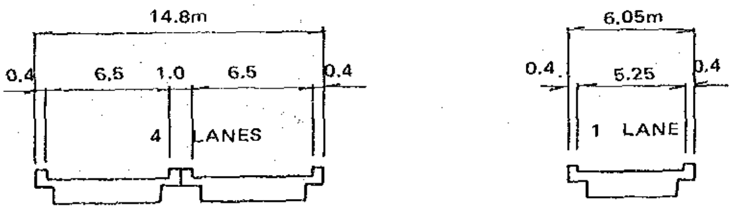
FLYOVER NO. 2



FLYOVER NO. 3



RAMP



FLYOVERS NO. 2 and No. 3

FLYOVERS No. 1 and No. 9
and No. 10

LEGEND: SW SIDE WALK
SR SERVICE ROAD

Fig. 10.2.9 Typical Cross Sections

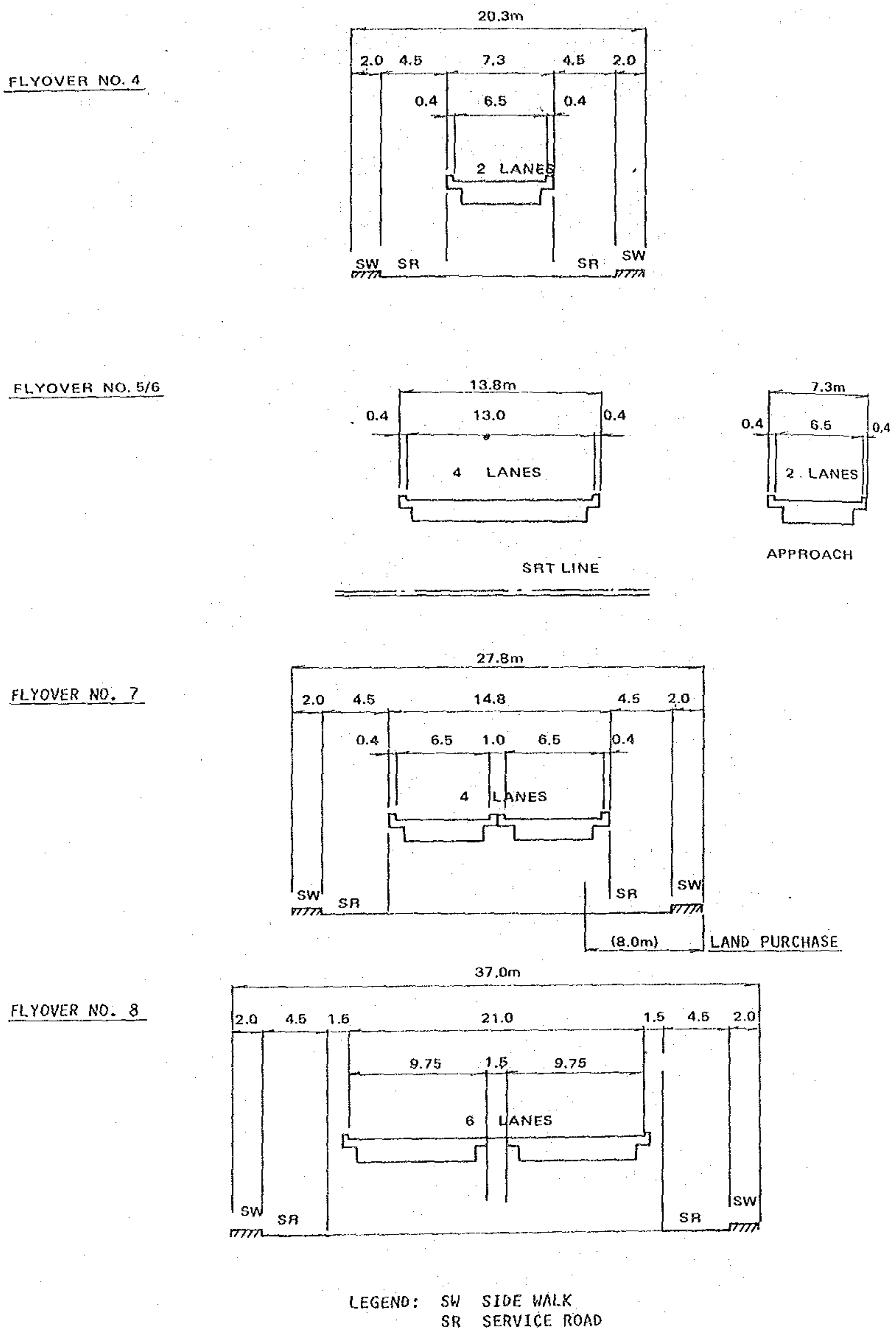


Fig. 10.2.10 Typical Cross Sections

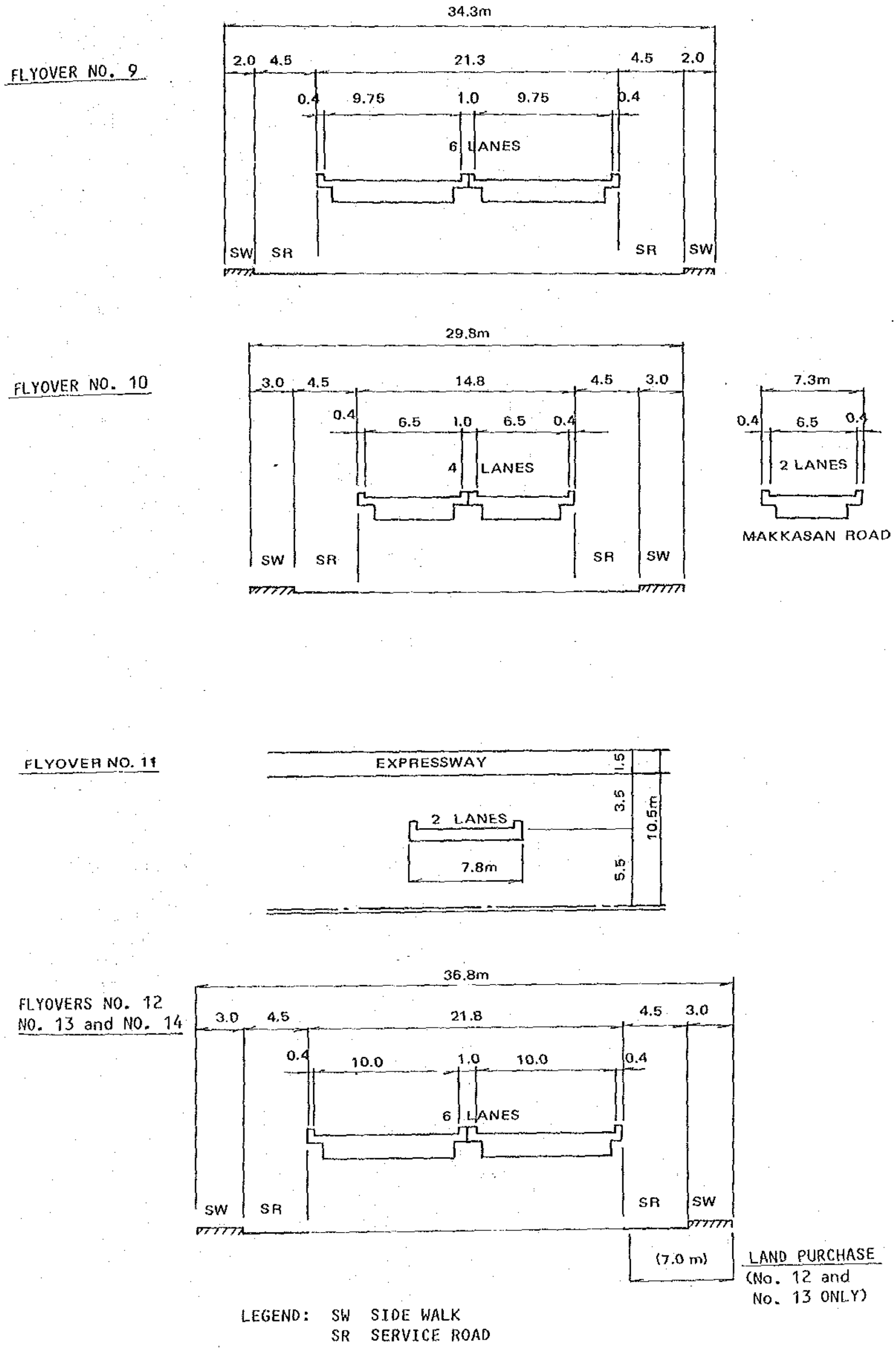


Fig. 10.2.11 Typical Cross Sections

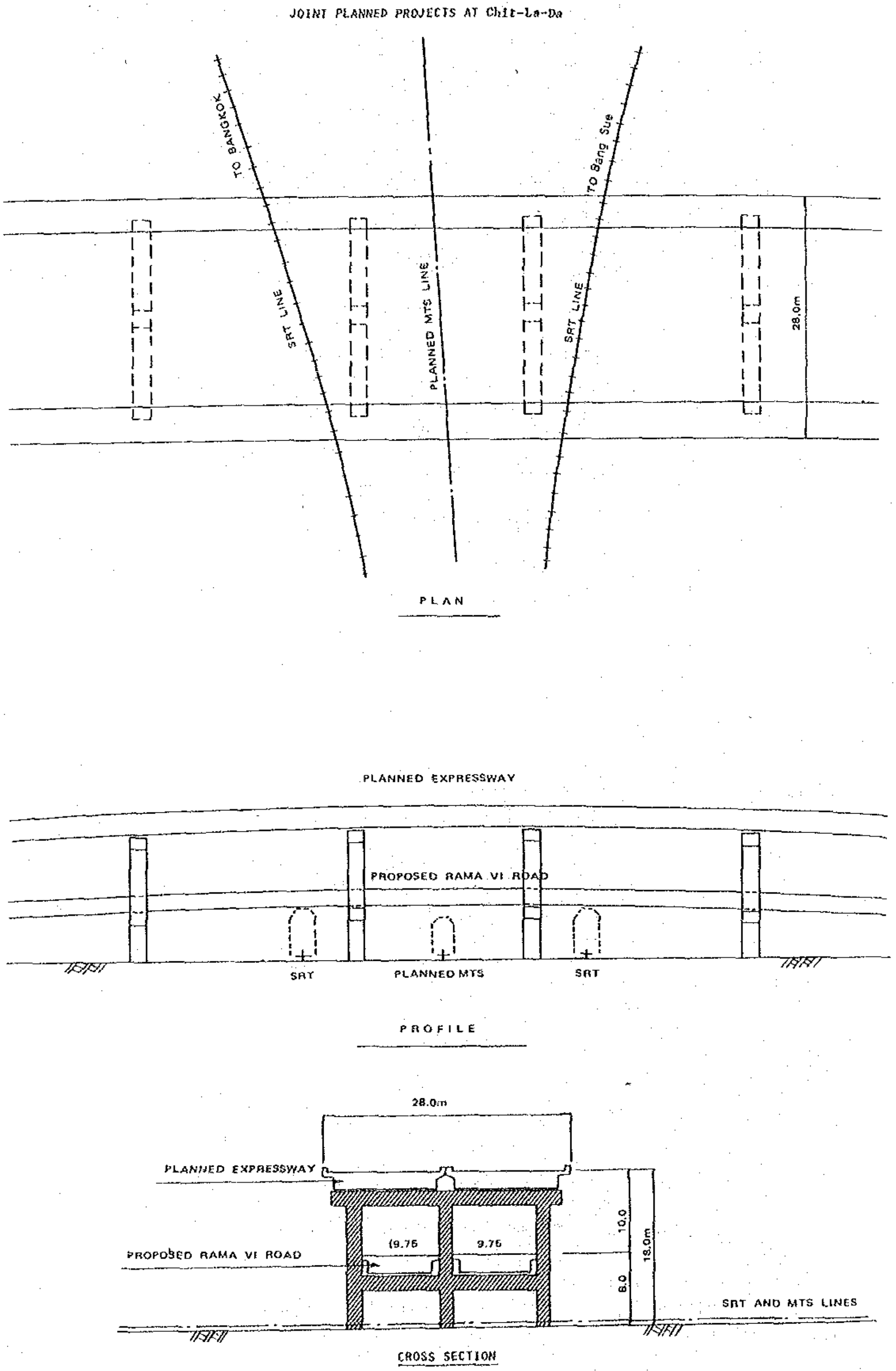


Fig. 10.2.12 Joint Planned Projects at Grade Crossing No. 8

10.3 Estimated Construction Cost

10.3.1 Criteria for Cost Estimation

Construction costs were computed in accordance with the following criteria.

(1) The unit costs were computed under the economic conditions prevailing in October 1983, and a price escalation factor was not considered.

(2) The cost was classified into foreign currency and domestic currency portions.

(3) The detailed engineering design and supervision fees were assumed to be 12% of the construction cost.

(4) Contingency allowance was set at 15% of the total of construction cost plus land purchase and compensation cost.

(5) The rates of exchange used to convert Baht to Japanese Yen and US Dollar are

US$1.0 = 23 Baht = ¥230

10.3.2 Construction Cost

Construction cost for each flyover on the Mae Nam Line, No. 12, No. 13 and No. 14, is extremely high (two to three times that of other flyovers) due to excessively long flyover and high land purchase/compensation costs.

The construction costs including loop roads are summarized for each railway line in Table 10.3.1. (Appendix 10.3.1)

Table 10.3.1 Summary of Project Costs (1983 Prices)

(Unit: Million Baht)

	Item	Foreign currency Portion	Domestic currency Portion	Total
Northern Line	Construction cost	264.3	362.6	626.9
	Land purchase and compersation cost	--	161.8	161.8
	Total	264.3	524.4	788.7
Eastern Line	Construction cost	172.8	234.7	407.5
	Land purchase and compensation cost	--	34.3	34.3
	Total	172.8	269.0	441.8
Mae Nam Line	Construction cost	390.6	535.8	926.4
	Land purchase and compensation cost	--	177.8	177.8
	Total	390.6	713.6	1,104.2
Grand total		827.7	1,507.0	2,334.7

Note: Engineering fee and contingency are included.

