CHAPTER SEVEN

MOTORWAY NETWORK MASTER PLAN

CHAPTER 7

MOTORWAY NETWORK MASTER PLAN

7.1 MOTORWAYS DEVELOPMENT POLICY

Roads including highways and motorways are the life blood of business, commerce and investments for development of the national economy in the sense of that roads are used for communications and transportation of people and freight including agricultural and industrial products which are essentials for the life of the nation. Roads, also, contribute to the dynamic and happy life of the nation through the convenience for recreaition and pleasure.

While the national economy grew within the targeted rate during the period of implementation of the Fifth National Economic and Social Development Plan (1982—1986), the annual growth rate of GDP for the Sixth Plan (1987—1991) is much higher than the targeted rate of 5.0%, with 8.4% for 1987, 11.0% for 1988 and expected 9.2% for 1989.

Moreover, Thailand will be geared to transform from agricultural economy to industrial economy in the near future, as the volume of industrial exports constitute more than 50% of total volume in 1989.

On the other hand, it can be noted that 49% of GDP has been realized in Bangkok and its suburbs, whereas 17.2% in the Central, 12.6% in the Northeastern, 11.2% in the Northern and 9.9% in the Southern Regions. Also, the economic expansion has created imbalance among the regions by economic developments centered in Bangkok, its suburbs and the major cities. This has resulted to serious income imbalance among people living in large cities and those in rural areas.

Due to this economic expansion, the total number of registered vehicles has drastically increased from 3.3 million in 1985 to 6.4 million in 1988 with an annual growth rate of 24.8%. Daily vehicle—kilometer of all vehicle types on the primary and

secondary highways, also, increased from 49 million veh—km in 1985 to 66 million veh-km in 1988 and is expected to reach 308 million veh—km in 2010 as forecasted in the results of this Study.

Therefore, the following problems are expected in transportation specially due to the delay in infrastructure development the road sector comparing with the rapid economic growth.

In an area with over a 100 km radius around Bangkok Metropolis, very severe traffic congestion occurs especially during rush hours of the morning and evenings, and even during off-rush hours traffic congestion continues by business operation. Moreover, on holidays and weekends, traffic congestion is severely bad and safety level is low for travelers using the main highways.

National and provincial highways that have been paved throughout the country stretch approximately 35,000 km in length. Traffic problems are not yet so severe, except in areas around Bangkok Metropolis with over 100 km radius. However, in the next 10 years, following the rapid economic expansion and government policy for regional development, volume of traffic will increase substantially, thereby creating problems on national highways, particularly in the Central Region.

In order to cope with structural changes in economy, to scatter development to all regions and to solve present and expected traffic problems, drastic change of highway network is a must. In other words, the nationwide motorway network should be urgently established in order to realize the following development policies of the Government of Thailand.

- To sustain the current remarkable economic growth by dealing effectively with increasing transport needs.
- To plan universal development of the whole nation by speedy and effective transportation system between regions.
- To promote decentralization of socio-economic activities from Bangkok and its surrounding areas by improving transportation conditions in regional areas.

— To promote development of industrial developing areas and growth pole cities designated in the National Plan by tightly connecting them.

— To alleviate regional disparities in socio-economic level by promoting development in regions, especially by generating or attracting industrial activities.

— To form a part of international highway network, particularly the Pan Asian Highway, to promote exchanges and trades to neighbouring countries.

— To ensure on-time and safe driving by alleviating traffic congestion and baring mixed traffic which is a main cause of traffic accidents.

— To create job opportunities in regional areas through investments for motorway construction.

The development of motorways requires a huge amount of cost. In order to raise this huge amount of the road investment with less government burden, introduction of "Special Funds System" and "Toll Road System" should be considered.

7.2 PROCEDURE FOR ESTABLISHMENT OF MASTER PLAN

Figure 7.1 shows the practical procedures for establishment of the master plan of the motorway network.

Target Length of Motorway

Target length of motorway is estimated, in Section 7.3, through analyzing the relationship between the socio-economic indicators and the length of motorways in various countries which have had well-developed motorways.

This target length is an important factor to decide the length of motorways required in Thailand.

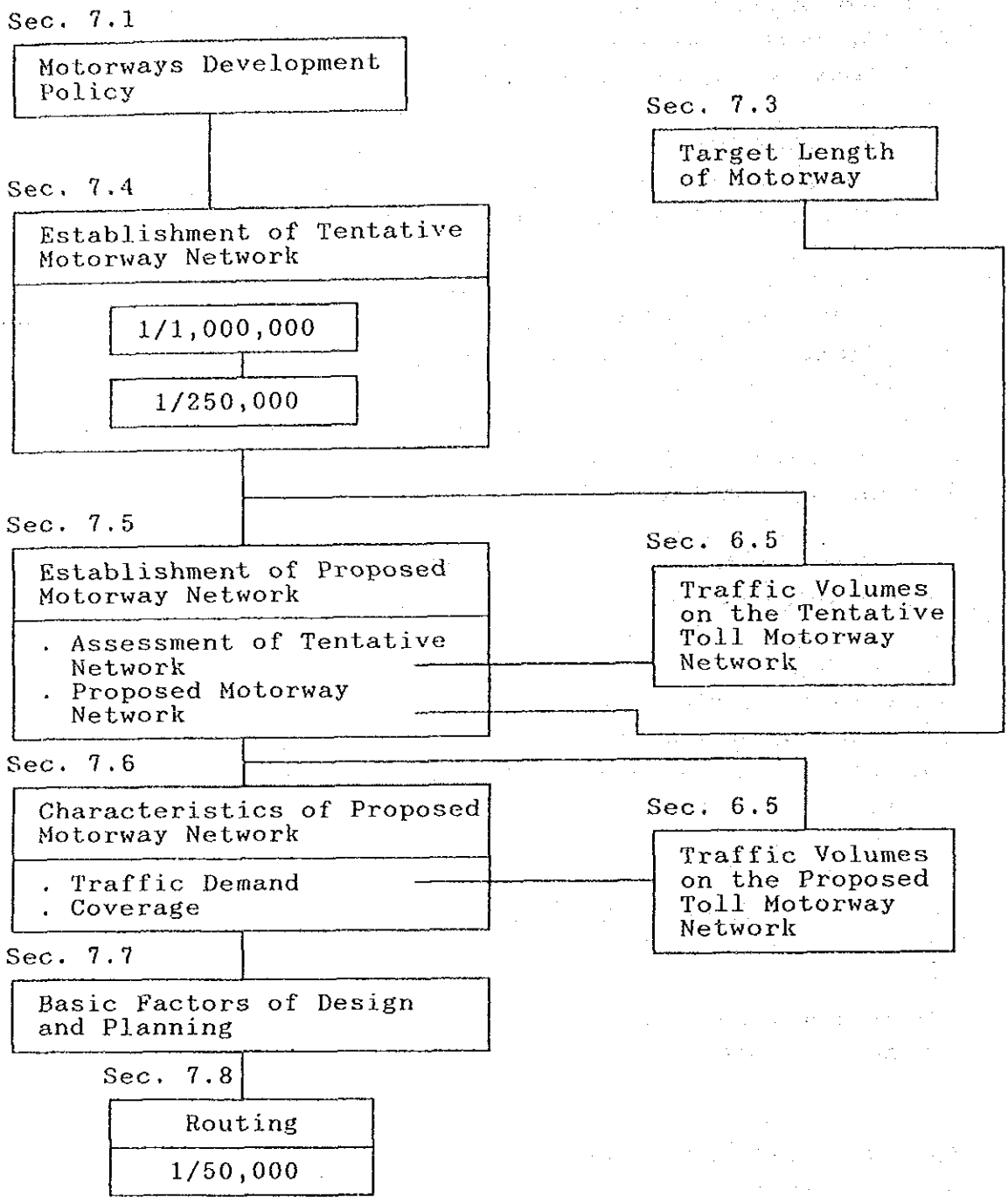


Figure 7.1 PROCEDURES FOR ESTABLISHMENT OF MASTER PLAN OF THE MOTORWAY NETWORK

Establishment of Tentative Motorway Network

Motorway network required to contribute to the achievement of

the development policy described in Section 7.1 is tentatively established based on 258 major points listed in Section 7.4.

Establishment of Proposed Motorway Network

Each route of the tentative motorway network is assessed by the major points and population coverages as well as the handled traffic volumes in order to establish a proposed motorway network.

The length of assessed motorway network is compared with the target length estimated in Section 7.3.

Characteristics of Proposed Motorway Network

The characteristics of the proposed motorway network are presented in the sense of the major points and population coverages as well as the traffic volume.

Basic Factors of Design and Planning

The basic factors for design and planning of motorways are recommended by reviewing the practices in various countries.

Routing

Each route of the proposed motorway network is planned with careful consideration of control points in social and environmental aspects.

7.3 TARGET LENGTH OF MOTORWAYS

Generally, the target length of roads required for a country or region is related to the indices of the area, population and per capita GNP, and can be estimated by the following equation:

$$L = K\sqrt{A \times P}$$

where,
- L : Target road length
- K : Function of per capita GNP (G)
- A : Area
- P : Population

Appendix 7.1 presents the length of existing and under planning motorways and indices of the area, population and per capita GNP of 12 selected countries which have well developed motorway networks.

Based on this data, K values of the selected countries are calculated and a regression analysis is carried out to get the relationship between K and per capita GNP (G), which is presented in the following equation and Appendix 7.2.

$$K = 0.000686056 + 0.000000087 \times G$$

Applying the following indices of Thailand in the above equations, the target length of motorways in Thailand is calculated to be 4,124 km, as shown in Table 7.1.

Table 7.1 TARGET LENGTH OF MOTORWAYS IN THAILAND

	in 1988
GNP Per Capita Income (US$)	1,062
Area (Km^2)	514,000
Population (1,000)	54,560
Target Length (Km)	4,124

7.4 ESTABLISHMENT OF TENTATIVE MOTORWAY NETWORK

7.4.1 Basic Idea for Planning

In order to contribute to realizing the development policies described in section 7.1, the motorway network is established through the following basic ideas:

— To connect Bangkok metropolitan area with all other regions as the arteries of the network aiming for drastic improvement in nationwide land transportation.

— To directly connect the industrial developing areas with the cities designated in the National Plan as cultural and industrial regional centers aiming at their development.

— To connect most of Changwat centers, large industrial developing estates, important airports, sea/inland ports and famous places of interest so that these major points can be connected through the motorway within reasonable time aiming for the universal development of national land, the effective utilization of cultural facilities and the promotion of tourism.

— To connect major points accessing to neighboring countries aiming for the formation of a part of the international highway network and encouragement of exchange and trades with them.

— To construct Outer Bangkok Ring Motorway which will redistribute the traffic pattern.

In areas with high potential but not covered by the basic ideas mentioned above, supplementary motorways are planned considering the population, economic and social importance in these areas so as to enjoy the benefits of the motorway network.

The major points such as designated developing areas and cities, Changwat centres, important transport centres, etc., considered in the formation of the motorway network are shown in Table 7.2.

Table 7.2 MAJOR POINTS

Category		Number
Designated City	1st priority (Regional urban growth centers)	5
	2nd priority (Second generation regional urban growth centers)	6
	3rd priority (Other regional urban growth centers)	13
Large City	population > 100,000	8
	population > 50,000	10
	population > 30,000	30
Industrial area in National Development Plan		5
Large size industrial area		36
Airport		25
Seaport		20
Inland-water port		14
Place of interest		13
Changwat center		73
Total		258

The details and location map of above major points are presented in Appendix 7.3 and Figure 7.2 respectively.

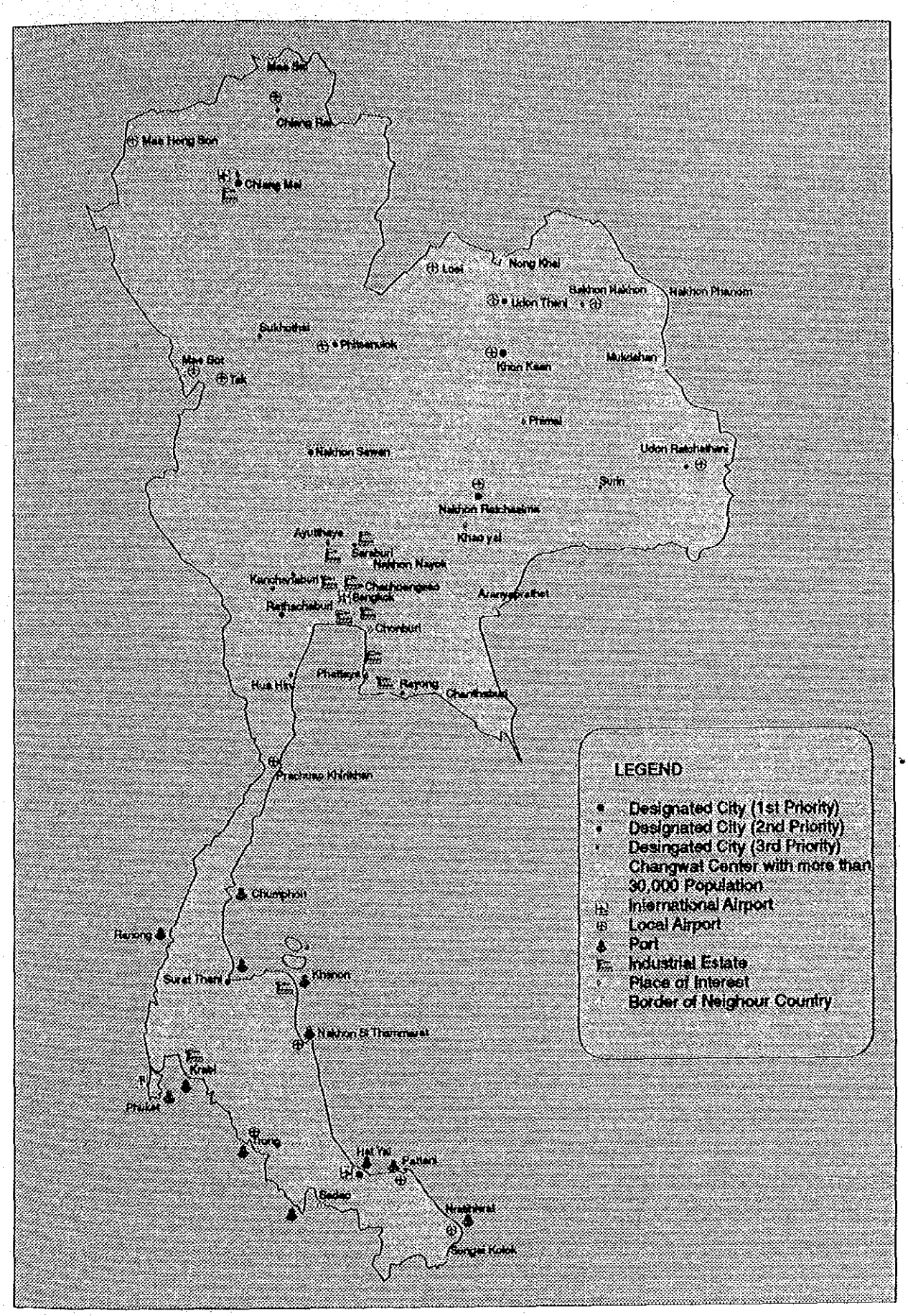


Figure 7.2 LOCATIONAL MAP OF MAJOR POINTS

7.4.2 Tentative Motorway Network

Establishment of the tentative motorway network is carried out in four steps according to the importance in function of each route.

STEP 1:

- Routes connecting Bangkok with designated cities (1st priority)
- Routes connecting designated cities (1st priority) with the main border points of the neighboring countries
- Routes connecting Bangkok with national industrial development areas
- Routes connecting Bangkok with the main places of interest
- Routes forming the Outer Bangkok Ring Road (OBRR)

STEP 2:

- Routes connecting designated cities (2nd priority) with the routes selected in STEP 1
- Routes connecting the remaining border points of the neighboring countries with the routes selected in STEP 1
- Routes directly connecting Eastern Seaboard Development Area with Northeastern Region
- Routes connecting some other places of interest with the routes selected in STEP 1

STEP 3:

- Routes connecting designated cities (3rd priority) with the routes selected in STEP 1 and STEP 2
- Routes forming an outer belt motorway within 50—100 km far from Bangkok

STEP 4:

- Routes connecting Changwat centers with more than 30,000 population and the routes selected in STEP 1, STEP 2 and STEP 3.

Practical routing for the tentative motorway network is carried out on 1/250,000 map considering the control points after rough trials on 1/1,000,000 map.

The total length of the established tentative motorway network is 5,851 Km. Details of the network are shown in Table 7.3 for each tentative route (TR), and Appendices 7.4 and 7.5.

Table 7.3 TENTATIVE MOTORWAYS BY STEP

STEP	NO.	ORIGIN	DESTINATION	LENGTH (km)
STEP 1	TR-1	OBRR	CHIANG MAI	578
	TR-2	OBRR	NONG KHAI	534
	TR-3	OBRR	RAYONG	196
	TR-4	OBRR	KLONG PRAUN (SONG KHLA)	941
	TR-5	OBRR	OBRR	170
	TR-6	KRABI	KHANOM	184
			SUB TOTAL	2,603
STEP 2	TR-11	UTTARADIT	MAE SAI (CHIANG RAI)	363
	TR-12	MAE SOT (TAK)	MUKDAHAN	696
	TR-31	OBRR	KANCHANABURI	101
	TR-32	OBRR	ARANYAPRATHET (PRACHIN BURI)	222
	TR-33	CHON BURI	NAKHON RATCHASIMA	230
	TR-41	PHRASAENG (SURAT THANI)	PHUKET	143
	TR-42	HAT YAI (SONG KHLA)	SUNGAI KOLOK (NARATHIWAT)	208
			SUB TOTAL	1,963
STEP 3	TR-101	CHIANG MAI	MAE SUAI (CHIANG RAI)	146
	TR-201	UDON THANI	SAKHOL NAKHON	146
	TR-202	NAKHON RATCHASIMA	UBON RATCHATHANI	299
	TR-301	RATCHABURI	THA WUNG (LOP BURI)	168
	TR-302	THA WUNG (LOP BURI)	BANG PAKONG (CHACHOENGSAO)	187
	TR-303	ORR	SUPHAN BURI	62
	TR-401	RON PHIBUN (NAKHON SI THAMMARAT)	NAKHON SI THAMMARAT	36
			SUB TOTAL	1,044
STEP 4	TR-2001	SAKHOL NAKHON	NAKHON PRANOM	78
	TR-3001	RAYONG	CHANTHABURI	98
	TR-4001	TUNG SONG (NAKHON SI THAMMARAT)	TRANG	65
			SUB TOTAL	241
			TOTAL	5,851

7.5 ESTABLISHMENT OF PROPOSED MOTORWAY NETWORK

7.5.1 Assessment of the Tentative Motorway Network

In order to establish a proposed motorway network, each route of the tentative motorway network is evaluated according to the covered major points and population as well as handled traffic volumes.

Criteria adopted in the assessment are as follows:

1. Major point-coverage value:

   is the number of the major points from where a traveler can arrive to the nearest interchange within 60 minutes.

Major points/100 kilometer	Marks
less than 5	**
5 - 10	*
more than 10	no

2. Population-coverage value:

   is the total population who can arrive to the nearest interchange within 60 minutes.

Population/kilometer	Marks
less than 10,000	**
10,000 - 20,000	*
more than 20,000	no

3. Traffic Volume:

   is the average daily traffic volume (ADT) without induced traffic, which is extracted from Section 6.5.

ADT	Marks
less than 8,000	**
8,000 - 12,000	*
more than 12,000	no

As seen above, routes to which many marks are attached are assessed as low priority routes.

Results assessed based on the above criteria for each route in the tentative motorway network are shown in Table 7.4.

Table 7.4 ASSESSMENT OF TENTATIVE NETWORK BY ROUTE

TR No.	Length (km)	Major Points: No. of Covered Points	Major Points: Coverage (points/100 km)	Major Points: Evaluation	Population: Covered (1,000 persons)	Population: Coverage (person/km)	Population: Evaluation	Traffic Volume: Traffic Volume (ADT)	Traffic Volume: Evaluation	Total Evaluation	
1	578	74	13		15,951	27,597		29,533			
2	534	61	11		15,631	29,272		23,621			
3	196	49	25		9,725	49,617		49,871			
4	941	78	8	*	13,994	14,871	*	24,366		**	
5	170	50	29		10,624	62,494		50,907			
6	184	11	6	*	983	5,342	**	21,440		***	
11	363	9	2	**	2,369	6,526	**	9,400	*	*****	D
12	696	26	4	**	7,559	10,861	*	8,526	*	****	D
31	101	39	39		9,856	97,584		33,511			
32	222	36	16		9,614	43,306		32,312			
33	230	28	12		3,745	16,283	*	9,834	*	**	
41	143	10	7	*	760	5,315	**	9,957	*	****	
42	208	21	10		2,294	11,029	*	9,003	*	**	D
101	146	12	8	*	2,103	14,404	*	9,949	*	***	
201	146	8	5	*	2,348	16,082	*	7,255	**	****	D
202	299	19	6	*	6,333	21,181		12,743		*	
301	168	58	35		11,543	68,708		21,615			
302	187	45	24		10,676	57,091		20,778			
303	62	34	55		9,787	157,885		35,351			
401	36	6	17		1,564	43,444		14,704			
2001	78	5	6	*	1,079	13,833	*	3,850	**	****	D
3001	98	10	10		1,342	13,694	*	18,733		*	
4001	65	5	8	*	1,536	23,631		10,563	*	**	D
TOTAL	5,851	694		* < 10 ** < 5			* < 20,000 ** < 10,000		* < 12,000 ** < 8,000		

Note: D: Deleted Routes

Routes with two or more marks in total are TR-4, TR-6, TR-11, TR-12, TR-33, TR-41, TR-42, TR-101, TR-201, TR-2001 and TR-

4001. They are assessed as low priority routes. However, the routes TR-4, TR-6, TR-33, TR-41 and TR-101 are reevaluated and remained as component routes of the proposed motorway network for the following reasons:

TR-4 : is a nationwide arterial route and connects Bangkok to the Southern Seaboard Development Area.

TR-6 : is a landbridge motorway in the Southern Seaboard Development Plan.

TR-33 : is the route which directly connects Eastern Seaboard Development Area with the Northeastern Region.

TR-41 : is the route diverted from TR-6 (Landbridge Motorway) to connect Phuket as one of the most famous places of interest.

TR-101 : is the route extended from Chiang Mai to Chiang Rai, as one of the designated cities (3rd priority) and one of the most famous places of interest.

In conclusion, 17 routes among 23 routes of the tentative motorway network are selected to be the component routes of the Proposed Motorway Network in Thailand. The selected routes are listed in Table 7.5.

7.5.2 Proposed Motorway Network – 4,300 km –

In Section 7.3, the target length of motorways required in Thailand is estimated to be 4,124 km based on the geographical and present socio-economic conditions compared with those of the countries which have well developed motorway networks.

Table 7.5 SELECTED ROUTES

NO.	ORIGIN	DESTINATION	LENGTH (km)
TR-1	OBRR	Chiang Mai	578
TR-2	OBRR	Nong Khai	534
TR-3	OBRR	Rayong	196
TR-4	OBRR	Klong Praun (Song Khla)	941
TR-5	OBRR	OBRR	170
TR-6	Krabi	Khanom	184
TR-31	OBRR	Kanchanaburi	101
TR-32	OBRR	Aranya Prathet (Prachin Buri)	222
TR-33	Chon Buri	Nakhon Ratchasima	230
TR-41	Phrasaeng (Surat Thani)	Phuket	143
TR-101	Chiang Mai	Mae Suai (Chiang Rai)	146
TR-202	Nakhon Ratchasima	Ubon Ratchathani	299
TR-301	Ratchaburi	Tha Wung (Lop Buri)	168
TR-302	Tha Wung (Lop Buri)	Bang Pakong (Chachoengsao)	187
TR-303	OBRR	Suphan Buri	62
TR-401	Ron Phibun (Nakhon Si Thammarat)	Nakhon Si Thammarat	36
TR-3001	Rayong	Chanthaburi	98
	Total		4,295

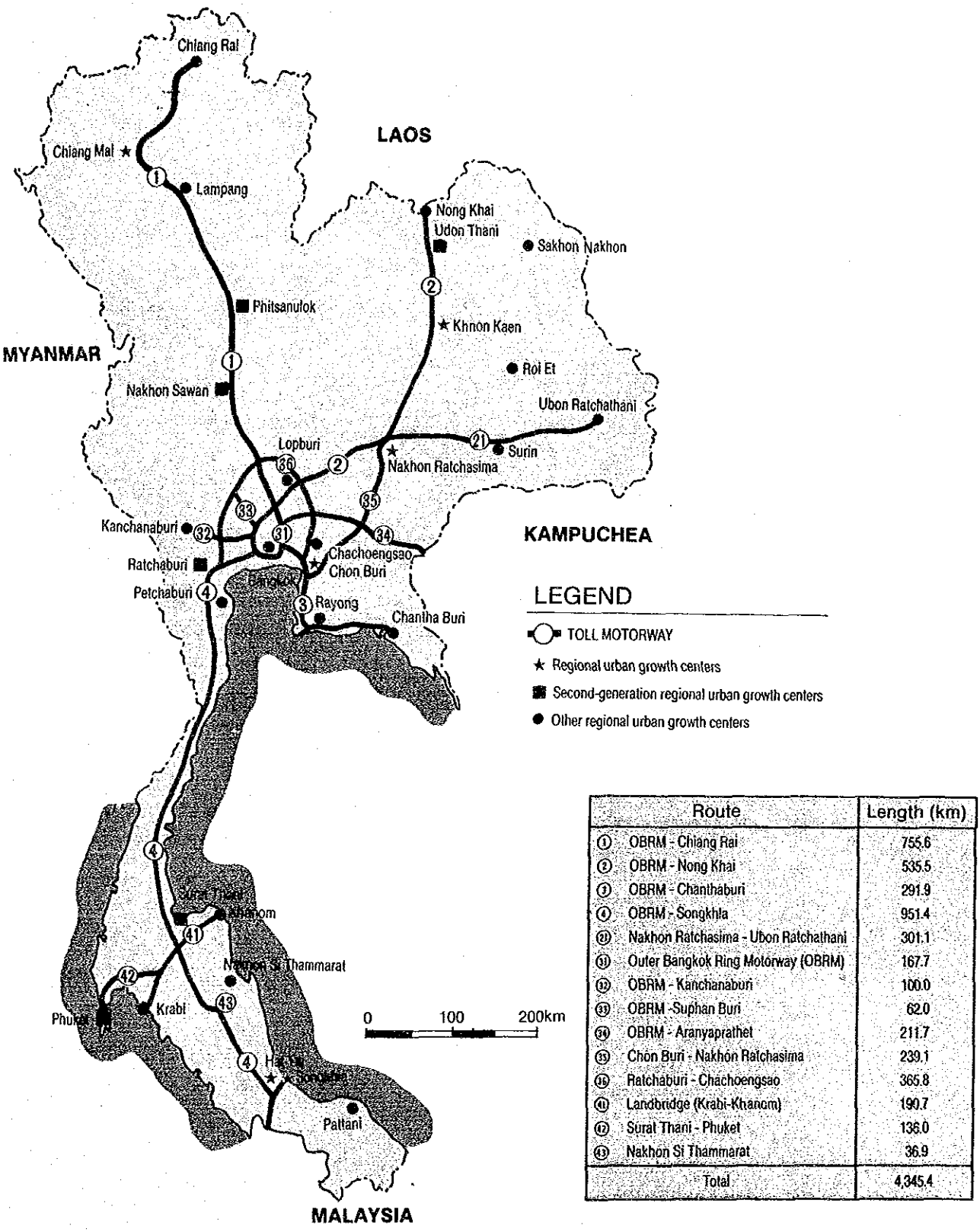
As a result of the previous section, 4,300 km of motorways are selected to cover the motorway development policy, which is called "4,300 KM NETWORK PLAN".

Table 7.6 gives the details of the proposed network by route, while a sketch of the proposed network is shown in Figure 7.3. The numbering order, origin, destination and length of routes are modified into a practical basis for the proposed network as shown in the table.

Table 7.6 4,300 KM MOTORWAY NETWORK

PROPOSED ROUTE NO.	ORIGIN	DESTINATION	LENGTH (KM)	SELECTED ROUTE NO.
TM-1	Bang Pa-In	Chiang Rai	755.6	TR-1,11,101
TM-2	Bang Pa-In	Nong Khai	535.5	TR-2
TM-3	Phra Khanong	Chanthaburi	291.9	TR-3, 3001
TM-4	Phasi Charoen	Malaysia Border	951.4	TR-4
TM-21	Nakhon Ratchasima	Ubon Ratchathani	301.1	TR-202
TM-31	Bang Pa-In	Bang Pa-In	167.7	TR-5
TM-32	Bang Yai	Kanchanaburi	100.0	TR-31
TM-33	Bang Bua Thong	Suphan Buri	62.0	TR-303
TM-34	Thanyaburi	Aranya Prathet	211.7	TR-32
TM-35	Chonburi	Nakhon Ratchasima	239.1	TR-33
TM-36	Wat Phleng	Bang Pakong	365.8	TR-31, 302
TM-41	Krabi	Khanom	190.7	TR-6
TM-42	Phrasaeng	Phuket	136.0	TR-41
TM-43	Ron Phibun	Nakhon Si Thammarat	36.9	TR-401
	Total		4,345.4	

Note : Lengths of the routes are subject to the more accurate results of routing in Section 7.8.



Route	Length (km)
① OBRM - Chiang Rai	755.6
② OBRM - Nong Khai	535.5
③ OBRM - Chanthaburi	291.9
④ OBRM - Songkhla	951.4
㉑ Nakhon Ratchasima - Ubon Ratchathani	301.1
㉛ Outer Bangkok Ring Motorway (OBRM)	167.7
㉜ OBRM - Kanchanaburi	100.0
㉝ OBRM -Suphan Buri	62.0
㉞ OBRM - Aranyaprathet	211.7
㉟ Chon Buri - Nakhon Ratchasima	239.1
㊱ Ratchaburi - Chachoengsao	365.8
㊶ Landbridge (Krabi-Khanom)	190.7
㊷ Surat Thani - Phuket	136.0
㊸ Nakhon Si Thammarat	36.9
Total	4,345.4

Figure 7.3 PROPOSED MOTORWAY NETWORK

7.6 CHARACTERISTICS OF 4,300 KM MOTORWAY NETWORK

The proposed motorway network is characterized on the basis of two main factors, which are traffic and coverage.

7.6.1 Traffic

Traffic is sub-characterized as vehicle-hour and trip length. They are extracted from Section 6.5 as shown in Table 7.6.

Table 7.7 TRAFFIC CHARACTERISTICS OF TOLL MOTORWAY AND NATIONAL HIGHWAY NETWORKS – 2010

		Toll Motorway Network	National Highway Network	Total
Vehicle-Hour (1000 Veh-hr)	W/O-MTW	-	9,411	9,411
	W-MTW (4300)	826	6,184	7,010
Average Trip Length (Km)	W/O-MTW	-	65.0	65.0
	W-MTW (4300)	159.5	53.0	70.5

Note : - W/O-MTW : without-motorway
- W-MTW (4300) : with-motorway of 4300 Km (proposed)

The total vehicle-hour in case of "With Project" is 7,010,000, while in case of "Without Project", it is 9,411,000. The ratio between this two cases, i.e. 0.745, indicates that time savings of 25.5% in terms of vehicle-hour is expected by introducing the 4,300 km motorway network.

As seen in Table 7.6, the average trip length on the motorway is 159.5 km, while on the national highway is 53.0 km. The difference is over 100 km.

Figure 7.4 shows the share of trip length distribution of motorway and national highway networks. The share of the motorways occupies 50% for trips longer than 200 km, while the national highways have more than 95% share in the short trips in the range between 0 – 40 Km.