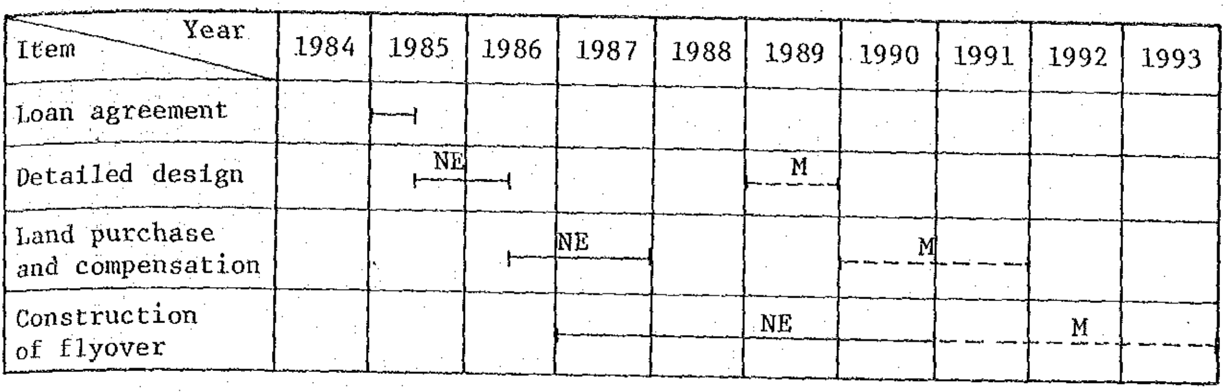
10.4 Implementation Plan

10.4.1 Implementation Schedule

The implementation schedule was prepared on the condition that construction of the flyovers on the Northern and Eastern Lines would be completed by the end of 1990, after that, the construction of those on the Mae Nam Line would be started.

The implementation schedule is shown in Table 10.4.1.

Table 10.4.1 Implementation Schedule



Note: NE Northern & Eastern Lines
M Mae Nam Line

10.4.2 Priority of Construction of Each Flyover

To determine the priority of each flyover, the blocked traffic by barrier (Appendixes 3.2.1 and 3.2.2), road network at present, land purchase and land use were considered.

The blocked traffic and road network have the greatest influence.

The priority is shown in Table 10.4.2.

Table 10.4.2 Priority

Line	Road Number	Road name	* Ranking			Priority
			Blocked traffic	Road network	Land purchase	
Northern Line	1	Phetburi	1	1	5	1
	2	Sriayutthaya	2	4	3	4
	3	Rajavithi	3	3	4	3
	4	Nakornchaisri	9	9	—	9
	5/6	Setsiri/Ranong I	8	5	—	6
	7	Pradipat	5	6	2	7
Eastern Line	8	Rama VI	6	8	—	8
	9	Phyathai	4	2	1	2
	10	Rajaprarop	7	7	1	5
Mae Nam Line	11	Makkasan	13	13	—	13
	12	Phetburi	11	10	6	10
	13	Sukhumvit	12	11	7	11
	14	Rama IV	10	12	—	12

* Note: Blocked traffic most → least Road network (importance) most → least
Land purchase least → more "–" means no Land purchase.

10.5 Utilization Planning under Flyovers

Business and commercial facilities will be able to make use of the open spaces created under the flyovers. The utilization plan is shown in Table 10.5.1.

Table 10.5.1 Utilization Plan

(unit: m^2)

Line	Road number	Road name	Area of utilization	
			Commercial facilities	Business facilities
Northern Line	1	Phetburi	0	1,400
	2	Sriayutthaya	0	2,700
	3	Rajavithi	0	500
	4	Nakornchaisri	0	0
	5/6	Setsiri/Ranong I	0	0
	7	Pradipat	0	500
Eastern Line	8	Rama VI	0	1,400
	9	Phyathai	800	1,400
	10	Rajaprarop	500	1,000
Mae Nam Line	11	Makkasan	0	0
	12	Phetburi	0	3,000
	13	Sukhumvit	0	3,000
	14	Rama IV	0	3,000
		Total area	1,300	17,900

Notes: 1. Commercial facilities, shopping areas

2. Business facilities, parking lots

CHAPTER 11 ECONOMIC ANALYSIS

CHAPTER 11 ECONOMIC ANALYSIS

11.1 Methodology

11.1.1 "With/Without" Analysis

It is generally known that the main objective of an economic analysis is to evaluate the economic viability of a project from the viewpoint of the national economy.

This analysis shall be conducted as a comparison of the case in which the Project is implemented ("With the Project") and the case in which it is not implemented ("Without the Project"). In other words, the costs which would be incurred in the case of "Without the Project" shall be deemed to be saved by implementing the Project and shall be deducted from the Project cost. In a similar way, the benefits shall be computed for the two cases and the difference between them shall be determined. It follows that, unless the benefits in the case of "With the Project" are greater than those in the case of "Without the Project", the Project's implementation should be reconsidered.

The flow chart of the above process is shown in Fig. 11.1.1.

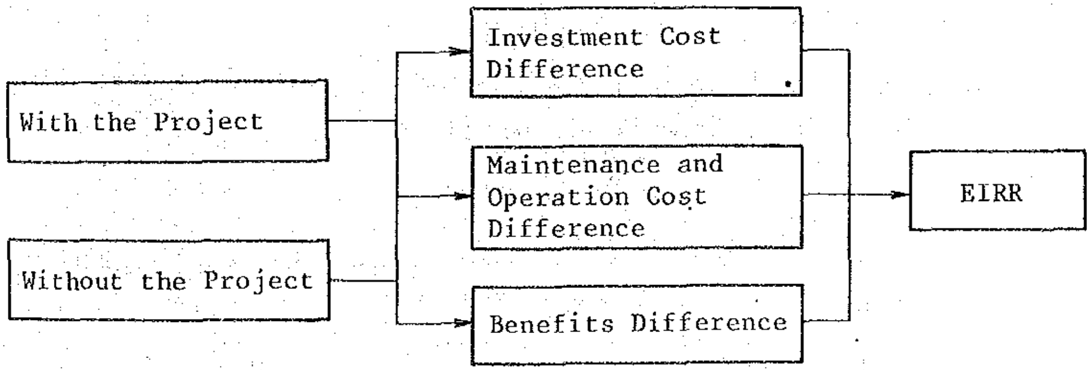


Fig. 11.1.1 Flow Chart of Economic Analysis

11.1.2 Study Cases

In accordance with the study cases mentioned in Chapter 1, the following two cases are set up in both the "With" and "Without" cases.

(1) "With the Project"

CASE-I: Track elevation in line with the "natural trend" of the traffic demand forecast.

CASE-II: Track elevation in line with "high-level service" in the traffic demand forecast.

(2) "Without the Project"

In the case of "Without the Project", flyover construction will be implemented as a substitute for railway track elevation.

CASE-I: Flyover construction with investment for SRT to cope with railway traffic demand forecasted in the "natural-trand type".

CASE-II: Flyover construction with investment for SRT to cope with railway traffic demand forecasted in the "high-level service type".

The main investment items in the case of "Without the Project" are as follows:

(i) Replacement and modernization of existing railway facilities in harmony with future railway traffic demand.

- 3 track from Chit-La-Da to Bang Sue on the Northern Line
- A double track from Makkasan to Hua Takhe on the Eastern Line
- A double track from Taling Chan to Sala Thammasop on the Southern Line (in Case-II)
- Construction of new stations
- Automatic block signal system and other modernization of electrical facilities
- Rolling stock

(ii) Construction of flyovers to eliminate traffic congestion at grade crossings.

However, construction of flyovers on the Mae Nam Line (Flyovers No. 11 to 14) was excluded both in Case-I and Case-II since it is not practical to construct them for the following reasons:

- As shown in Appendix 10.3.1, the average construction cost per flyover on the Mae Nam Line is about 2.24 times higher than for the other two lines (Northern and Eastern Lines). Moreover, the expected benefits to the Mae Nam Line promise to be relatively low. If flyover construction on the Mae Nam Line is included in "Without the Project" costs, it is feared that the result of the economic evaluation will be substantially distorted.
- Difficulties in implementation of construction due to geographical conditions.