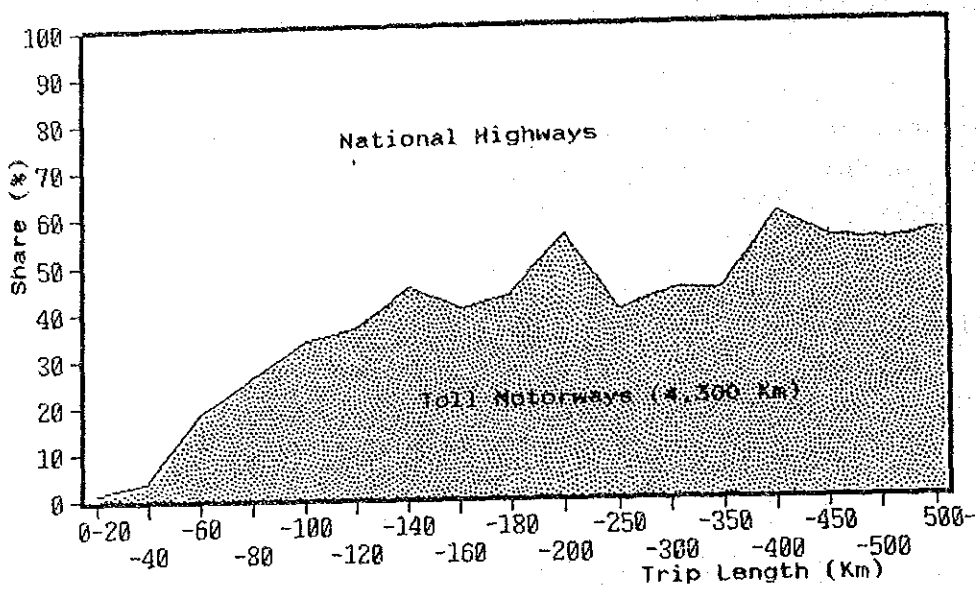


Figure 7.4 SHARE IN TRIPS BETWEEN NATIONAL HIGHWAY AND TOLL MOTORWAY NETWORKS — 2010

7.6.2 Coverage

The coverage rates of 4,300 km network are presented on the viewpoints of: 1) population and area, and 2) major points.

1) Population and Area-coverage Rates

The characteristics of population- and area-coverage defined in Section 7.5.1, are shown in Table 7.7.

Table 7.8 POPULATION AND AREA COVERAGE RATES — 2010

	0 - 30 min.	0 - 60 min.
Population	54.7 %	72.1 %
Area	32.8 %	53.5 %

As shown in the above table, 72.1% of people in the whole nation will be able to gain access to motorways within 60 minutes by car.

On the other hand, the area-covered within 60 minutes by car is at a lower rate of 53.5%. Figure 7.5 illustrate the boundaries of the area covered within 60 minutes.

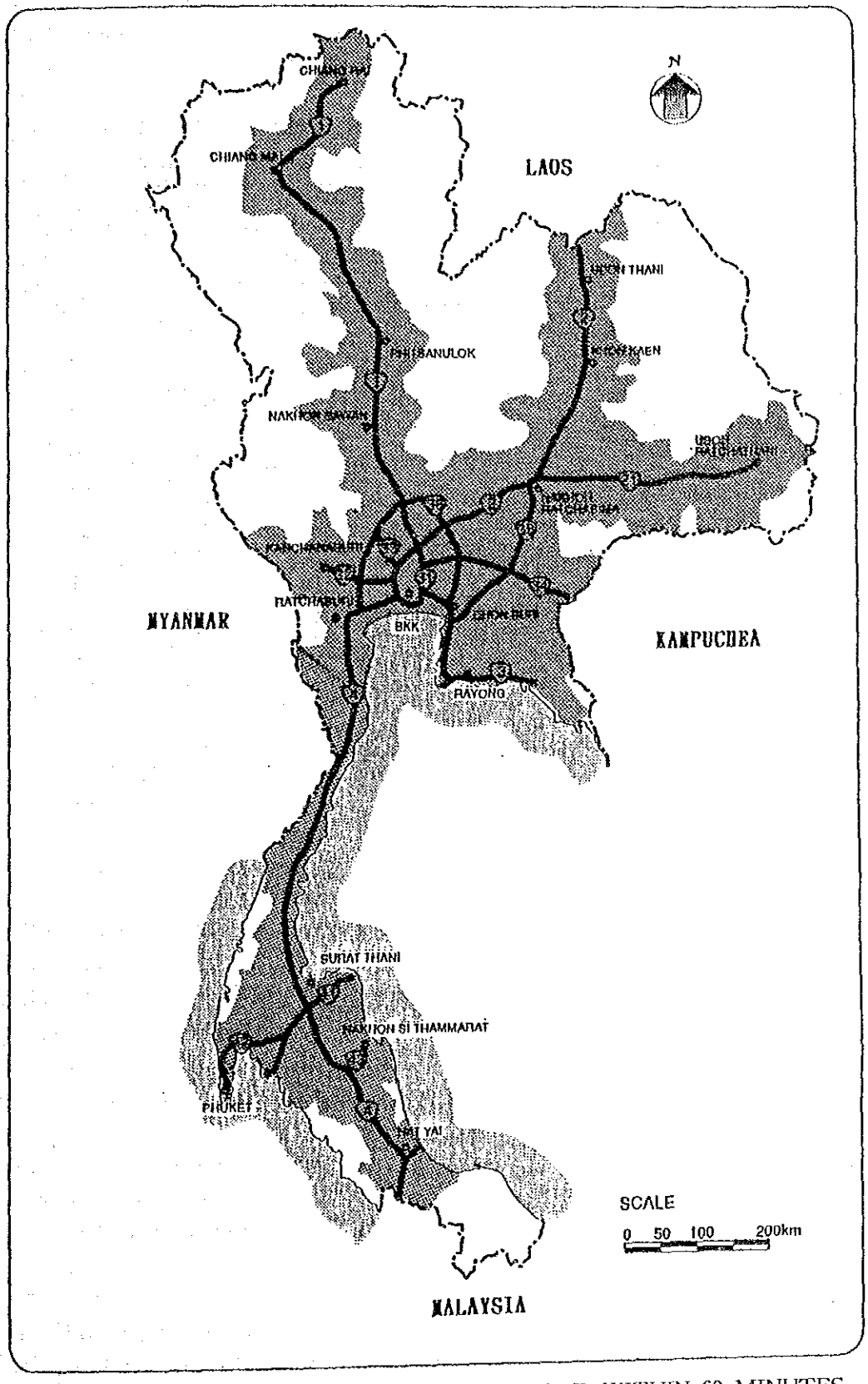


Figure 7.5 BOUNDARIES OF AREA-COVERED WITHIN 60 MINUTES

2) Major Point-coverage

Table 7.8 gives the number of major points of each category which is covered by the 4,300 km network.

Table 7.9 COVERED MAJOR POINTS BY 4,300 KM NETWORKS

Category		Total	4,300 Km Network			
			0-30 min		0-60 min	
		Number	Number	%	Number	%
Designated City	1st	5	5	100.0	5	100.0
	2nd	6	6	100.0	6	100.0
	3rd	13	10(*1)	76.9	10	76.9
Large City	>100,000	8	8	100.0	8	100.0
	> 50,000	10	9(*2)	90.0	9	90.0
	> 30,000	30	22(*3)	73.3	25	83.3
Industrial Area	Nation Plan	5	5	100.0	5	100.0
	Other	36	35(*4)	97.2	35	97.2
Airport	International	5	5	100.0	5	100.0
	Local	20	10(*5)	50.0	11	55.0
Seaport	Deep Seaport	8	8	100.0	8	100.0
	Other Port	12	6(*6)	50.0	7	58.3
Inland-water port		14	14	100.0	14	100.0
Place of Interest		13	10(*7)	76.9	11	84.6
Changwat center		73	48(*8)	65.8	55	75.3
Total		258	201	77.9	214	82.9

*: Uncovered major points.

The network covers 83% of the total major points in number, which are connected to the motorways within 60 minutes by car.

In particular, the network covers 100% of the designated cities of 1st and 2nd priority, large cities with more than 100,000 in population, national plan industrial areas, international airports, deep-seaports and inland-ater ports.

On the other hand, points covered at the rate of less than 60% are local airports which have not the ability to operate jet airplanes, and coastal ports with small capacities located in the Southern Region.

The major points which are not covered by the network in each category, with an access time less than 60 minutes, are as follows:

(1) Designated City (3rd)
- Sakhon Nakhon
- Roi Et
- Pattani

(2) Large City > 50,000 in population
- Yala

(3) Large City > 30,000 in population
- Roi Et
- Kalasin
- Nakhon Phanom
- Pattani
- Narathiwat

(4) Industrial Area (not national plan)
- Phrae

(5) Local Airport
- Phrae
- Nan
- Tak
- Mae Sot
- Mae Hong Son
- Sakhon Nakhon
- Loei
- Pattani
- Narathiwat

(6) Sea Port (not deep)
- Pattani
- Narathiwat
- Trang
- Satun
- Ranong

(7) Interest Place
- Sungai Kolok
- Ko Samui

(8) Changwat Center
- Nan
- Tak
- Mae Hong Son
- Roi Et
- Kalasin
- Yasothon
- Nakhon Phanom
- Sakhon Nakhon
- Mukdahan
- Loei
- Pattani
- Narathiwat
- Satun
- Yala
- Ranong
- Phrae
- Phetchabun

7.7 BASIC FACTORS OF DESIGN AND PLANNING

A motorway should offer high traffic mobility service by providing the following characteristics:

- to control access
- to handle heavy traffic volumes
- to provide safety, speedy and comfortable driving conditions.

The basic design standards to satisfy the above requirements which include the road classification, design speed, cross section, radius and grade, etc., are proposed. Their details are presented in Appendix 7.6 Also, basic concepts of planning the facilities, such as interchanges, rest facilities and bus stops, are proposed and supplemental explanations are described in Appendix 7.7

7.7.1 Basic Factors of Design

1) Motorway Classification

Motorway classification system to be adopted for motorway design is defined in Table 7.10.

Table 7.10 MOTORWAY CLASSIFICATION

Class	Design Speed (Km/h)	Design Traffic Volume (Veh/day)		
		Over 24,000	24,000-16,000	16,000-8,000
M-1	120 - 100	Flat and Hilly	Flat	
M-2	100 - 80	Mountainous	Hilly and Mountainous	Flat and Mountainous

A motorway classification system is necessary to adopt uniform design standards so as to maintain economical project cost as well as safety, comfort and continuity in the different conditions of surrounding terrain.

2) Design Unit

A design unit is a section classified by the system in Table 7.10, and is defined in the following manner:

a. A road section where its geographical and topographical conditions are homogeneous can be considered as one design unit.

b. A design unit should have enough length so that all motorcars can run safely and comfortably.

c. The connecting point between two different design units is planned at where the geographical, topographical or traffic conditions vary, or at main connecting points such as junctions.

d. Two successive design units having more than 20 Km/h difference in design speeds can not be directly connected, except at interchanges, junctions or toll barriers.

The practical length of one design unit is usually determined so as to keep constant driving speed within that unit. Table 7.11 gives the recommendable minimum length of one design unit.

Table 7.11 MINIMUM LENGTH OF ONE DESIGN UNIT

	Standard
Minimum length of one design unit	20 - 30 km

3) Design Speed

Standard and allowable design speeds are defined in Table 7.12.

Table 7.12 DESIGN SPEED

Class	Design Speed (Km/h)	
	Standard	Allowable
M-1	120	100
M-2	100	80

The allowable design speed is adopted only in special cases restricted by the topographical conditions.

Design speed is the maximum safe speed that can be maintained over a specific section of the motorway. Design features of the motorway are governed by the design speed which should be logical in respect to the topography.

4) Cross Section

Width of cross section elements of motorways are defined in Table 7.13.

Table 7.13 WIDTH OF CROSS SECTION ELEMENTS

Class	Lane Width (m) 4-Lane		6-Lane			Shoulder Width (m)		Median (m)
	Left	Right	Left	Middle	Right	Left	Right	
M-1	3.50	3.75	3.50	3.75	3.50	3.00	1.50	variable
M-2	3.50	3.50	3.50	3.75	3.50	3.00	1.50	@ 10.0

A cross section of the motorway consisting of traffic lanes, shoulders and median, is illustrated in Figure 7.6.

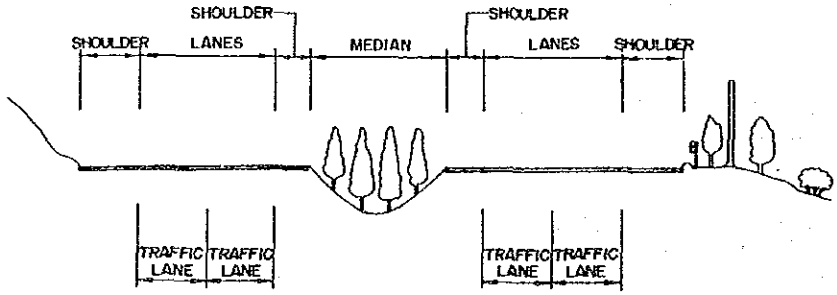


Figure 7.6 CROSS SECTION ELEMENTS

5) Radius and Grade

Minimum radius to be adopted to the center line of curved sections is defined in Table 7.14 according to the design speed. Standard values of minimum radius in this table are adopted only in the special cases restricted by the topographical conditions.

Table 7.14 MINIMUM RADIUS

Design Speed (Km/h)	Desirable (m)	Standard (m)
120	1,000	710
100	700	460
80	400	280

Maximum grades to be adopted for sloped sections are defined in Table 7.15 according to the design speed. Maximum values in this table are adopted only in the special cases restricted by the topographical conditions.

Table 7.15 MAXIMUM GRADE

Design Speed (Km/h)	Standard (degree)	For Special Cases Grade (degree)	slope length (m)
120	2	5	400
100	3	6	400
80	4	7	400

Radius and grade, in general, should be designed through the following principal considerations:

- safety and comfort while driving
- drivers sight distance
- harmony with environment and landscape
- economical construction
- continuity of alignment.

6) Design Standard Traffic Volume and Number of Lanes

Design standard traffic volume per one lane is defined in Table 7.16.

Table 7.16 DESIGN STANDARD TRAFFIC VOLUME

Class	Design standard volume / one lane	
	flat	mountainous
M-1 and M-2	12,000/day	9,000/day

The design standard traffic volume is the basic value required to estimate the number of lanes. The selection of the number of lanes is carried out through a comparison between the following two traffic volumes:

- the traffic volume which is expected to pass on a road (planned traffic volume).
- the traffic volume which can be handled by a road (design standard traffic volume).

7.7.2 Planning of Motorway Facilities

1) Interchanges and Junctions

Interchanges and junctions are defined as follows:

- Junction: is to connect two or more motorways through the ramps having the functions of diverging and merging the traffic flow.

- Interchange: is to connect the motorway and other roads through the ramps having the functions of the entrance and exit to and from the motorway.

The locational planning of interchanges is carried out in the following manner through integrated considerations of traffic, social, environmental conditions, etc.:

a. To be located at or near intersections crossing important trunk roads, i.e. national highways.

b. To be located at areas in the suburbs of cities having more than 30,000 of population, or where a population of 50,000—100,000 will be served by that interchange.

c. To be located at or near intersections crossing roads connected to the important sea ports, air ports, places of interest, transportation facilities and other major points.

d. To be located at intervals whereas on-off traffic volumes handled by one interchange is less than 30,000 veh./day.

e. To be located at intervals of 5 km to 50 km.

2) Rest Facilities

The provision of rest facilities at proper intervals is indispensable for comfortable and safe driving.

Rest facilities are classified into the following two categories:

a. Service Area
To include: Restaurant, Parking Area, Public Lavatory, Gas Station, Free Rest Place, Route Information, Repair Shop, Garden, Patrol and Rescue Stations.

b. Parking Area
To include: Vending Machines, Parking Area, Public Lavatory, Garden.

They are located in appropriate combinations at intervals of 50 km to 100 km for service areas and 15 km to 20 km for parking areas.

3) Bus stops

Bus stops are installed at interchanges and at intermediate points along the route.

Regular bus service on the motorways can offer a high speed transportation system to the communities along motorways by shortening the traveling time for route buses.

The bus stops on motorways are located at sufficient intervals, so as not to interfere high speed bus operation by requiring too frequent stops and not to unnecessarily disturb the traffic flow in the main lanes by frequent bus entry.

7.8 ROUTING

Table 7.17 lists the control points which are considered in the routing of the 4,300 km proposed motorway network.

Main considerations for routing of each route are described below and the results are illustrated in Appendix 7.8 as route planning charts.

1) TM-1 (Bang Pa-In — Chiang Rai, L = 755.6 km)

TM-1 is the arterial route connecting Bangkok to the northern region. It passes through 5 designated cities: Chiang Mai, Nakhon Sawan, Phitsanulok, Lampang and Chiang Rai.

Table 7.17 CONTROL POINTS

Category	Control Point
1. Natural conditions i. Topographical conditions	- Mountain range - Valley - Wide river - Large lake and marsh
ii. Geographical conditions	- Large soft ground area
2. Traffic facilities	- Rough location of interchange
3. Environmental conditions i. Life-environmental conditions	- City, town and industrial area - Wat and other religious facility - School, and other social facility - Power transmission line - Irrigation facility
ii. Natural-environmental conditions	- National park and other restricted area
4. Public works and public facilities	- City plan and land use plan - Royal irrigation area - Road, Railway, Port, Airport - Army base - Dam - Mining
5. Cultural properties	- Historic site - Scenic spot

a. Section from Bang Pa - In to Nakhon Sawan is planned along the east side of Rt. 32 to avoid crossing many rivers in the west side although it contains many cities.

b. Section from Nakhon Sawan to Phitsanulok is planned along the east side of Rt. 117 considering convenient access to the motorway from cities located in surrounding area.

c. Phitsanulok interchange is located on Rt. 12 considering an access to Sukhothai, too.

d. Section from Phitsanulok to Lampang is planned to be as short as possible because it locates in a mountainous area with steep topographical features.

Since the section is shortened, Rt. 102 is used as an access road to Uttradit giving up direct access from the motorway.

For this mountainous section, M-2 class design standard (80 km/h, 4-lane) is applied and a tunnel is planned considering natural environment and avoidance of severe alignment.

e. Since the section from Lampang to Chiang Mai passes through a mountainous area, M-2 class design standard is applied and a tunnel is planned, too. The section from Lamphun to Chiang Mai is planned east of the by-pass operated recently.

f. Section from Chiang Mai to Chiang Rai passes through steep mountainous area and comparatively low traffic is forecasted in this section. Therefore, allowable provisions of M-2 class design standard is applied and a tunnel is also planned.

TM - 1		Description
Origin		Bang Pa-In
Destination		Chiang Mai
Length		755.6 km
No. of Passed Changwat		14
Class, Speed, Lanes	M-1, 120, 6	102.5 km
	M-1, 120, 4	269.8 km
	M-1, 100, 4	-
	M-2, 100, 4	164.1 km
	M-2, 80, 4	219.2 km
No. of Junction		2
No. of Interchange		21
No. of Service Area		7
No. of Parking Area		13
Major Structure		9
No. of Crossing N.H., P.R.		1
No. of Crossing Railway		2,900 m
Crossing River		9,100 m
Tunnel		

Note : N.H. ; National Highway
P.R. ; Provincial Highway

2) TM-2 (Bang Pa-In — Nong Khai, L = 535.5 km)

TM-2 is the arterial route to connect Bangkok with the Northern Region, passing through Nakhon Ratchasima, Khon Kaen and Udon Thani and finally reaches Nong Khai which is a border city to Laos.

a. Section between Bang Pa-In and Saraburi is planned to pass northwest of Rt. 2 and to cross Rt. 1 south of Saraburi.

b. Section from Saraburi to Nakhon Ratchasima is planned mainly along the south of Rt. 2. However, section from Lam Ta Khong Dam diverts to the north of Rt. 2 after crossing the route and railway, since there are an airbase, etc., south of Nakhon Ratchasima.

c. Section from Nakhon Ratchasima to Nong Khai is planned along the west of Rt. 2 and railway to be as short as possible.

TM - 2		Description
Origin		Bang Pa-In
Destination		Nong Khai
Length		535.5 km
No. of Passed Changwat		6
Class, Speed, Lanes	M-1, 120, 6	49.3 km
	M-1, 120, 4	188.5 km
	M-1, 100, 4	49.6 km
	M-2, 100, 4	248.1 km
	M-2, 80, 4	-
No. of Junction		4
No. of Interchange		15
No. of Service Area		5
No. of Parking Area		10
Major Structure		
No. of Crossing N.H., P.R.		10
No. of Crossing Railway		2
Crossing River		1,000 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

3) TM-3 (Phra Khanong – Chanthaburi, L = 291.9 km)

TM-3 is planned to support Eastern Seaboard Development Plan and tourism industry in Pattaya. The route passes through Chonburi, Rayong and Chanthaburi.

a. Section from Phra Kanong to Pattaya is in same alignment of Bangkok – Chonburi – Pattaya New Highway which is under design and construction by DOH.

b. Three branch roads from the main line to Laem Chabang area, to Pattaya and to U-Taphao and Sattahip Port are planned applying the design standard of motorway.

c. An interchange is planned at a crossing with Rt. 319 in order to support the development in Map Tha Phut Industrial Complex.

d. Section from Rayong to Rt. 344 is planned to run north of Rt. 3, and section from Rt. 344 to Chanthaburi in the south of Rt. 3 in order to shorten its length.

TM - 3		Description
Origin		Phra Khanong
Destination		Chanthaburi
Length		291.9 km
No. of Passed Changwat		5
Class, Speed, Lanes	M-1, 120, 6	111.7 km
	M-1, 120, 4	93.6 km
	M-1, 100, 4	-
	M-2, 100, 4	86.6 km
	M-2, 80, 4	-
No. of Junction		6
No. of Interchange		13
No. of Service Area		2
No. of Parking Area		3
Major Structure		
No. of Crossing N.H., P.R.		15
No. of Crossing Railway		3
Crossing River		1,000 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

4) TM-4 (Phasi Charoen — Malaysian Border, L = 951.4 km)

TM-4 is an arterial motorway to connect Bangkok with the Southern Region. It starts at Phasi Charoen and runs through Ratchaburi Hua Hin, Prachuap Khiri Khan, Chumphon, Surat Thani, (Phetchaburi) and Hat Yai (Song Khla), and finally reaches to Malaysia border.

a. Section from Phasi Charoen to Rachaburi is planned along the right side of Rt. 35 to avoid soft ground area.

b. Section from Rachaburi to Prachuap Khiri Khan is also planned in the right side of Rt. 4.

c. Section from Prachuap Khiri Khan to Chumphon is planned in the area between Rt. 4 and railway.

d. Section from Chumphon to Surat Thani is planned mainly west of Rt. 41. However, it is shifted to the east side of TM-41 near Surat Thani City to avoid an air military base located in its vicinity.

e. Section from Surat Thani to TM-41 crosses Rt. 41 twice to avoid a swamp and mountainous area.

f. Interchanges on the section from Prachuap Khiri Khan to Surat Thani are planned at a rather long interval, approximately 60 km, because there are no particular cities.

g. Section from TM-41 to Thung Song is planned along railway line considering location of cities and topographical conditions. A tunnel is planned near Thung Song to shorten route length in the mountainous area.

h. Section from Phatthalung to Hat Yai is planned along the railway to shorten the route length.

i. Section from Hat Yai to Malaysia border is planned in the west of Rt. 4 considering the locations of railway and power-transmission line. Branch route from Hat Yai to Song Khla, 28 km, is planned north of Rt. 407.

TM - 4		Description
Origin		Phasi Charoen
Destination		Malaysia Border
Length		951.4 km
No. of Passed Changwat		10
Class, Speed, Lanes	M-1, 120, 6	72.1 km
	M-1, 120, 4	308.5 km
	M-1, 100, 4	70.8 km
	M-2, 100, 4	-
	M-2, 80, 4	-
No. of Junction		5
No. of Interchange		28
No. of Service Area		9
No. of Parking Area		13
Major Structure		
No. of Crossing N.H., P.R.		15
No. of Crossing Railway		3
Crossing River		1,700 m
Tunnel		600

Note : N.H. ; National Highway
P.R. ; Provincial Highway

5) TM-21 (Nakhon Ratchasima — Ubon Ratchathani, L = 301.1 km)

TM-21 is planned to contribute to the development of the south part of Northeastern Region. The route separates from TM-2 in Nakhon Ratchasima and passes through 3 Changwat centers; Buri Ram, Surin and Si Sa Ket, and reaches to Ubon Ratchathani.

a. A junction from TM-2 is located at the north of Nakhon Rachashima, considering locations of rivers, national highways, railway and an interchange.

b. Section from Nakhon Ratchasima to Si Sa Ket is planned north of Rt. 226 and a railway.

c. Section from Si Sa Ket to Ubon Rachathani is shifted in the south of Rt. 226 to avoid Mun River and its flooded areas.

d. A interchange in Ubon Ratchathani is planned on a bypass in the south of Rt. 226.

TM - 21		Description
Origin		Nakhon Ratchasima
Destination		Ubon Ratchathani
Length		301.1 km
No. of Passed Changwat		5
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	110.8 km
	M-1, 100, 4	-
	M-2, 100, 4	190.3 km
	M-2, 80, 4	-
No. of Junction		1
No. of Interchange		8
No. of Service Area		3
No. of Parking Area		3
Major Structure		
No. of Crossing N.H., P.R.		5
No. of Crossing Railway		1
Crossing River		550 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

6) TM-31 (Bang Pa-In — Bang Pa-In, L = 166.7 km)

TM-31 is planned to cope with huge traffic volume forecasted on this Outer Bangkok Ring Road (OBRR) in near the future, and also to play the role as a ring motorway by connecting with proposed radial motorways from Bangkok such as TM-1, TM-2, TM-3 and TM-4.

a. TM-31 is planned within the right-of-way of OBRR.

b. The whole section is planned as a 6-lane motorway.

c. Junctions are planned at all connecting points with TM-1, TM-2, TM-3, TM-4, TM-32, TM-33 and TM-34.

TM - 31		Description
Origin		Bang Pa-In
Destination		Bang Pa-In
Length		167.7 km
No. of Passed Changwat		6
Class, Speed, Lanes	M-1, 120, 6	167.7 km
	M-1, 120, 4	-
	M-1, 100, 4	-
	M-2, 100, 4	-
	M-2, 80, 4	-
No. of Junction		6
No. of Interchange		14
No. of Service Area		-
No. of Parking Area		1
Major Structure		
No. of Crossing N.H., P.R.		5
No. of Crossing Railway		4
Crossing River		1,850 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

7) TM-32 (Bang Yai — Kanchanaburi, L = 100.0 km)

TM-32 is mainly planned to cope with the increased traffic due to the urbanization of Nonthaburi and Nakhon Pathom, and the increase of tourists to Kanchanaburi.

a. A connection point with OBRR is planned in the north of Rt. 338 and a straight alignment is applied to the section till Bang Phong.

b. In the section between Bang Yai and Nakhon Pathom, with 53 km in total length, no interchange is planned so that traffic is completely separated on the same corridor from that of Rt. 4 and Rt. 338.

c. Since expected traffic volume on the above section is more than 60,000 in ADT even with no interchange, a 6-lane motorway is applied.

d. Section from Nakhon Pathom and Kanchanaburi is planned along the north side of Rt. 323 and a railway considering topographical conditions and locations of villages.

TM - 32		Description
Origin		Bang Yai
Destination		Kanchanaburi
Length		100.0 km
No. of Passed Changwat		4
Class, Speed, Lanes	M-1, 120, 6	53.0 km
	M-1, 120, 4	22.3 km
	M-1, 100, 4	-
	M-2, 100, 4	24.7 km
	M-2, 80, 4	-
No. of Junction		2
No. of Interchange		3
No. of Service Area		1
No. of Parking Area		1
Major Structure		
No. of Crossing N.H., P.R.		4
No. of Crossing Railway		1
Crossing River		200 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

8) TM-33 (Bang Bua Thong — Suphan Buri, L = 62.0 km)

The area enclosed between OBRR and TM-36 (outer belt motorway which is described in 11), is divided in appropriate extent by proposed radial motorways from Bangkok such as TM-1, TM-2, TM-3, TM-4, TM-32 and TM-34.

In the area surrounding Suphan Buri, however, such radial motorways are not located. Therefore, TM-33 is planned to form well-balanced motorway network by filling this space.

a. The route is planned parallel to Rt. 340.

b. At the middle part of the route, an interchange is planned to promote development of this area.

TM - 33		Description
Origin		Bang Bua Thong
Destination		Suphan Buri
Length		62.0 km
No. of Passed Changwat		3
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	62.0 km
	M-1, 100, 4	-
	M-2, 100, 4	-
	M-2, 80, 4	-
No. of Junction		2
No. of Interchange		2
No. of Service Area		-
No. of Parking Area		1
Major Structure		
No. of Crossing N.H., P.R.		2
No. of Crossing Railway		-
Crossing River		450 m
Tunnel		-

Note : N.H. ; National Hi nway
P.R. ; Provincial Highway

9) TM-34 (Thanyaburi — Aranya Prathet, L = 211.7 km)

TM-34 is planned so as to connect Bangkok with Kampuchea border by way of Nakhon Nayok and Prachin Buri for contributing to develop the area along the route and promoting international exchange with Kamphuchea.

a. Section from Thanyaburi to Ongkharak is planned in the north area close to Rt. 305 to avoid channels which exist in the south area and to lessen influence on the Royal Irrigation Area.

b. Section from Ongkharak to Prachin Buri is planned south of Nakhon Nayok and north of Prachin Buri, so as to shorten the route length.

c. Section from Prachin Buri to Aranya Prathet is planned in south of Rt. 33 and a railway considering locations of military bases, rivers, topographical conditions, and na tional and provincial highway network.

TM - 34		Description
Origin		Thanyaburi
Destination		Aranya Prathet
Length		211.7 km
No. of Passed Changwat		3
Class, Speed, Lanes	M-1, 120, 6	59.0 km
	M-1, 120, 4	131.0 km
	M-1, 100, 4	-
	M-2, 100, 4	21.7 km
	M-2, 80, 4	-
No. of Junction		3
No. of Interchange		6
No. of Service Area		1
No. of Parking Area		1
Major Structure		
No. of Crossing N.H., P.R.		2
No. of Crossing Railway		1
Crossing River		950 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

10) TM-35 (Chon Buri — Nakhon Ratchasima, L = 239.1 km)

TM-35 is planned so as to directly connect Eastern Seaboard Industrial Area to the Northeastern Region. This route plays an important role to support Eastern Seaboard Development Plan and resources development in the Northeastern Region. Also this route will have a function as a detour of TM-2 and Rt. 2.

a. Section from the origin located on TM-3 east of Chon Buri to Kabin Buri is planned south of Rt. 304.

b. Section from Kabin Buri to Nakhon Ratchasima passes through a mountainous area, but, no tunnel is required. Since this area is a national park, examination for environmental conservation is necessary.

c. A junction with TM-2 is planned in the west area of Nakhon Ratchasima.

TM - 35		Description
Origin		Chon Buri
Destination		Nakhon Ratchasima
Length		239.1 km
No. of Passed Changwat		4
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	16.2 km
	M-1, 100, 4	-
	M-2, 100, 4	172.9 km
	M-2, 80, 4	50.0 km
No. of Junction		3
No. of Interchange		3
No. of Service Area		1
No. of Parking Area		3
Major Structure		
No. of Crossing N.H., P.R.		9
No. of Crossing Railway		2
Crossing River		200 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

11) TM-36 (Wat Phleng — Bang Pakong, L = 365.8 km)

TM-36 is planned as an outer belt motorway in the area of about 50—100 km far from Bangkok.

In this area, there are many medium size cities with high development potential. This route not only contributes to develop these cities but also to decentralize socio-economic activities out of Bangkok.

a. Section from Ratchaburi to Suphanburi is planned along the east side of the railway.

b. Section from Sing Buri to Ang Thong is planned considering the crossing points at Chao Praya River, Rt. 311 and Rt. 32.

c. At Lop Buri and Saraburi, the route is planned to the north of them.

d. Section from Nakhon Nayok to Chon Buri is planned as to avoid the crossing with Bang Pakhon River.

TM - 36		Description
Origin		Wat Phleng
Destination		Bang Pakong
Length		365.8 km
No. of Passed Changwat		8
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	207.8 km
	M-1, 100, 4	-
	M-2, 100, 4	158.0 km
	M-2, 80, 4	-
No. of Junction		7
No. of Interchange		8
No. of Service Area		3
No. of Parking Area		3
Major Structure		
No. of Crossing N.H., P.R.		22
No. of Crossing Railway		4
Crossing River		3,100 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

12) TM-41 (Krabi — Khanom, L = 190.7 km)

TM-41 is a landbridge motorway in the Southern Seaboard Development Plan.

a. Route is planned so as to run toward the north direction parallel with Rt. 4037.

b. A distribution center planned in the Southern Seaboard Development Plan is located near Ban Na San considering the topographical and land use conditions.

c. The section from the distribution center to Khanom is planned selecting the shortest route through examining topographical conditions and location of villages.