11.1.3 Alternatives for Track Elevation Sections

The track elevation section of each case was studied in terms of the following two alternatives by considering the peculiarities of the Mae Nam Line (i.e., ① no passenger transportation service, ② restrictions on trains running in the daytime and ③ existence of an expressway running parallel to the railway line).

ALTERNATIVE I :	All proposed elevated track (Northern Line, Eastern Line and Mae Nam Line) will be constructed.
ALTERNATIVE II:	Track elevation of the Mae Nam Line will not be constructed.

The alternatives are illustrated in Table 11.1.1.

Table 11.1.1 Alternative Matrix

		Name of Case	With the Project	Without the Project
CASE-I	Alternative I	Case-I-3	Track elevation in line with the "Natural Trend Type"	Flyovers in line with the "Natural Trend Type"
	Alternative II	Case-I-2		
CASE-II	Alternative I	Case-II-3	Track elevation in line with the "High-level Service Type"	Flyovers in line with the "High-level Service Type"
	Alternative II	Case-II-2		

11.1.4 Assumptions

The following assumptions are made:

(1) The sphere of economic analysis covers the commuter areas mentioned in subsection 3.2.4.

(2) Considering the construction term and useful life of new railway facilities, a project life of 30 years (1984 to 2013) is assumed.

(3) Exchange rate
230 Yen = 1 US$ = 23 Baht

(4) Inflation
The inflation factor was excluded from the analysis.

(5) Increase of passenger volume accompanying the transport improvement by SRT.

It is assumed that, as a result of the demand forecast discussed earlier, passenger traffic will be diverted only from buses, which are currently the only public transportation.

11.1.5 Evaluation

With respect to each of the aforesaid four cases (Case-I-3 to Case-II-2), the difference in investment, operating and maintenance costs, and benefits shall be calculated and compared with the "Without the Project" case on an annual basis. This shall be called a "net flow."

The net flow is used to calculate the Economic Internal Rate of Return (EIRR), which is the most commonly used indicator to evaluate the feasibility of a railway project.

$$0 = \sum_{i=1}^{30} \text{Net flow}_i/(1+\text{EIRR})^{i-1}$$

11.2. Economic Cost Estimation

11.2.1 Investment Cost

Adjustments such as those mentioned below were made to the total financial cost of the construction work, and the economic cost was estimated.

(1) Tax adjustment

(i) Foreign currency portion

Import duties and business and municipal taxes were excluded. Although these taxes are related to the foreign currency portion, they should be classified in the domestic currency portion.

(ii) Domestic currency portion (Materials and equipment)

Business tax and municipal tax are to be excluded.

(iii) Domestic currency portion (Labor)

A personal income tax (10%) is estimated and is excluded from labor costs.

(2) Reinvestment

To have a common basis for calculating the investment for the cases of both With and Without the Project, it is assumed that the same amounts shall be reinvested for all depreciated assets in the year following the expiration of their useful life.

(3) Salvage value

The designated project life of 30 years is the period used for analytical purposes. The railway facilities shall continue to be used. Therefore, residual value (undepreciated value) has been counted as a minus cost in the final year of the project life.

A summary of the economic investment cost is shown in Table 11.2.1.

Table 11.2.1 Summary of Economic Values of Investment

(Unit: Mil. Baht)

With/ Without		With the Project				Without the Project	
		Case-I-3	Case-I-2	Case-II-3	Case-II-2	Case-I	Case-II
Construction cost by term	1984∿1990	2,608.8	2,235.8	2,891.1	2,509.2	2,051.2	2,354.6
	1991∿1997	1,305.0	1,300.3	1,382.3	1,384.6	1,089.5	1,154.7
	1998∿2013	1,642.9	1,642.5	1,675.0	1,674.9	1,642.5	1,675.0
	Reinvest- ment	652.6	652.6	829.5	829.5	652.6	829.5
Total investment		6,209.3	5,831.2	6,777.9	6,398.2	5,435.8	6,013.8
Construction cost by kind	Civil engineering work (Flyovers)	2,369.6	2,003.8	2,453.7	2,086.8	1,633.6 (1,104.8)	1,713.3 (1,104.8)
	Station facilities	116.3	116.3	169.0	169.0	87.7	142.3
	Signals & telecommunications	591.4	579.1	625.2	612.4	582.4	628.2
	Land purchase	52.1	52.1	79.8	79.8	52.2	79.8
	Rolling stock	3,079.9	3,079.9	3,450.2	3,450.2	3,079.9	3,450.2
Total investment		6,209.3 (3,129.4)	5,831.2 (2,751.3)	6,777.9 (3,327.7)	6,398.2 (2,948.0)	5,435.8 (2,355.9)	6,013.8 (2,563.6)

Notes: 1 Figures include reinvestment of each item but exclude residual values.

2 ( ) in total investment indicates investment value excluding rolling stock.

11.2.2 Differences in Maintenance and Operating Costs

Maintenance and operating costs will be calculated as the difference between costs for "With the Project" and "Without the Project."

(1) Maintenance cost difference

To estimate the maintenance and replacement cost of railway facilities, the estimating method used by JNR is applied due to the absence of any other appropriate method.

(i) Maintenance cost of depreciable assets

= Maintenance ratio × Undepreciated value of depreciable assets

(ii) Maintenance cost of replaceable assets

= 0.95/durable year × Maintenance ratio × Total of replaceable assets

(iii) Replacement cost of replaceable assets

= 0.95/durable year × Total of replaceable assets

Maintenance ratios and durable years of assets are shown in Table 11.2.2.

Table 11.2.2 Maintenance Ratios and Durable Years of Assets

		Maintenance Ratio	Durable Years	Type of Assets
Civil engineering	Foundation	0.0004	57	Depreciated assets
	Elevated track structure	0.0027	40	"
	Platform	0.0041	40	"
	Overbridge	0.0051	40	"
	Station buidlings (RC)	0.0067	40	"
	Building (RC)	0.0057	40	"
	Flyover	0.0027	40	"
	Track	0.15	25	Replacement assets
Signals & telecommunications	Safety measures at the grade crossing	0.0292	32	Depreciated assets
	Signals	0.0210	32	"
	Telecommunications equipment	0.0312	32	"
	Signal line	0.035	32	Replacement assets
	Communication line	0.12	20	"
	Track circuit	0.035	32	"
Electrical work	Transformer equipment	0.0008	30	Depreciated assets
	Buildings for transformer station	0.0057	40	"
	Overhead contact wire	0.03	32	Replacement assets
	Electrical distribution wire	0.15	32	"
Rolling stock	Diesel locomotive	0.025	20	Depreciated assets
	Diesel railcar	0.0174	12	"
	Passenger car	0.0051	33	"
	Freight car	0.0147	33	"

Notes:
1. Durable years are adjusted to SRT standards from JNR standards except for foundations, elevated track structure and track items since those durable years are not available to SRT.
2. Depreciated assets are to be replaced after their durable years.
3. A certain percentage of the replaceable assets are to be replaced annually.

(2) Operating cost difference

With or Without the Project, the demand for transportation, the number of stations, and the number of trains needed will basically remain the same, and, therefore, there will be no large difference in personnel expenses or power costs.