TM - 41		Description
Origin		Krabi
Destination		Khanom
Length		190.7 km
No. of Passed Changwat		3
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	190.7 km
	M-1, 100, 4	-
	M-2, 100, 4	-
	M-2, 80, 4	-
No. of Junction		2
No. of Interchange		5
No. of Service Area		2
No. of Parking Area		0
Major Structure		
No. of Crossing N.H., P.R.		5
No. of Crossing Railway		1
Crossing River		250 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

13) TM-42 (Phra Saeng — Phuket, L = 136.0 km)

TM-42 is planned to connect TM-41 with Phuket which is a very famous international resort.

a. Section inside Changwat/Phangnga is located in a mountainous area, therefore, the route is planned along the coast the shortest route. However, detailed study on environmental aspects will be required.

b. The bridge connecting with Phuket Island is planned at the east of the existing bridge.

c. At Phuket, location of an interchange is determined considerating the access to the airport, and the route terminates at the bypass of Rt. 402.

TM - 42		Description
Origin		Phra Saeng
Destination		Phuket
Length		136.0 km
No. of Passed Changwat		4
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	-
	M-1, 100, 4	-
	M-2, 100, 4	136.0 km
	M-2, 80, 4	-
No. of Junction		1
No. of Interchange		5
No. of Service Area		1
No. of Parking Area		2
Major Structure		
No. of Crossing N.H., P.R.		5
No. of Crossing Railway		-
Crossing River		1,250 m
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

14) TM-43 (Ron Phibun — Nakhon Si Thammarat, L = 36.9 km)

TM-43 is a branch motorway to connect TM-4 with Nakhon Si Thammarat which is a designated city in the National Development Plan.

a. Location of junction with TM-4 is planned considering the distance between a planned tunnel and railway crossing with TM-4.

b. The end point in Nakhon Si Thammarat is determined in due consideration of the land use and urban street network of the city.

c. The shortest route to link above two points is planned west of Rt. 403.

TM - 43		Description
Origin		Ron Phibun
Destination		Nakhon Si Thammarat
Length		36.9 km
No. of Passed Changwat		1
Class, Speed, Lanes	M-1, 120, 6	-
	M-1, 120, 4	-
	M-1, 100, 4	-
	M-2, 100, 4	36.9 km
	M-2, 80, 4	-
No. of Junction		1
No. of Interchange		1
No. of Service Area		0
No. of Parking Area		0
Major Structure		
No. of Crossing N.H., P.R.		2
No. of Crossing Railway		1
Crossing River		-
Tunnel		-

Note : N.H. ; National Highway
P.R. ; Provincial Highway

7.9 ROUTES INSIDE OBRR TO CONNECT WITH PROPOSED MOTORWAYS

For effective utilization of proposed motorways outside OBRR, optimum connection with main roads inside OBRR is indispensable.

The study is limited to the area outside OBRR. Therefore, only routes to directly connected with main roads inside OBRR close to the end points of proposed motorways are roughly examined.

The main roads include existing and planning highways under DOH and BMR, and expressways under ETA.

As a result, 5 routes are temporarily selected as the routes to be newly constructed for connecting with proposed motorways. They are shown in Table 7.18 and Figure 7.7. However, for final determination of these routes, more detailed study in cooperation with ETA, BMA and other concerned agencies is required.

Table 7.18 CONNECTED ROUTES INSIDE OBRR

No.	Origin	Destination
1	Thanyaburi (TM-34)	Dan Muang
2	Phra Khanong (TM-3)	Ban Kapi
3	Phasi Charoen (TM-4)	Dao Kanong
4	Bang Yai (TM-32)	Nonthaburi
5	Bang Bua Thong (TM-33)	Nonthaburi

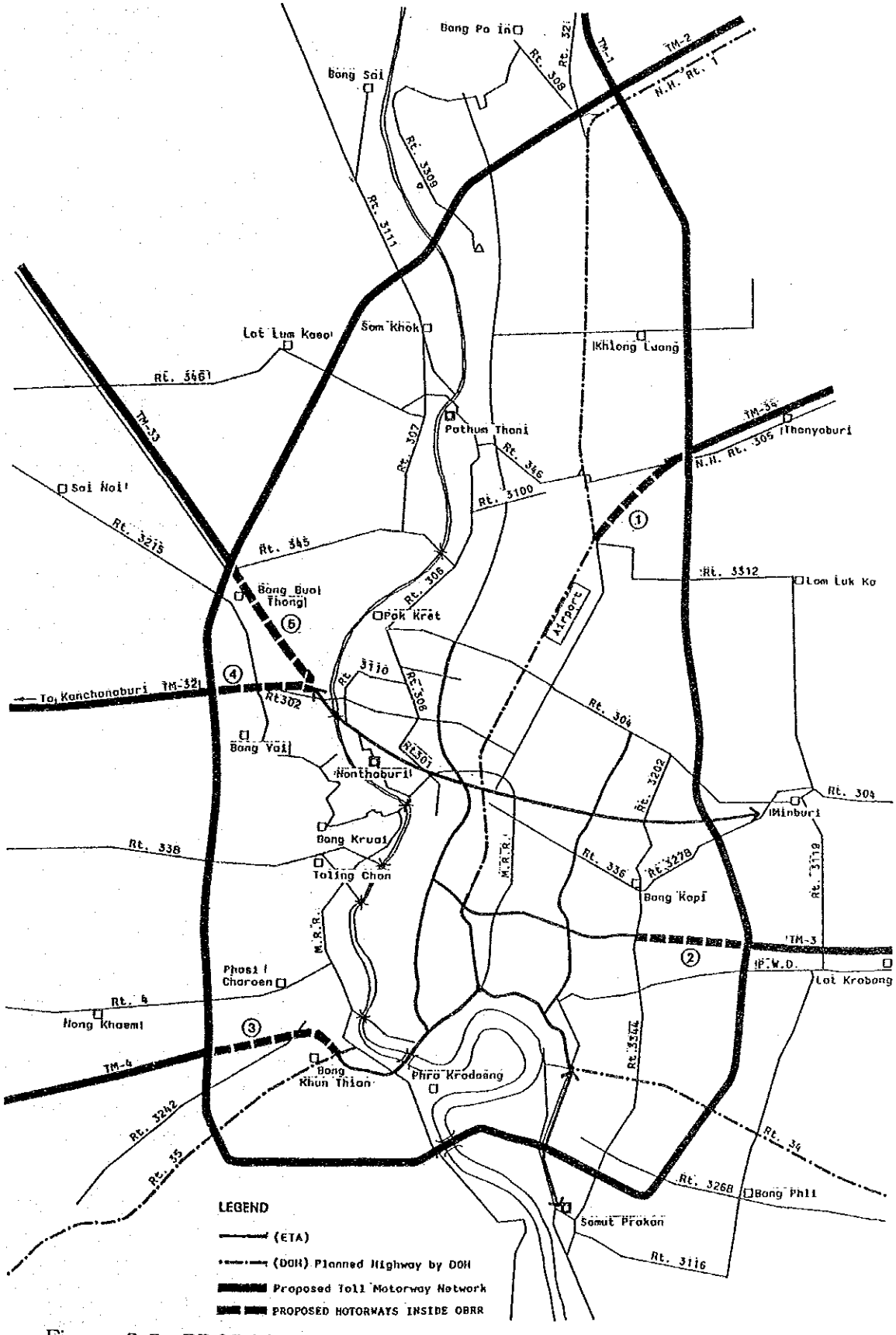


Figure 7.7 PROPOSED URBAN MOTORWAY NETWORK INSIDE OBRR

CHAPTER EIGHT

ENVIRONMENTAL CONSIDERATIONS

CHAPTER 8

ENVIRONMENTAL CONSIDERATIONS

For the motorways, some environmental problems may occurred, which are almost the same as for ordinary roads. However, it is confident that the newly constructed motorways have better environmental conditions than ordinary roads, since environmental considerations are taken in the designing and planning stages of motorways and their facilities. In addition, the traffic volumes diverted from ordinary roads to motorways have a favorable influence upon the environmental conditions in surrounding areas of both roads and motorways.

Some measures for the environmental conservation, such as an environmental impact assessment, must be conducted at the beginning stage of the motorway planning in order to preserve the environment and to fulfill the public demands who expect the motorways to provide harmony with environment.

This chapter includes first the outline of motorway environmental problems, impact assessment, protection measures and the improvement of motorway environment through introducing the practice and examples in Japan. Next, main environmental considerations for each route in the proposed network are generally investigated taking into considerations that further detailed studies are required in later stages.

8.1 OUTLINE OF MOTORWAY ENVIRONMENTAL PROBLEMS

The environmental problems of motorways can be generally categorized into 3 groups depending on their causes, i.e. problems caused by traffic, problems caused by construction activities and problems caused by constructed structures.

The first group includes the damages of life and natural-environment, such as air pollution, noise, vibration, etc. The second includes the air and water pollution, noise, vibration, etc., which can be almost controlled by the improvement of the construction methods and/or machines. And the third includes

the settlement of surrounding grounds, the drying up of underground water, the sunshine interruption, the radio wave jamming, etc., which, most likely in Japan, have been dealt with as individual issues and measured by the compensation for loss. Some of these environmental problems are as follows:

1) Air Pollution

With the rapid development of motorization, air pollution caused by automotive traffic has become a serious social problem in areas adjoining motorways and in urban communities with heavy traffic.

Vehicle exhaust gases contain water vapor, carbon dioxide and nitrogen oxides as principal components, along with carbon monoxide, hydrocarbons and particles produced by incomplete combustion.

In Japan, the vehicle exhaust gas restrictions prescribed under the Air Pollution Control Law place volumetric limitations on carbon monoxide, hydrocarbons, nitrogen oxides and particles. Lead compounds, one of the principal pollution sources, have already disappeared from the pollutant list in Japan through the use of lead-free gasoline.

2) Water Pollution

Source substances of water pollution include road surface drainage water, waste water from rest facilities, and tunnel washing water.

Because the drain water from motorways which pass mountainous areas and from areas with poor sewer systems is inevitably discharged into the rivers, the drain water is treated before discharge to prevent water pollution.

3) Noise

The problem of noise is a particularly important factor in the environmental pollution caused by traffic and is one of the principal causes of the movements by residents against road construction and repair. The noise in urban areas includes not only traffic noise but also construction noise and factory and workshop noise, and the latter noises are greater than the

traffic noise. The traffic noise, however, is constant and wide spread and therefore presents more serious problems.

4) Vibration

Although some surface roads through urban districts produce vibration problems, motorways with a reasonable slope area for a frontage road between the roadway and the residential zone produce very little vibration which rarely becomes a problem.

5) Obstructed Sunlight and TV Reception

The obstruction of sunlight and TV reception is another environmental problem. Such obstruction is produced by the construction of elevated motorways, embanked roads and in many cases motorways in urban areas.

6) Natural Environment

The effects of road construction and automobile traffic on the natural environment are considered from the aspects of harmony of the development and recovery capability of the natural surroundings.

Destruction of the natural environment occurs for plants through the destruction of the forest by changes in the supply of underground water, direct sunlight and ventilation and the introduction of dust and exhaust gases emitted from vehicles, and for animals in extinction, degeneration, movement and dispersion caused by the division of their territories.

7) Other

Infrasound found in the vicinity of bridges has many causes in ordinary inhabited areas and occurs in various places. However, infrasound at levels high enough to adversely affect daily life rarely occurs.

8.2 ENVIRONMENTAL IMPACT ASSESSMENT AND FORECAST

8.2.1 Environmental Impact Assessment

In recent years, most countries take into account the reservation of the roadside living environment and natural environment as well as the harmony with local scenery, everywhen they plan, construct and manage their roads and motorways. Especially in planning stage, they consider the environmental phenomena as much as possible, and evaluate the probable impacts to the roadside environment while the road will be constructed and in operation. After several trials of the environmental impact assessment, the most suitable route and structural design including construction method are selected for road project to be implemented

The assessment method is one in which the environmental impact is measured quantitatively to the extent possible with qualitative report for impacts which are difficult to be measured quantitatively. The procedures are as shown in Figure 8.1, and the environmental phenomena to be assessed are as follows.

1) Environmental phenomena which affect human health and living environment

   a. Air pollution
   b. Water pollution
   c. Noise
   d. Vibration
   e. Ground subsidence

2) Environmental phenomena which affect the natural environment

   a. Configuration of ground and geological features
   b. Plants
   c. Animals

3) Environmental phenomena which affect the natural landscape

Environmental assessment is also applied as necessary to historic spots, beauty spots, natural monuments, traditional architecture and historic landscapes.

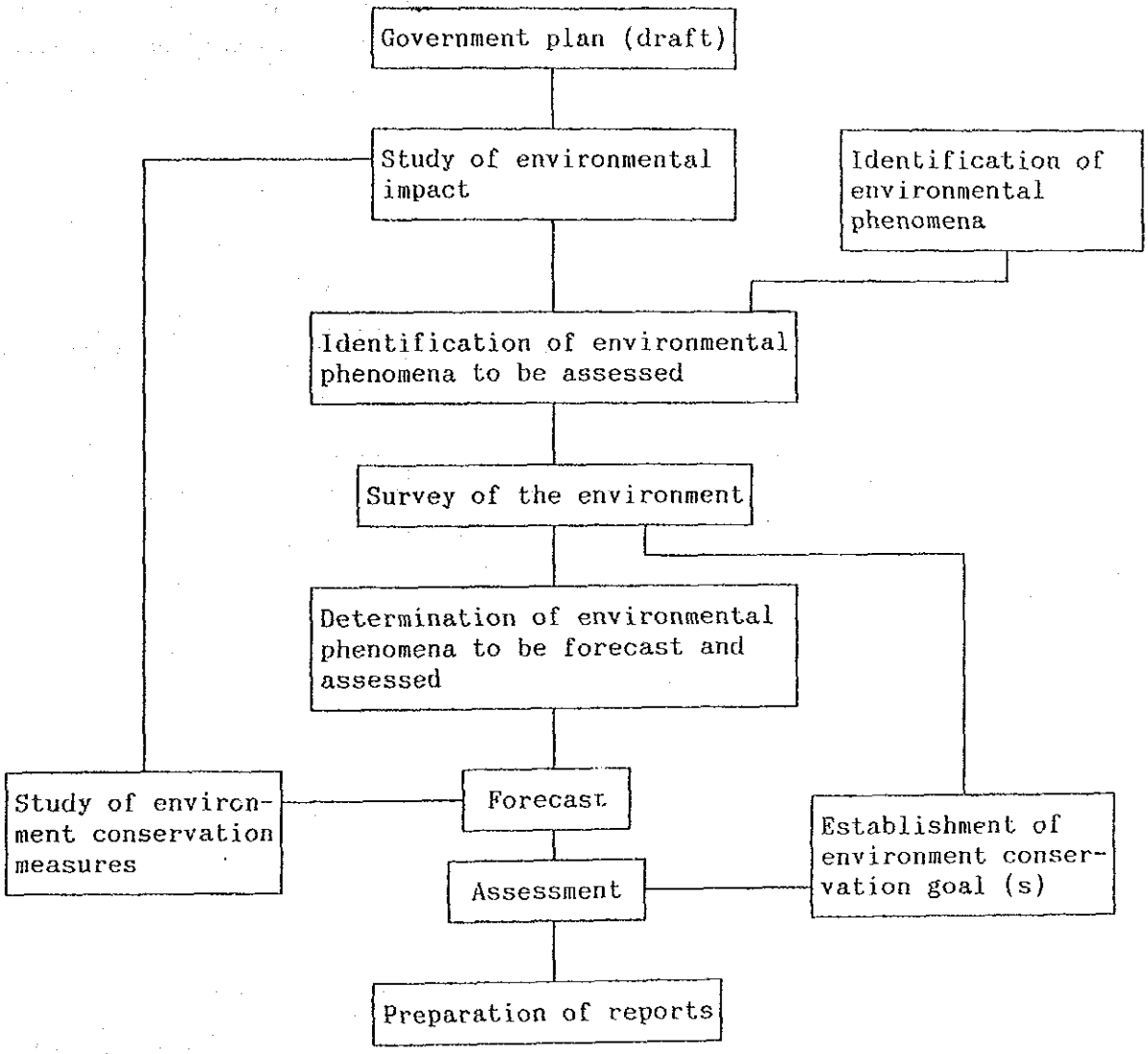


Figure 8.1 ENVIRONMENTAL IMPACT ASSESSMENT PROCEDURE

8.2.2 Forecasting Methodology

As shown Figure 8.1, forecast of environmental related values such as dB for noise and vibration, subsidence, etc., is required for environmental impact assessment. Forecast procedures are briefly explained in the following sections as practical examples.

1) Air Quality

Quantity of Nitrogen Dioxide (NO_2), as the main factor for air quality, is estimated through the procedure shown in Figure 8.2.

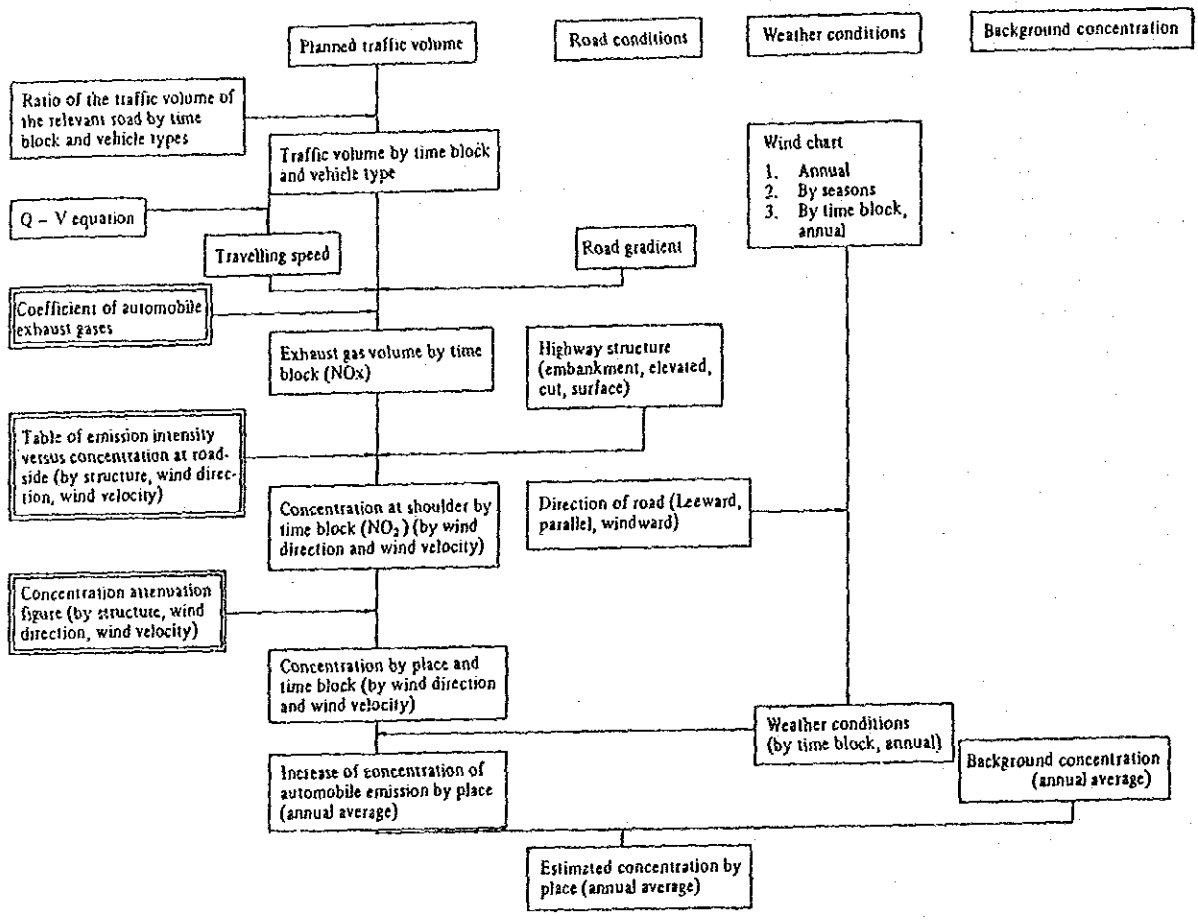


Figure 8.2 NITROGEN DIOXIDE (NO_2) CALCULATION PROCEDURE

2) Water Quality

The forecasting of water quality is made in terms of BOD in discharged water. The forecasting procedure is as shown in the flow chart in Figure 8.3.

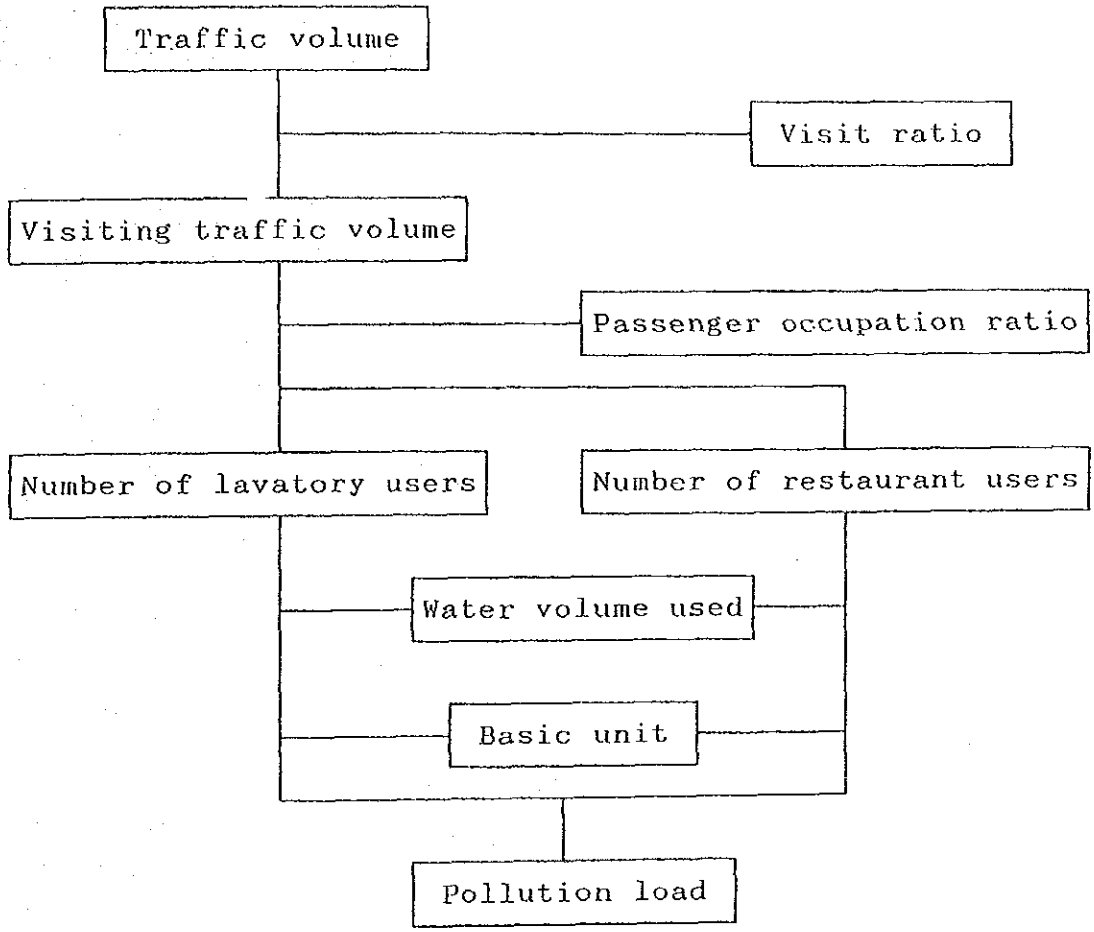


Figure 8.3 WATER QUALITY FORECASTING PROCEDURE

3) Noise

A median value of noise magnitude is used in the evaluation of the road traffic noise. An outline of the forecast equation to calculate the median value is as described below.

Calculation of an estimated median value is based on the assumption that vehicles, each considered as an omni-directional sound source with the same acoustic energy, are traveling along an indefinite straight road at an even spacing and an equal speed.

a. Scope of application

The equation basically applies to calculation of median values of traffic noise at points within 80m from the shoulder edge of a road where vehicles are traveling steadily at speeds between 30 and 100 km/h.

b. Basic forecasting equation

The following is the basic equation to calculate median value of traffic noise.

$$L_{50} = Lw - 8 - 20 \log_{10} l + 10 \log_{10} \left(\pi \frac{l}{d} \tanh 2\pi \frac{l}{d}\right) + ad + ai$$

$$Lw = 87 + 0.2\ v + 10 \log_{10} (a_1 + 10 a_2)$$

Where,

L_{50} : Median value of road traffic noise [dB(A)].
Lw : Average A-corrected sound pressure level [dB(A)] of an automobile, depends on the average speed and composition of vehicle types.
l : Distance between the sound source and the measuring point (m).
d : Average headway (m), d = 1,000 v/N.
N : Traffic volume (Number of vehicles/hour).
v : Average traveling speed (km/h).
ad : Correction factor for diffraction [dB(A)], used to correct the diffraction attenuation when an obstacle exists on a line connecting the sound source and the measuring point.
ai : Correction factor for various factors [dB(A)], used to make correction for the difference between the calculated value and actual measurements for highway structure, height of the sound receiving point and distance.
a_1 : Ratio of small vehicles when the traffic is classified into two categories.
a_2 : Ratio of large vehicles when the traffic is classified into two categories.

$$a_1 + a_2 = 1.0$$

4) Road Traffic Vibration

For flat roads and embanked roads, following equation is used.

$$L_{10} = a \text{ long } (\log Q^*) + b + \alpha l$$

Where,

L_{10} : Estimated value (dB) of the supreme value of 80% range of vibration level.

a, b: Values to be determined by the number of lanes and speed.

Q* : Equivalent traffic volume per one lane during 500 sec-

$$Q^* = \frac{500}{3600} \cdot \frac{1}{M} \cdot (Q_1 + 12Q_2)$$

Q_1 : Hourly traffic volume of small vehicles (vehicles/hour).

Q_2 : Hourly traffic volume of large vehicles (vehicles/hour).

M : Number of total lanes in both directions.

αl : Distance attenuation value

5) Land Subsidence

When an embankment is constructed on soft ground, the weight of the embankment causes compaction subsidence of the foundation resulting in land subsidence. Such land subsidence accordingly affects the paddy fields and houses in the vicinity. Possible land subsidence due to an embankment can be forecasted using actual measurement data of similar conditions or records of past construction. The value of subsidence at the toe of the slope of embankment is generally estimated at 20 percent of the center of the embankment.

Value of subsidence S = Si + Sc + Ss

Where,

Si : Immediate subsidence

Sc : Compaction subsidence

Ss : Long term subsidence

6) Natural Environment

Natural environment is classified into such environmental elements as topography and geology, vegetation and wildlife.

a. Topography and Geology

Surveys of topography and geology are conducted, and the results are collected into a topographical map and subsurface

geological map. The possibility of land shape changes is then forecasted for important areas containing historic spots, beauty spots and natural monuments.

b. Vegetation and Wildlife

Surveys are conducted of habitat conditions, habitat environment, distribution, number and ecology of rare kinds of wildlife, and conditions of vegetation, their communities, etc. Possible influence in the wildlife and vegetation is then forecasted, mainly for scientifically important items, and these appear in the major wildlife and vegetation map. Places for which forecasts will be made and forecasting methods are determined as necessary, using the recommendations of experienced scholars.

7) Natural Landscape

Surveys are conducted on elements of landscape, views from major landscape spots and actual condition of recreation zones. Forecasting is then carried out for the possible influences on the landscape and the possible size of impact on the elements of landscape, for areas where the planned facilities will be noticeable and zones which will be affected by the construction works.

8.3 ENVIRONMENTAL PROTECTION MEASURES

8.3.1 General

Measures for vehicles, major sources of environmental pollution, and improvement of the vehicle structure are very important and effective in the environment conservation of roadside areas. Because the major environmental pollution elements are noise, air pollution and vibration, significant reduction in engine and exhaust noise, better tires and engines with fewer pollutants in the exhaust will remarkably improve the environmental conditions of roadside areas. In this regard technical

development work is in progress to respond to the requirements of the emission and noise regulations. The results of the technological improvements are found in many areas. However, improvement of the environmental condition through the technological improvement of the vehicles is effective only to a limited extent; therefore, comprehensive measures should be taken. These include highway planning, improved highway structures, appropriate traffic control, optimum use of the roadside land and urban renewal plans. Environmental protection measures possible for road administrators are also limited to certain areas and may be classified as follows.

1) Measures incorporated in highway planning
2) Measures embodied in highway structure
3) Measures taken for roadside area and vicinity
4) Others (maintenance and administration)

8.3.2 Environmental Protection Goals

Environmental protection measures should be measured against the targeted environmental quality levels established for the various environmental components.

1) Air Quality

Many prefectural bodies where air quality is a serious problem have established pollution prevention plans. Therefore, the environmental protection target for highways routed through those areas must accord with those plans. National environmental quality standards are used for other areas.

2) Noise

Environmental quality standards approved in Japan by Cabinet Decision of May 25, 1971, as presented in Table 8.1 are used.

3) Road Traffic Vibration

Permissible limits of road traffic vibration, presented in Table 8.2 are used.

Table 8.1 ENVIRONMENTAL QUALITY STANDARDS FOR NOISE

Category of area		Time blocks			Remarks
		Daytime	Morning and evening	Nighttime	
AA		Not more than 45 dB (A)	Not more than 40 dB (A)	Not more than 35 dB (A)	(Pertinent area) The area conforming to the divisions designated by the prefectural governors in Paragraph 2 of the "Government ordinance authorizing the designation of the locations and water areas relating to the environmental quality standards." (Attainment period) For areas facing roads the required standards shall be attained within five years following the establishment of the standards. For areas facing trunk roads with heavy traffic, when attainment within five years is very difficult, an effort shall be made to reach the goal as soon as possible after the five years.
A		Not more than 50 dB (A)	Not more than 45 dB (A)	Not more than 40 dB (A)	
Special standards for "areas facing roads"	Two lanes	Not more than 55 dB (A)	Not more than 50 dB (A)	Not more than 45 dB (A)	
	More than two lanes	Not more than 60 dB (A)	Not more than 55 dB (A)	Not more than 50 dB (A)	
B		Not more than 60 dB (A)	Not more than 55 dB (A)	Not more than 50 dB (A)	
Special standards for "areas facing roads"	Two lanes	Not more than 65 dB (A)	Not more than 60 dB (A)	Not more than 55 dB (A)	
	More than two lanes	Not more than 65 dB (A)	Not more than 65 dB (A)	Not more than 60 dB (A)	

(Note) AA : Areas requiring extraordinary quiet.
A : Areas primarily residential.
B : Areas used for commerce and industry containing also a fair number of residences.
Lane: A roadway wide enough for safe and smooth transit by automobiles in single file.

Table 8.2 EMERGENCY PROCEDURE STANDARDS FOR ROAD TRAFFIC VIBRATION

	Daytime	Nighttime
Class 1 Area	65 dB	60 dB
Class 2 Area	70 dB	65 dB
Remarks	When the actual condition exceeds the standard values, the prefectural governors shall request the road administrator or prefectural Public Safety Committee to take the necessary measures.	

(Note) Class 1 and 2 Areas correspond approximately to the following areas and shall be designated by the prefectural governors.

Class 1 Area — Class 1 Exclusive Housing Areas
Class 2 Exclusive Housing Areas
Ordinary Housing Area

Class 2 Area — Area adjacent to commercial area, Commercial Area, Quasi-industrial area and industrial area

4) Water Quality

The controlled values specified by law and regulation are respected, and environmental quality standards are used for the target.

5) Natural Environment

Protection targets shown in Table 8.3 are applied for natural environment.

Table 8.3 ENVIRONMENT PROTECTION TARGET FOR NATURAL ENVIRONMENT

	Classification	Protection target
A	Protected species of national importance	Maximum preservation of the existing environment
B	Protected species of regional importance	Partial preservation of the present environment
C	Protected species of prefectural importance	
D	Protected species of local importance	Minimize impact on the environment to the extent possible

8.3.3 Measures Incorporated in Highway Planning

In planning trunk roads the utmost attention should be given to the living environment of roadside areas with due consideration of the fact that vehicular speeds will be higher than on other highways. Highway routings are planned so that they will not run close to hospitals, schools and other densely inhabited areas requiring specially quiet environments.