The differences stated are as follows:

(i) Security personnel at grade crossings

There are 43 security personnel at 14 grade crossings in elevated track areas. By eliminating these crossings, security personnel costs will be reduced.

(ii) Difference in power cost

Additional power needed by trains to negotiate the upgrade of the elevated tracks (With the Project).

Additional power cost consumed at the grade crossings for trains reducing their speed and/or temporarily stopping (Without the Project).

Additional fuel consumed per train is shown in Table 11.2.3.

Table 11.2.3 Fuel Consumed per Train

(Unit: litres)

Kind of Train \ Additional fuel per train		Negotiating an Upgrade	Reducing Speed	Temporary Stops
DL	1,000 ton (Freight train)	5.15	14.50	8.60
	600 ton (Passenger train)	2.44	8.70	5.15
DRC	500 ton (DRC of 10)	2.56	8.87	5.26
	300 ton (DRC of 6)	1.54	5.32	3.15
Precondition		Gradient: 10‰ Distance: 500m	60km/H → 30km/H Frequency: one time per train	40km/H → 0 Frequency: 0.25 times per train

Notes: 1 JNR's actual results were adopted to calculate additional fuel.

2. Economic price of diesel oil: 5.58 Baht per litre.

11.3 Benefit Estimation

The benefits to the national economy gained from this project are quantified as the difference between "With the Project" and "Without the Project".

The benefits which cannot be quantified, or which can be so only with difficulty, are merely described in 11.3.5 as "secondary benefits".

11.3.1 Time Saving Benefits

Track elevation can change grade crossings to grade-separated crossings, and road traffic which was previously interrupted at crossings can flow smoothly, so road vehicles can reach their destinations earlier.

This benefit can not only be enjoyed by occupants but will also influence cost saving of vehicles.

Moreover, in the case of "With the Project", there is no need for train operators to pay attention to road traffic or to reduce or stop at crossings, which will result in faster train operation.

The following three benefits are considered in the study and are calculated by the following equations.

(1) Time saving benefit of road vehicles at railway crossings

Benefit = blocked time benefit + stop time benefit

Blocked time benefit

$$= \sum_{i=1}^{m} \{\text{average blocked time}_i \times \sum_{j=1}^{n} (\text{blocked traffic volume}_j \times \text{vehicle time value})\}$$

Stop time benefit

$$= \text{avera e stop time for glance} \times \sum_{i=1}^{m} \sum_{j=1}^{n} (\text{traffic volume}_{ij} \times \text{vehicle time value}_j)$$

m = number of crossings (excluding flyovers)

n = number of type of vehicles

Preconditions to this benefit quantification are as follows:

(i) Average blocked time, blocked traffic volume and traffic volume are based on Appendixes 3.2.1 and 2.

(ii) Traffic volume conversion ratio from 12 hours to 24 hours: 1.4

(iii) Future traffic volume increase ratio: 1982 = 1.0, 1990 = 1.4, 2000 = 1.91, 2010 = 2.25

Data: F/S for Second Stage Expressway System in 1983.

(iv) Average stop time for visual check: 5 seconds

(v) Vehicle time value: Shown in Fig. 11.3.1.

Table 11.3.1 Time Value of Road Vehicles

Kind of Vehicle	Occupants Average Time Value per Vehicle			Vehicle Time Cost						(10) Time Value of Vehicles (Baht per hour)
	(1) Average Occupacy/ vehicle (Persons)	(2) Time Value per Occupancy (Baht per hour)	(3) Time Value per Vehicle/ hour (Baht per hour)	(4) Economic Cost of Vehicle (Baht)	(5) Durable Years (Years)	(6) Total Running Distance for Durable Years (Km)	(7) Average Speed (Km/H)	(8) Total Usage Time (Hours)	(9) Vehicle Time Cost (Baht per hour)	
Motorcycle	1.7	14.9	25.4	14,250	6	78,000	55	1,418	10.0	35.4
Samlor (Note) (tricycle)	3.0	12.9	38.6	42,750	10	130,000	55	2,364	18.1	56.7
Sedan (Private car, Taxi)	3.0	15.5	46.4	122,817	10	230,000	70	3,285	37.4	83.8
Light Bus	8.0	10.2	81.6	117,312	8	272,000	60	4,533	25.9	107.5
Bus	37.5	6.3	234.7	516,137	11	770,000	60	12,833	40.2	274.9
Truck	3.0	14.3	42.8	309,749	12	480,000	60	8,000	38.7	81.5
Calculation method			(3)=(1)×(2)					(8)=(6)÷(7)	(9)=(4)÷(8)	(10)=(3)+(9)

Source: DOH - F/S on "Road User Costs for Hat Yai Bypass and Route 35" July 1983.

Note: Time value of tricycle was estimated because there is no available data.

(2) Time saving benefit of railway passengers

Benefit = time value of railway passenger ×

$$\left(\begin{array}{l} \text{total bus passenger-hours} \\ \text{difference per year} \\ \text{between Case I/Case II} \end{array} - \begin{array}{l} \text{total railway passenger-hours} \\ \text{difference per year between} \\ \text{Case I/Case II} \end{array} \right)$$

The time value of a railway passenger was estimated at 6.3 Baht per hour, which is the same amount as that of a bus passenger.

Passenger-hours difference for both bus and railway are derived from the results of the traffic demand forecast.

Table 11.3.2 Comparison of Passenger-hours Difference

(Unit: Million/year)

	Bus Passenger-hours Difference	Railway Passenger-hours Difference
1991	2.92	0.85
1998	3.87	1.33
2003	4.10	1.20

Note: This benefit does not arise in Case I because the conversion traffic from bus to railway is not estimated in the traffic demend forcast.

11.3.2 Fuel Saving Benefit

All cars must stop at railway crossings for a visual check and accelerate again. All cars idle at crossings when they are stopped, resulting in the consumption of extra fuel.

On the other hand, in the case of a flyover, the car needs extra fuel to negotiate the slope of the bridge.

If the project is implemented, such fuel waste would be avoided.

Table 11.3.3 shows additional fuel consumed per vehicle for each case.

Table 11.3.3 Additional Fuel Consumed per Vehicle

	Additional Fuel at Crossings (cc)	Additional Fuel at Flyovers (cc)	Remarks
Motorcycle	2.3	2.0	
Tricycle	3.8	3.0	Mean between Motorcycle/Sedan
Sedan	5.2	4.3	
Light Bus	6.0	4.4	In terms of gasoline
Bus	22.9	37.8	
Truck	15.0	12.0	
Precondition	Speed: 0 to 40km/H Distance: 100 m	Speed: 40 km/H Climbing 200 m on a slope of 4‰.	

Source: DOH; F/S on "Road User Costs for Hat Yai Bypass and Route 35", July 1983.

11.3.3 Benefit of Averting Accidents at the Railway Crossing Points

Accidents at railway crossings can be averted by elevating the railways and eliminating grade crossings.

On the basis of the accident statistics of railway crossings supplied by SRT, this benefit was estimated as follows:

Direct benefit = $^{(1)}$ Cost saving for SRT + $^{(2)}$ Cost saving for road traffic

Indirect benefit = $^{(3)}$ Time saving benefit for railway passenger

Table 11.3.4 Benefits Actual

(Unit: 1,000 Baht)

	Benefit Amount	Remarks
(1) Cost saving for SRT	450	Average amount of actual SRT results for the most recent 4 years (1979 - 1982)
(2) Cost saving for road traffic	(Injuries) 42 (Deaths) 1,153 (Vehicle damage) 411	Human life value = average annual income × average number of years employed × 1/2 Economic price of a sedan × 1/2 × average number of accidents
(3) Time saving benefit for railway passenger	5	Average number, of accidents × total train delay time × average number of passengers per train × time value of passenger
Grand Total	2,061	

Preconditions:
1. Number of persons injured: 11.5 persons per year
2. Number of persons killed: 1.75 persons per year
3. Average number of accidents: 6.75 times per year

11.3.4 Land Use Benefit

The land use benefit consists of the followings:

(1) Utilization of the space under elevated tracks.