Therefore, when the basic highway plan is designed, surveys of the affected areas are conducted for possible influence by the road.

The survey covers weather, land use, urban planning, industries, cultural properties, wildlife, vegetation, living conditions, population, public facilities, recreation facilities and other aspects. Based on the survey results, a comprehensive study is made on alternative routings. The degree of possible environmental impact, technical feasibility, cost, road function and social and economical aspects are considered before the highway plan is made final.

8.3.4 Measures Embodied in Highway Construction

Road traffic pollution includes a variety of environmental problems such as noise, air pollution and vibration. Because the predominant problem is noise and since protective measures built into the highway against other forms of pollution are technically difficult, the environment protection measures taken in the highway structure are aimed at noise attenuation and landscape preservation. Measures to attenuate traffic noise are shown in Figure 8.4, and include:

a. Noise barrier

A noise barrier attenuates traffic noise through the diffraction effect of the barrier. Since drastic modification of existing highways is very difficult, noise barriers are widely used as the solution of noise problems.

b. Mound earth bank

Mound earth banks are used in place of barriers although mound earth bank and noise barriers are often used in combination. The slope and the top of a mound earth bank are planted to harmonize with the surrounding landscape.

c. Buffer zone

In countering noise, air pollution and vibration, distance between the road and housing zones will generally provide significant attenuation effects. Therefore, the land within 10 to 20 meters from the edge of a road is procured as a portion of the road on which noise barriers and plantings are installed as necessary.

d. Special design (semi-underground structure)

This highway structure provides the increased diffraction effect of a cut structure and must be used in densely inhabited areas, often provided with a buffer zone.

e. Special design (shelter)

A section of the road is enclosed by a covering structure. This is necessarily used in areas with medium and high-rise buildings which would not permit other measures. But the concentration of noise and emissions at the entrances and exists generates another traffic problem.

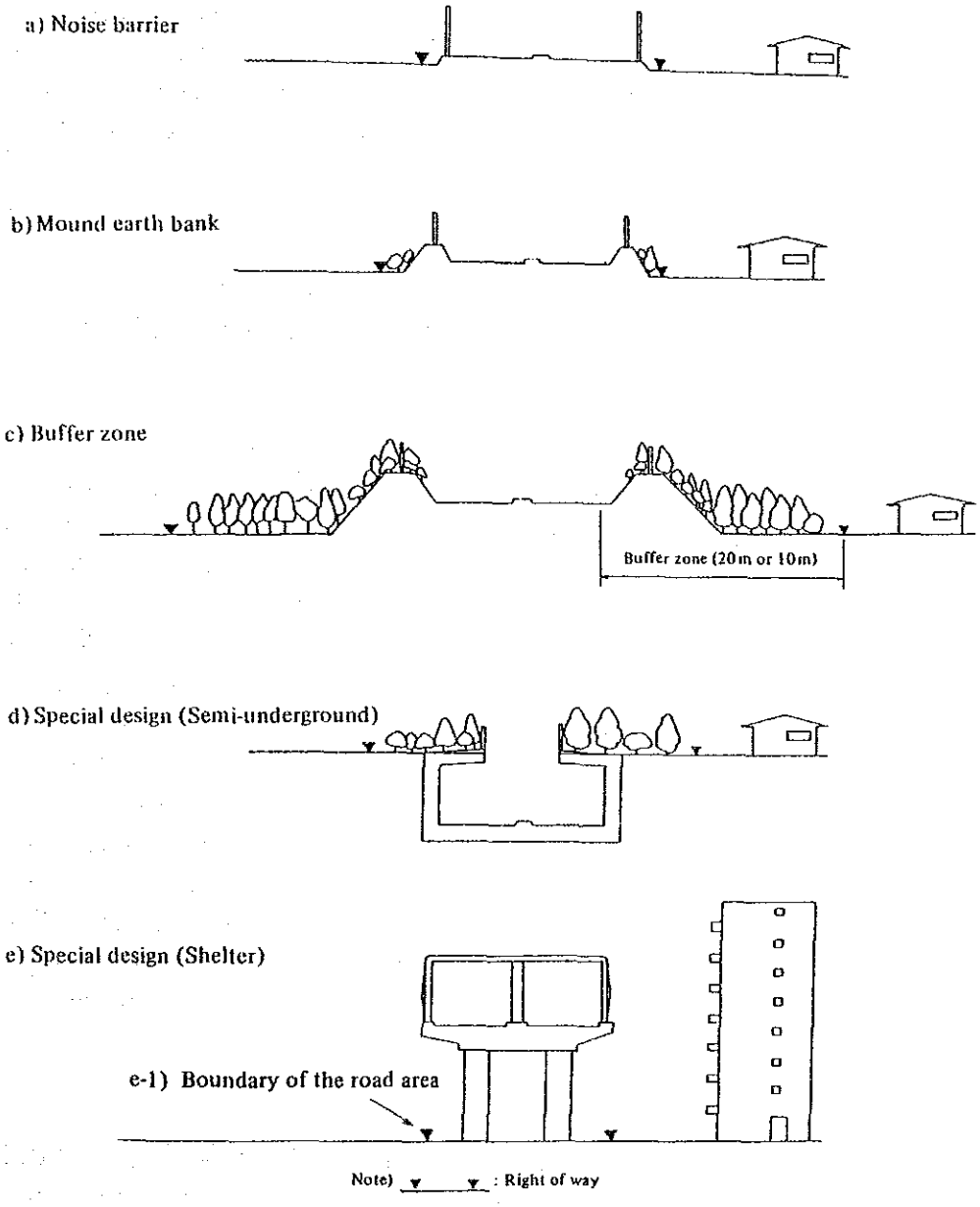


Figure 8.4 MEASURES FOR NOISE IN HIGHWAY STRUCTURE

8.3.5 Measures Taken for Roadside Areas and Vicinity

Some of the road environmental problems can be solved by comprehensive means to improve the motorway structure. However, as it is difficult to solve the existing problems in a short time, the governmental monetary assistance will be needed. An example of the governmental monetary assistance for noise insulation measures in Japan is as follows.

1) Highways affected:

National expressways and motorways under the control of Nihon Doro Kodan, the Metropolitan Expressway Public Corporation and the Hanshin Expressway Public Corporation.

2) Assistance:

Monetary assistance for noise insulation measure construction, relocation and government acquisition of abandoned land.

3) Recipients of the assistance:

a. Assistance for noise insulation:
Those houses in the vicinity of national expressways subject to traffic noise during nighttime exceeding 65 dB (A) (median value) of either design value or actually measured value.

b. Assistance for relocation:
Those houses for which prevention or alleviation of the traffic noise hazard with noise insulation measure construction is not practical.

c. Acquisition of abandoned land:
Land whose inhabitants have been relocated and which can be used for construction of facilities for public use.

4) Amount of financial assistance:

a. Assistance for noise insulation construction:
Reasonable cost to modify construction of the openings and walls to insulate bedrooms and living rooms exposed to noises exceeding 65 dB (A) and to install air condi-

tioning equipment and ventilation fans.

b. Assistance for movement:
Reasonable expense related to relocation.

c. Acquisition of abandoned land:
Fair market price.

d. Responsible organization:
Public Corporations.

e. Houses affected:
For areas in the vicinity of existing expressways; houses inhabited as of August 1, 1976. For other areas; houses inhabited as of the opening date of the expressway.

8.4 IMPROVEMENT OF MOTORWAY ENVIRONMENT

Considering the motorway environment, it is needed not only to measure the environmental problems but also to improve the surrounding environment of the motorways and to more positively create higher environmental conditions, which are expected to be achieved at the designing stage.

For the above aspects, landscaping and aesthetic improvement has been standardized in the motorway design from 1980th in Japan.

Landscaping which is aimed to achieve the harmony between surrounding environmental conditions and the motorway structure and facilities has such functions of aesthetic improvement, conservation of life and natural environment, road safety, disasters prevention and creation of green shade.

8.5 MAIN ENVIRONMENTAL CONSIDERATIONS BY ROUTE

Main environmental considerations for each route in the proposed

toll motorway netwark are described as follows.

1) TM-1 (Bang Pa-In — Chiang Rai, L = 755.6 km)

a. As the section from Bang Pa—In to Nakhon Sawan mostly passes through paddy fields, considerations must be paid to not directly discharge the contaminated drainage water from the motorway surface to the paddy fields.

b. As the route runs through the national park area at Changwat border of Phitsanulok and Lampang, first priority must be given to the preservation of natural environment, especially, to the vegetation. Also, considerations for the landscape should be paid sufficiently.

c. Since the route section at Changwat border of Lampang and Chiang Rai passes through mountainous area, satisfactory tree-planting is needed in this area.

d. The section from Chiang Mai to Chiang Rai is also running through ravine area, therefore, an important measure to be applied is vegetation on the slopes to conserve natural environment as much as possible.

2) TM-2 (Bang Pa-In — Nong Khai, L = 535.3 km)

a. For the section from origin to Saraburi, running through paddy fields, considerations must be paid not to directly discharge the contaminated drainage water from the motorway surface to the paddy fields.

b. In the section from Saraburi to Nakhon Ratchasima, the first half of this route is running through forms in hilly/mountainous area, therefore, considerations to prevent noise problems must be paid. In the vicinity of Lake Lam Ta Khong, the harmony of motorway landscape with its surrounding area is needed to conserve a beautiful scenery.

c. As the section from Nakhon Ratchasima to Nong Khai is running through mostly agricultural area, measures for environmental protection of agricultural activities are needed.

3) TM-3 (Phra Khanong — Chanthaburi, L = 291.9 km)

a. The whole section from origin to Rt. 36 at Pattaya has the same planning of the Bangkok - Chonburi - Pattaya New Highway which is under construction. For the section from origin to Lat Krabang, which is passing through residential and industrial zones, a study on noise protection facilities, such as buffer zone, is needed.

b. In the agricultural area from Lat Krabang to Chon Buri, measures for protection of agricultural activities are needed.

c. Section from Chon Buri to the end passes mostly through a hilly area and has no much serious environmental problems. However, considerations for landscape are only needed.

4) TM-4 (Phasi Charoen — Malaysia Border, L = 951.4 km)

a. In the section from origin to Rachaburi, which is running on a soft ground area, the study on the measurements for settlement is needed.

b. As the section from Ratchaburi to Chumphon is running through orchard/paddy field areas nearby mountain side, environmental measures for protection of agricultural activities are needed.

c. In the section from Chumphon to Hat Yai, which is running through orchard and paddy fields, environmental measures for protection of agricultural activities are needed.

d. Since there are many villages along the section from Hat Yai to Song Khla, measures for environment preservation and landscape should have high priority, and an environmental protection belt zone such as buffer zone is needed.

5) TM-21 (Nakhon Ratchasima — Ubon Ratchathani, L = 301.1 km)

a. This route runs mostly through paddy fields. Considerations must be paid not to directly discharge the contaminated drainage water from the motorway surface to the paddy field.

6) TM-31 (Bang Pa-In — Bang Pa-In, L = 166.7 km)

a. The northwest portion and half of the northeast portion of this route, from Bang Bau Thong to Lam Luk Ka, are located in paddy field areas. Considerations are needed for environmental protection of agricultural activities and for the scattered residential areas.

b. The southwest portion and half of the southeast portion of this route are located in residential area. High priority is placed here, in which the favourable residential environment can be formed. Vegetation plant is needed such as a buffer zone.

7) TM-32 (Bang Yai — Kanchanaburi, L = 100.0 km)

a. The section from origin to Nakhon Pathon, running through soft ground area and scattered villages, therefore, satisfactory measures for settlement and environmental protection are needed.

8) TM-33 (Bang Bua Thong — Suphan Buri, L = 62.0 km)

a. Mostly, this route passes through paddy fields and scattered villages with soft ground area. Measures for environmental protection of agricultural activities and settlement are needed.

9) TM-34 (Thanyaburi — Aranyaprathet, L = 211.7 km)

a. Since the area around the route is designated as Royal Irrigation Project, sufficient considerations must be paid on environmental protection of agricultural activities.

b. Favourable residential environment has been formed at the urban area of Prachin Buri, sufficient environmental protection and landscape measures are needed for the section passing this area.

c. From Prachin to Aranyaparathet, environmental protection measures for military base (such as jamming, etc.) will be needed.

10) TM-35 (Chon Buri — Nakhon Ratchasima, L = 239.1 km)

a. This route is in a national park area, therefore, environmental impact assessment for protection of natural environment will be needed.

11) TM-36 (Wat Phleng — Bang Pakong, L = 365.8 km)

a. Saraburi to Nakhon Nayok section passes hilly area and the other sections run mostly through paddy fields. Considerations must be concentrated on the environmental protection of agricultural activities.

12) TM-41 (Krabi — Khanom, L = 190.7 km)

a. As this route passes almost through forest reserve zones, environmental measures for afforestation are needed.

13) TM-42 (Phra Saeng — Phuket, L = 136.0 km)

a. In the section along the coastal line, environmental impact assessment for plants is needed.

b. For the bridge acrossing to Puket island, sufficient consideration on the oceanic design is needed.

14) TM-43 (Ron Phibun — Nakhon Si Thammarat, L = 36.9 km)

a. As the end of the route passes through a residential district nearby Nakhon Si Thammarat, considerations for environmental measures such as buffer zones are needed.

CHAPTER NINE

SYSTEM AND ORGANIZATION

CHAPTER 9

SYSTEM AND ORGANIZATION

9.1 FINANCIAL SYSTEM

The development of motorways requires a huge amount of cost. In addition to this amount, DOH has to continue the works of repair, maintenance, upgrading and construction of ordinary highways as routine works.

Figure 9.1 illustrates the past trends of road investments expressed in terms of the percentage to GNP in the U.S., Japan and Thailand. About 3% of the GNP in the U.S. was spent for road works between 1920s and 1930s and about 1.5% — 2.0% in the years after 1950. In Japan, it was less than 1% until 1957, but has risen to about 2% — 2.5% from 1963. Such a trend can be generally seen also in other western industrial countries. At the stage when arterial highways or motorways are vigorously being constructed, high level of road investments costed from 2% to 3% of the GNP are made. Meanwhile, at the stage when arterial highways or motorways have nearly been completed, the level of road investments drops to about 1% — 1.5% of the GNP.

As seen in Figure 9.1, the ratio of a recent road investment to GNP in Thailand (1985) is very low, only 0.7%. It should be increased to a level of more than 2% of the GNP at the stage which is just about to start motorway development.

In order to raise a huge amount of road investment with less government burden, it is necessary to introduce the following financial systems beside appropriation of the general tax revenue.

1) Introduction of the "Special Funds" ("Earmarked Tax Revenues") raised from the road user taxes.

2) Introduction of the toll road system for early construction with loaned funds from international financial institutions and private sector, and payback later by the toll revenue.