(2) Benefit stemming from promoting more productive use of land around railway stations.

Due to the difficulty of quantifying it and in order to be conservative in calculating benefits, the second type of benefit is omitted here.

Moreover, land use benefits under the flyovers have been considered.

The following are estimates of available space under elevated tracks or flyovers by usage as shown in Table 9.2.1 and Table 10.5.1.

(Land Use under the Elevated Track)

Usage	Commercial Facilities	Business Facilities	Other (Note)
Space	37,500 m^2	24,900 m^2	24,000 m^2

Note: "Other" was excluded from benefit calculation.

(Land Use under the Flyovers)

Usage	Commercial Facilities	Business Facilities	Other
Space (m^2)	1,300 (1,300)	17,900 (8,900)	0 m^2

Note: Figures in ( ) show the space excluding the Mae Nam Line.

The following indices, which indicate the productivity of land usage, are utilized to estimate the land use benefit.

Usage	Measurement of Productivity	Yearly Value (Baht/m^2)
Commercial use	Gross sales profit	9,960 (Note 1)
Service buseness use	Warehouse rent	428 (Note 2)
Others (Playground)		

Notes: 1. Data from a department store.

2. Data from a small warehousing facility.

In actually calculating the benefit from commercial use, however, yearly value has been reduced to 50%, namely 4,980 Baht per m^2, by considering the following factors:

(i) The department store which supplied the data is located in a good commercial area of Bangkok.

(ii) Height limitation due to elevated track structure.

(iii) Geographical conditions

Furthermore, it is estimated that Case-II will result in higher productivity of land than that of Case-I because of the difference in railway passenger volume. It is, however, assumed that the productivity of land in each case is on the same level in this analysis.

11.3.5 Secondary Benefits

In addition to the benefits quantified above, attention should also be paid to the following primary unquantified benefits (i.e., secondary benefits) which will arise from this railway track elevation project.

(1) Benefits stemming from promoting the more productive use of land around railway stations.

(2) Dissolution of areal division and resultant obstructions of road traffic.

(3) Relief of congestion on roads based on conversion traffic from bus to railway arising from improving the passenger traffic service level in SRT.

(4) Job generation during the construction period.

11.4 Evaluation

(1) The contents of the evaluating indices were mentioned in 11.1.5. The EIRR of this project, calculated by the foregoing process, are shown in Table 11.4.1.

Table 11.4.1 Comparison of EIRR

Case	Case-I-3	Case-I-2	Case-II-3	Case-II-2
EIRR	16.2%	20.4%	16.3%	20.1%
Cashflow analysis is set out in	Appendix 11.4.1	Appendix 11.4.2	Appendix 11.4.3	Appendix 11.4.4

(i) As seen in the above table, it can be concluded that the implementation of the Project is reasonable and viable from the viewpoint of the national economy since the EIRR of each case surpasses the internationally acceptable level of 12 or 13 percent.

(ii) The relatively high level of EIRR in Case-I-2 and Case-II-2 indicates that each "net flow" from the Mae Nam Line in Case-I-3 and Case-II-3 is relatively lower than that of the other two lines (Northern and Eastern Lines).

(iii) EIRR of Case-I and Case-II differs very little. However, considering the following unquantified benefits in Case-II, it can be said that the EIRR of Case-II is superior to that of Case-I.

① Relief of congestion at roads based on conversion of traffic from bus to railway arising from an improvement in the passenger traffic service level in SRT.

② The relatively higher productivity of land in Case-II based on the difference in railway passenger volume.

(2) The case where no flyovers are constructed in "Without the Project" was also analyzed. Table 11.4.2 gives the results.

Table 11.4.2 EIRR (Case of no flyovers constructed)

Case	Case-I-3	Case-I-2	Case-II-3	Case-II-2
EIRR	17.7%	19.3%	18.6%	20.4%
Cashflow analysis is set out in	Appendix 11.4.5	Appendix 11.4.6	Appendix 11.4.7	Appendix 11.4.8

Even in this case, the EIRR does not show a significant difference from those of Table 11.4.1 and also indicate the Project is feasible.

A sensitivity analysis in this case was also done in section 11.5.

11.5 Sensitivity Analysis

(1) In this section the sensitivity analysis is executed by changing the pessimistic key parameters of Case-I-2, such as construction cost and road traffic volume.

The results are shown in Table 11.5.1.

Table 11.5.1 Sensitivity Analysis (EIRR)

No.	Base Case	20.4%
1	Construction cost: +10%	19.5%
2	Road traffic volume: -10%	20.9% (Note)
3	1 + 2	20.0%

Note: Sensitivity Analysis No. 2
Despite a 10% decrease of road traffic volume, the EIRR increases by 0.5% due to the difference in when the time saving benefit occurs in the "With/Without" case.

(2) Results of sensitivity analysis in the case of no flyovers constructed in relation to Case-I-2.

Table 11.5.2 Sensitivity Analysis (EIRR)

No.	Base Case: Case-I-2 (No flyovers constructed)	19.3%
A	Construction cost: +10%	18.1%
B	Road traffic volume: -10%	18.6%
C	A + B	17.4%

CHAPTER 12 FINANCIAL ANALYSIS

CHAPTER 12 FINANCIAL ANALYSIS

12.1 Purpose and Assumptions

12.1.1 Purpose of Financial Analysis

Unlike a project involving investment in new railway construction, this project will have the financial peculiarity that investment in elevation of the existing railway line alone will not basically produce any new and/or additional fare income for SRT except for income from the land use under the elevated track.

Nevertheless, the Project, as one of the effective solutions to traffic congestion in the Study Area (which is anticipated to become even worse), will be of great benefit to the regional society, so that some Government financial support to SRT will be desirable regardless of the revenue and expenditure the Project entails.

Considering such circumstances, a financial analysis will be done in the Study whose primary objective is to determine how much Government financial support for SRT is necessary in the execution of the Project.

12.1.2 Assumptions

(1) In the economic analysis, the capital investment and the maintenance and the operation costs did not include taxes. However, in the financial analysis, the tax portion was included, and all costs have been based on market values.

(2) Other assumptions are similar to those of the economic analysis (refer to 11.1.4).

(3) Considering the scale of the capital investment, a financial analysis was done for the following two cases:

(i)	Case-I-2 :	Case of the lowest investment amount among four cases
(ii)	Case-II-3:	Case of the highest investment amount among four cases

12.2 Financial Analysis Method

The marginal analysis method was adopted in this financial analysis, by which we analyze the relation between the additional investments to the existing railway facilities (sunk cost) and the additional revenue obtained in the commuter area set up in subsection 3.2.4.

12.3 Revenue and Expenditure

12.3.1 Revenue

Railway operating income, both passenger and freight, and rent income from land beneath viaducts were projected.

(1) Railway operating income

The fare income was calculated by multiplying the fare rate by the additional annual passenger and freight traffic volume (passenger-km, ton-km) in the commuter area, with traffic volume in 1984 being the benchmark for both.

In accordance with the current fare rates and the actual SRT results, the following rates were adopted in this analysis:

Passenger rate: 0.20 Baht per passenger-km
Freight rate: 0.40 Baht per ton-km

It is assumed that the fare rates will remain unchanged during the project life.

The calculated traffic volumes (additional) are shown in Table 12.3.1.

Table 12.3.1 Additional Traffic Volumes

(Unit: Million passenger-km
Million ton-km)

	Year	(1984)	1991	1998	2003	2013
Case-I-2	Passenger	(863.5)	420.2	586.4	713.7	1,004.2
	Freight	(259.9)	77.6	176.1	263.7	495.1
Case-II-3	Passenger	(863.5)	542.2	749.6	889.3	1,208.8
	Freight	(259.9)	77.6	176.1	263.7	495.1

(2) Rent income from land beneath viaducts

To estimate rent income, the estimating method used by JNR is applied in the absence of any SRT figures or any other appropriate methods.

In the Study, it is estimated that an annual return of 12.6% on the market price of the land will be obtainable. Calculation method is as follows:

Rent income = Market price of land × Annual rental rate
Annual rental rate = Capital interest rate per year + Management fee rate

Notes:

1. Capital interest rate: 12/100 (0.12) estimated
2. Management fee rate: 5/100 on capital interest rate (0.006) estimated

Estimated rental space and the market price of land are shown in Table 12.3.2.

Table 12.3.2 Land Rental and Market Price

	Northern Line	Eastern Line	Mae Nam Line
Space of land (m^2)	19,200	28,900	14,300
Market price of land (Baht/m^2)	4,375	5,625	5,000

Notes:

1. Space of land beneath the viaducts: Table 9.2.1.
2. Market price of land was estimated from the market price of land adjacent to the track elevation area, which was obtained from the Bangkok Metropolitan Authority.

12.3.2 Operating Expense

The operating expense is composed of the working costs which include maintenance costs of railway facilities, personnel costs and energy costs; interest costs; and depreciation costs.

The depreciation costs were calculated in accordance with the useful life as applied in the economic analysis. Moreover, interest during the construction period is assumed to be capitalized.

12.3.3 Operating Profit and Net Profit

The operating profit is obtained by subtracting the operating expense from the revenue. Further, the net profit is obtainable by deducting income tax (40% was estimated) from the operating profit.

12.4 Investment and Fund Raising Plan

12.4.1 Investment Plan

The investment plan used in the economic analysis was applied. All costs are based on market values including taxes.

Tables 12.4.1 and 2 show a breakdown of investment calssified by type of construction, kind of currency and construction term.

Table 12.4.1 Financial Cost of Investment (Case-I-2)

(Unit: Million Baht)

Year		1984∿1990	1991∿1997	1998∿2013	Reinvest-ment	Total
Civil engineering works	F.C.	575.4	178.8	0	0	754.2
	D.C.	1,254.2	305.1	0	0	1,559.3
Station facilities	F.C.	33.9	5.6	0	0	39.5
	D.C.	81.4	13.2	0	0	94.6
Signals & telecommunications	F.C.	349.2	52.9	0	0	402.1
	D.C.	256.8	36.4	0	0	293.2
Land purchase	F.C.	0	0	0	0	0
	D.C.	52.2	0	0	0	52.2
Rolling stock	F.C.	0	784.8	1,643.0	652.6	3,080.4
	D.C.	0	172.6	361.4	143.3	677.3
Total	F.C.	958.5	1,022.1	1,643.0	652.6	4,276.2
	D.C.	1,644.6	527.3	361.4	143.3	2,676.6
Grand Total		2,603.1	1,549.4	2,004.4	795.9	6,952.8

Notes:

1. The costs include reinvestment, but exclude residual values.
2. F.C.: Foreign Currency, D.C.: Domestic Currency

Table 12.4.2 Financial Cost of Investment (Case-II-3)

(Unit: Million Baht)

Year		1984∿1990	1991∿1997	1998∿2013	Reinvestment	Total
Civil engineering works	F.C.	801.7	138.5	0	0	940.2
	D.C.	1,642.8	255.8	0	0	1,898.6
Station facilities	F.C.	53.4	5.3	0	0	58.7
	D.C.	123.6	12.4	0	0	136.0
Signals & telecommunications	F.C.	377.8	56.2	0	0	434.0
	D.C.	279.9	36.5	0	0	316.4
Land purchase	F.C.	0	0	0	0	0
	D.C.	79.8	0	0	0	79.8
Rolling stock	F.C.	0	945.8	1,675.3	829.7	3,450.8
	D.C.	0	208.1	368.4	182.3	758.8
Total	F.C.	1,232.9	1,145,8	1,675.3	829.7	4,883.7
	D.C.	2,126.7	512.8	368.4	182.3	3,189.6
Grand Total		3,359.0	1,658.6	2,043.7	1,012.0	8,073.3

Notes:

1. The costs include reinvestment, but exclude residual values.
2. F.C.: Foreign Currency, D.C.: Domestic Currency

12.4.2 Fund Raising Plan

The means of financing the Project will considerably influence the result of the financial analysis (net cash flow).

The following assumptions are made for the base plan in this study:

(1) Foreign currency portion

Through overseas Governmental loans

Interest: 3 percent per annum

Period: 30 years (including grace period of 10 years)

Repayment: Equal semiannual installments for 20 years

(2) Domestic currency portion

Through debt in the domestic market

Interest:	12 percent per annum
Period:	15 years (including grace period of 5 years)
Repayment:	Equal semiannual installments for 10 years

Further, the following three financing variations were studied and their effect on both the profitability of the Project and the cash flow projection are given in section 12.5.

Financing variations are shown in Table 12.4.3.

Table 12.4.3 Estimated Finance Plans

Finance plan	Method of financing
Base plan	SRT will raise all funds as described in 12.4.2 (1) and (2).
Finance plan No. 1	Governmental subsidies will be made for 50% of domestic currency portion
Finance plan No. 2	Governmental subsidies will be made for 100% of domestic currency portion
Finance plan No. 3	Governmental subsidies will be made for 100% of domestic currency portion and for 100% of interest on foreign currency portion.

12.5 Net Cash Flow Analysis

By utilizing a net cash flow projection, we studied how debt service payments related to the finance plans will influence the cash flow.

Net cash flow (as the difference between cash in-flow items and cash out-flow items) is obtained by the following equation.

Net cash flow = (Net income (interest paid) after tax + Depreciation + Borrowings) - (Investments + Interest during construction + Loan repayment)

Details on net cash flow in CaseI-2 and Case-II-3 are given in Appendixes 12.5.1 and 2.

12.5.1 Result of Operating Income and Expense (Profit & Loss)

The results of operating income and expense based on the financing variations mentioned in 12.4.3 are shown in Fig. 12.5.1 and 2 and Tables 12.5.1. and 2.

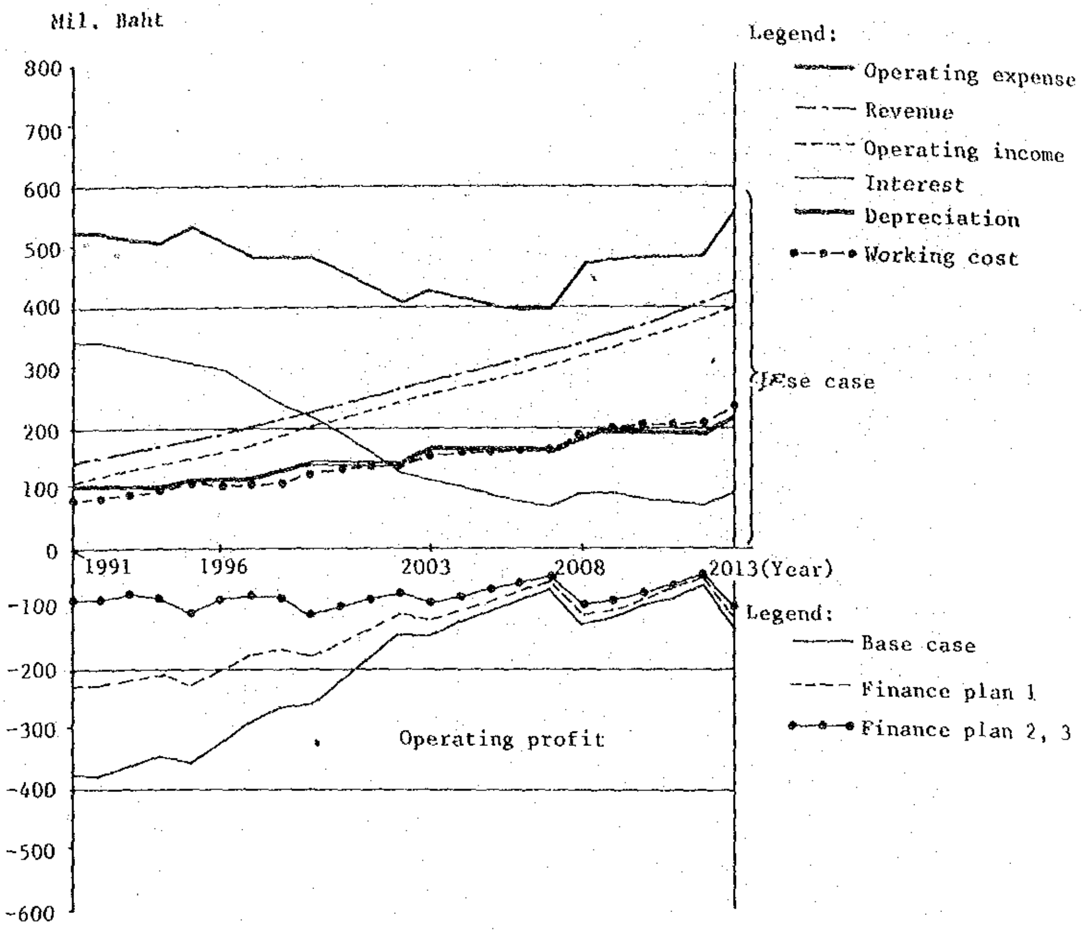


Fig. 12.5.1 Profit & Loss (Case-I-2)

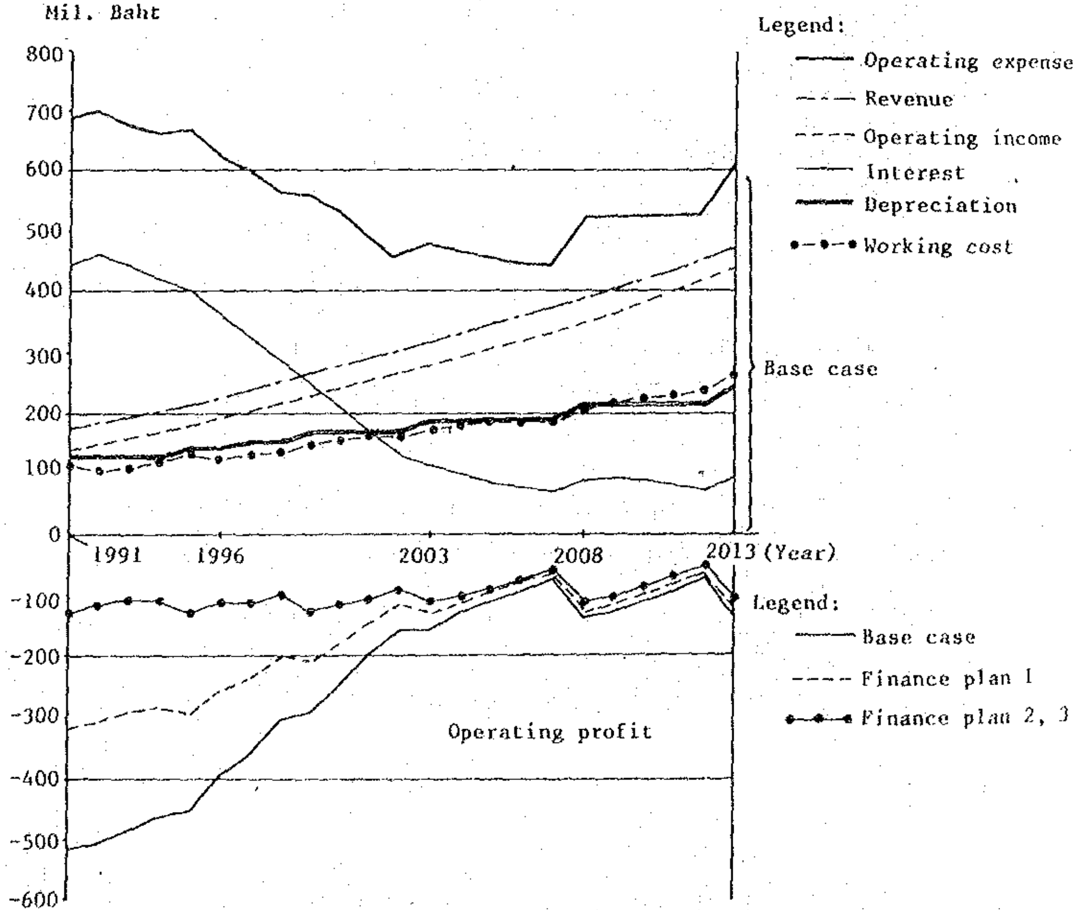


Fig. 12.5.2 Profit & Loss (Case-II-3)

Table 12.5.1 Profit & Loss Statement (Case-I-2)

(Unit: Million Baht)

			1991	1996	2003	2013
Revenue		Revenue	144	996	2,685	6,242
		(Operating income)	(115)	(824)	(2,299)	(5,546)
Operating expense and operating profit	Base case	Operating expense	519	3,118	6,293	10,832
		(Working cost)	(84)	(572)	(1,482)	(3,388)
		(Interest payment)	(337)	(1,927)	(3,247)	(4,103)
		(Depreciation)	(99)	(618)	(1,564)	(3,341)
		Operating profit	-375	-2,122	-3,608	-4,590
	Finance plan No. 1	Operating expense	373	2,313	5,047	9,457
		(Working cost)	(84)	(572)	(1,482)	(3,388)
		(Interest payment)	(191)	(1,122)	(2,001)	(2,728)
		(Depreciation)	(98)	(618)	(1,564)	(3,341)
		Operating profit	-229	-1,317	-2,362	-3,215
	Finance plan No. 2 & No. 3	Operating expense	227	1,507	3,801	8,082
		(Working cost)	(84)	(572)	(1,482)	(3,388)
		(Interest payment)	(45)	(316)	(755)	(1,354)
		(Depreciation)	(98)	(618)	(1,564)	(3,341)
		Operating profit	-83	-511	-1,116	-1,840

Note: Figures show cumulative amount.