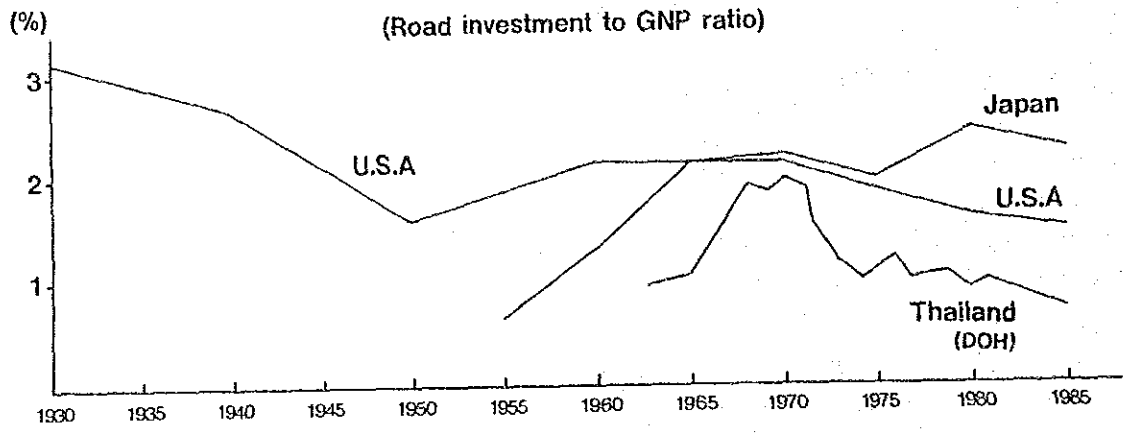
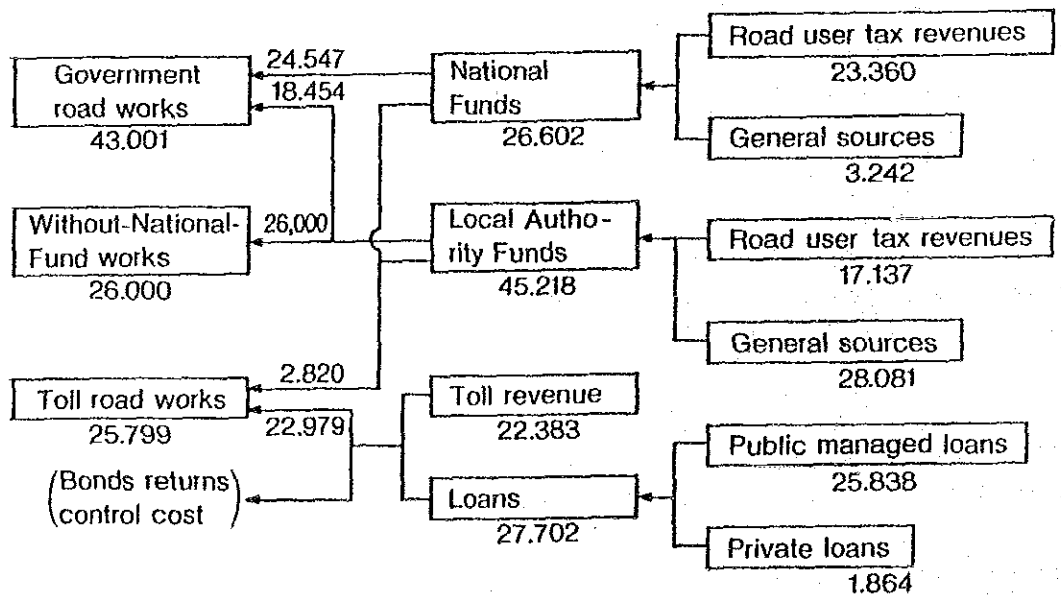


Figure 9.1 PAST TRENDS OF ROAD INVESTMENT AS RATIO TO GNP

Road investments are usually carried out by combining the above financial systems as shown in the case of Japan in Figure 9.2.



(100 million yen)

Figure 9.2 ROAD WORK FINANCIAL SYSTEM IN JAPAN -- 1989

9.1.1 Special Fund System (Earmarked Tax Revenue System)

In general, the "Special Fund" is defined as the specific tax revenue to be appropriated for the specific purpose. The earmarked tax has the same meaning.

The "Special Fund" for road improvement/construction should reflect the "Beneficiaries Pay Principle", i.e. road users have to pay for road improvements through the road users taxes such as gasoline tax, oil tax, vehicle tax, etc., because the road users enjoy the benefits by using roads. The toll charges on the motorways is one of the applications of this principle.

Many countries, such as Japan, U.S.A., F. R. Germany, France, Korea, etc., have special fund system for road works. Figure 9.3 shows proportions of road users taxes which consist of the special funds in various countries. In many countries, the fuel tax (gasoline and diesel taxes) occupies a large part in the total amount of the tax.

The reasons why the special fund system for road development has been adopted in many countries are as follows:

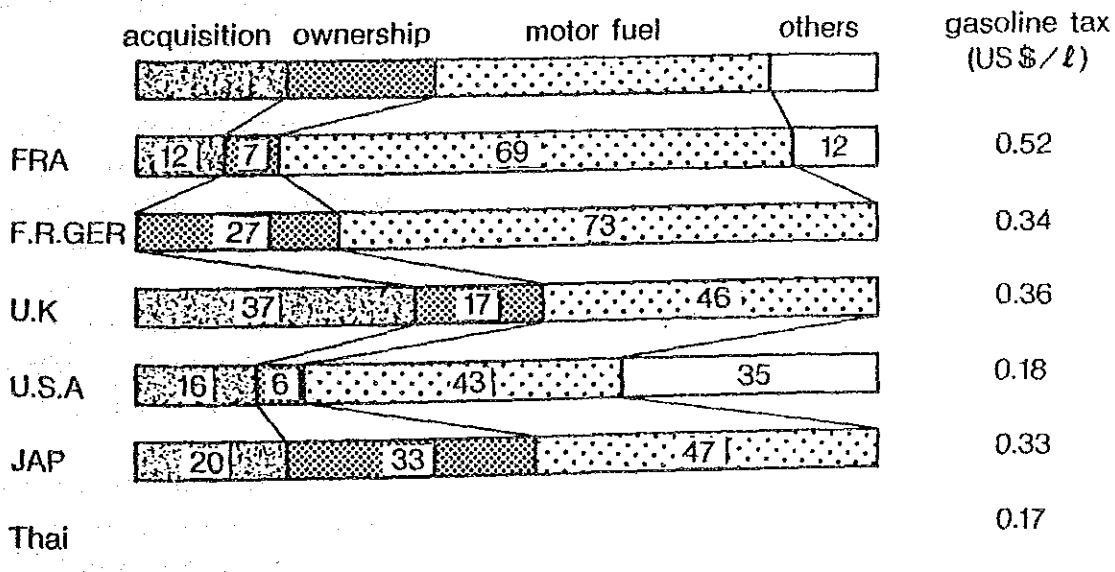


Figure 9.3 STRUCTURE OF ROAD USERS TAX

- Efficiency
  The demands or needs for the road transport will be adequately reflected in the road investment. The over-investment or under-investment will be, therefore, prevented and the effective resource allocation will be realized.

- Equity
  The road services are directly enjoined by a specific group in society, i.e. road users. Unlike the public services of which benefits are enjoined equally by all members in society, the Beneficiaries Pay Principle is justified in the case of road services from the point of view of equity. The "Special Fund" based on the above principle is more fair than application of the general tax revenues.

- Stability
  The road network is a basic social capital and has to be implemented based on a long term planning. The "Special Fund" will ensure the stable funds required for road improvement/construction during the long planning period.

- Persuadability
  The "Special Fund" is a system that the taxes charged on road users are appropriated solely for purposes of road improvement/construction. Tax payers, therefore, will be able to clearly recognize the purposes of this system.

The Sixth National Plan has suggested the necessity of restructuring the tax system:

> "Consider restructuring taxes on road users, especially vehicle tax and taxes on fuel and oil used for road transport purposes. Restructuring will make the taxes more suitable and equitable."

The "suitable" and "equitable" taxes in the above suggestion reflect the same thought of the Beneficiaries Pay Principle. This aims at establishing the Special Fund for road works.

However, this system is not yet introduced in Thailand. In order to promote the highway and the motorway development which is the most important and predominant transportation means in Thailand, the establishment of the "Special Fund" for road works is strongly recommended.

The "Special Fund" will be allocated mainly to the ordinary road sector, and other parts of it to execution agencies as the capital funds or subsidies for the implementation of the toll motorways.

The capital fund is a kind of loans from the Government with no interest charges and with a long grace period. The roles of this capital funds are to reduce the burden of interest charges of other loans necessary for the execution agency and to keep the average cost of loans at a constant level.

9.1.2 Toll Road System

Non-toll motorways are mainly constructed by using the national budget whose basis is general tax revenues. Meanwhile, toll motorways are constructed with loans, which are to be paid back with future toll revenues. Sometimes subsides from the state and local governments are granted to help maintain sound management.

A classification for some selected countries based on the systems applied is presented in Table 9.1.

Table 9.1 SYSTEMS OF MOTORWAYS IN SELECTED COUNTRIES

System	Execution Bodies	
Non-Toll	Government	U.S.A., F.R. GERMANY, U.K.
Toll	Public Corporation	Japan, Korea, Indonesia
Toll	Concession Company	Italy, France, Spain, Austria Other many European Countries, Malaysia, Indonesia
Toll	Government	Taiwan

In U.S.A., most of the motorways are non-toll, but there are toll motorways too, such as the New Jersey Turnpike, Blue Grass Parkway, etc.

In Italy, motorways are toll as a general rule, but non-toll motorways are constructed in the less development areas, such as at Southern Italy.

In Indonesia, there are two kinds of toll motorways; one is constructed by the Indonesia Highway Corporation (PT Jasa Marga), and the other by concession companies.

Reasons why the toll road system is introduced for construction of motorways are:

— Huge amount of initial investment costs required for construction of motorways can be redeemed with future toll revenues.

— The motorways which are to be newly constructed will provide users with higher quality of services such as on-time, comfortable and safe driving conditions. These differences in the service quality between existing roads and new motorways are the bases of charging the toll fees because the users will enjoy more benefits by using them.

— Although the construction of motorways requires huge amount of initial investment costs, once they are opened to the public, they will provide the society with great benefits for a long time, not only to the present generation but also to the next generations to come.

  Considering these characteristics of motorways as nation's wealth, it is unreasonable to cover the whole costs with the taxes charged on the generation at that time from the aspect of inter-generation equity.

  The toll road system is a procedure to distribute the initial burden equally between present and coming generations by collecting toll fees until the redemption of the initial costs is completed (30 years, for example).

— For the toll road system, since loans independent of the government budget are used, raising funds for construction

of motorways is comparatively easy and the early implementation is expected.

For the above mentioned reasons, many countries which lagged behind such countries as the U.S. and West Germany in starting motorway construction, namely, France, Italy, Japan, etc., adopt the toll road system and have achieved a highly successful level in motorway development within a comparative short period.

In the light of the facts of other countries, the Sixth National Plan suggests to introduce the toll road system as follows:

> "Set fee to enable services to become self-reliant and reduce government subsidies. The collection of road tolls will be increased"

According to this policy, some non-toll highways have been changed to toll highways. However, that bring about the dissatisfaction of road users.

The toll road system should be introduced only to highways or motorways newly constructed with alternative routes so as the road users can choose which route they use.

Loaned funds for motorway construction are usually classified as follows.

- The long term loans with low interest charges are available from international financial institutions.

- On the other hand, the long term loans from private sector are quite limited in terms of availability and the rates of interest are relatively higher.

Therefore, it is recommendable to combine, not only with the bank loans but also with the resources in bond markets for the long term loans. The Government-Guaranteed Bonds will have high priority as quasi-government bonds and will be accepted by a syndicate composed of main banks.

In conclusion, since the initial investment of the motorway construction is a huge amount, introduction of the toll road system is strongly recommended.

1) Toll Rate

The toll rates have been generally decided by the governments in various countries under two principles, which are:

a. Redemption principle:

The total amount of toll collected through the entire collection period should cover the total project cost.

b. Benefit Principle:

The toll rates should not exceed the benefit normally available by the use of the toll roads.

The actual toll rates, however, widely vary from country to country, reflecting socio-economic situations, such as the balance among those of other transportation means, paying capability of the users and other policies related to commodity price stability.

Figure 9.4 shows the relationship between the average toll rates and G.N.P. Per Capita in various countries based on 1988 data.

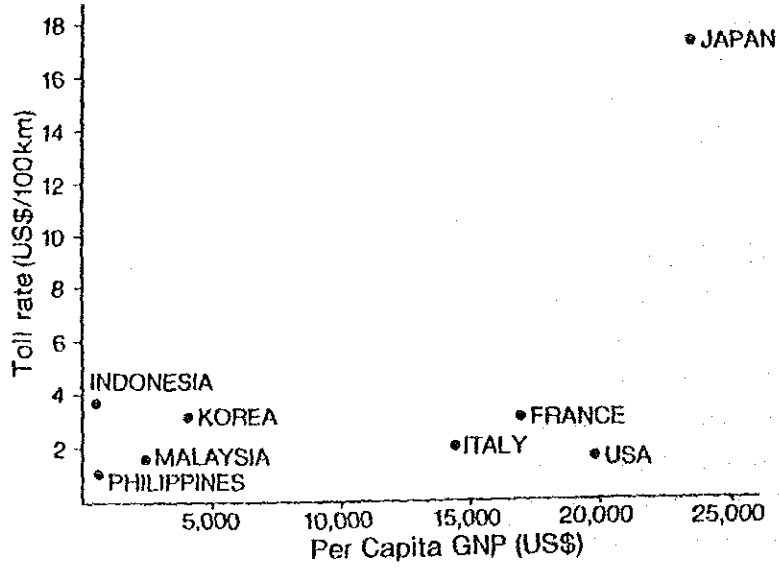


Figure 9.4 TOLL RATES AND GNP PER CAPITA

The average toll rates for motorways shown in Figure 9.4, except that in Japan, range between US$ 1.0 and US$ 4.0/100 km, i.e. 0.25 Baht/km to 1.0 Baht/km.

The toll rates of motorways in Thailand should be comprehensively decided by considering various factors. The most important matter to be considered in constructing motorways by utilizing the toll system is to secure profitability. Huge loans involve the risk of inducing various future problems. It is, therefore, essential to adopt a system by which such risks could be properly avoided as mentioned below.

a. Tasks
   - Raising long-term and low-interest funds
   - Avoiding risks of interest fluctuations
   - Taking measures to increase income
   - Maintaining independent management

b. Measures
   - Taking over or guaranteeing the payment of debts by the government
   - Relaxing interest burdens through government subsidies
   - Independent decision of toll rates by executing body
   - Eliminating political pressure on management

To assure repayment, the outstanding balance must not grow larger. In other words, it calls for an annual revenue in excess of the annual costs for maintenance, management, toll collection and loan interest as shown in Figure 9.5.

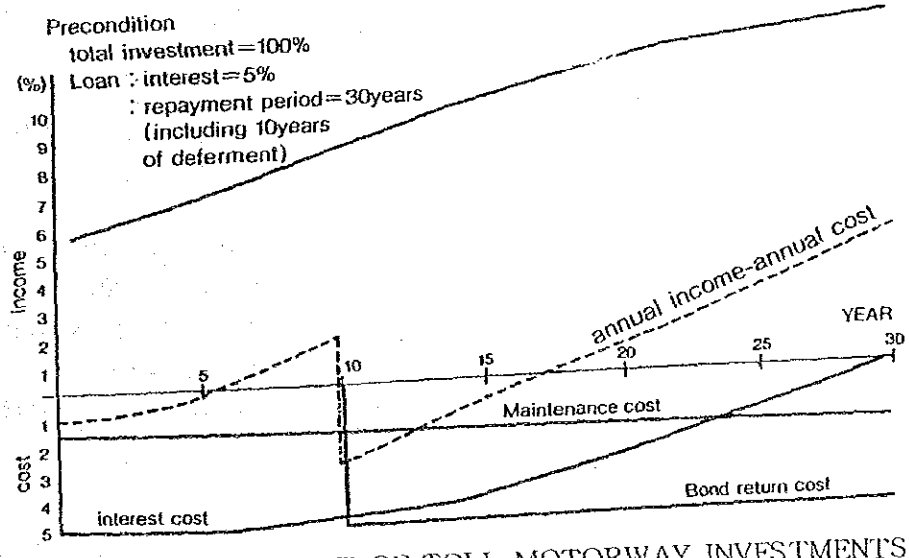


Figure 9.5 REPAYMENT OF TOLL MOTORWAY INVESTMENTS

2) Toll Collection Systems

Toll collection system is categorized in two types, which are:

a. Open system:

In this system, fee is paid once at the entrance, exit or mainline in the middle of the toll motorway sections. A fixed fee is usually imposed for some type of vehicles.

This system has been generally adopted to urban motorway networks, and toll road sections whose length is not so long, usually 50—60 Km, sometimes including long bridge or tunnel which cost much for implementation.

b. Closed system:

In this system, a toll ticket is issued at the entrance and the toll fee is paid at the exit according to the distance traveled. In practice, the toll fee is determined by the distance between interchanges where a vehicle enters and leaves, and vehicle type in round numbers for easy payment.

This system has been mostly applied to toll motorways whose coverage is long and nationwide.

The section which is usually called Outer Bangkok Ring Motorway is suited for the "Open System" because this section has urban motorway features, such as short trip length, heavy traffic on through lanes, short intervals between interchanges and relatively small percentage of heavy trucks.

So, the study would like to propose the "Open System" to be adopted for the Outer Bangkok Ring Motorway.

For the motorways outside the Outer Bangkok Ring Road, two alternatives can be raised as shown in Figure 9.6 from the practical viewpoints, such as fairness that long-distance car should pay according to the distance traveled, and easy collection of fee. In the easiness of toll collection, toll booth barrier is superior to ramp toll barrier.

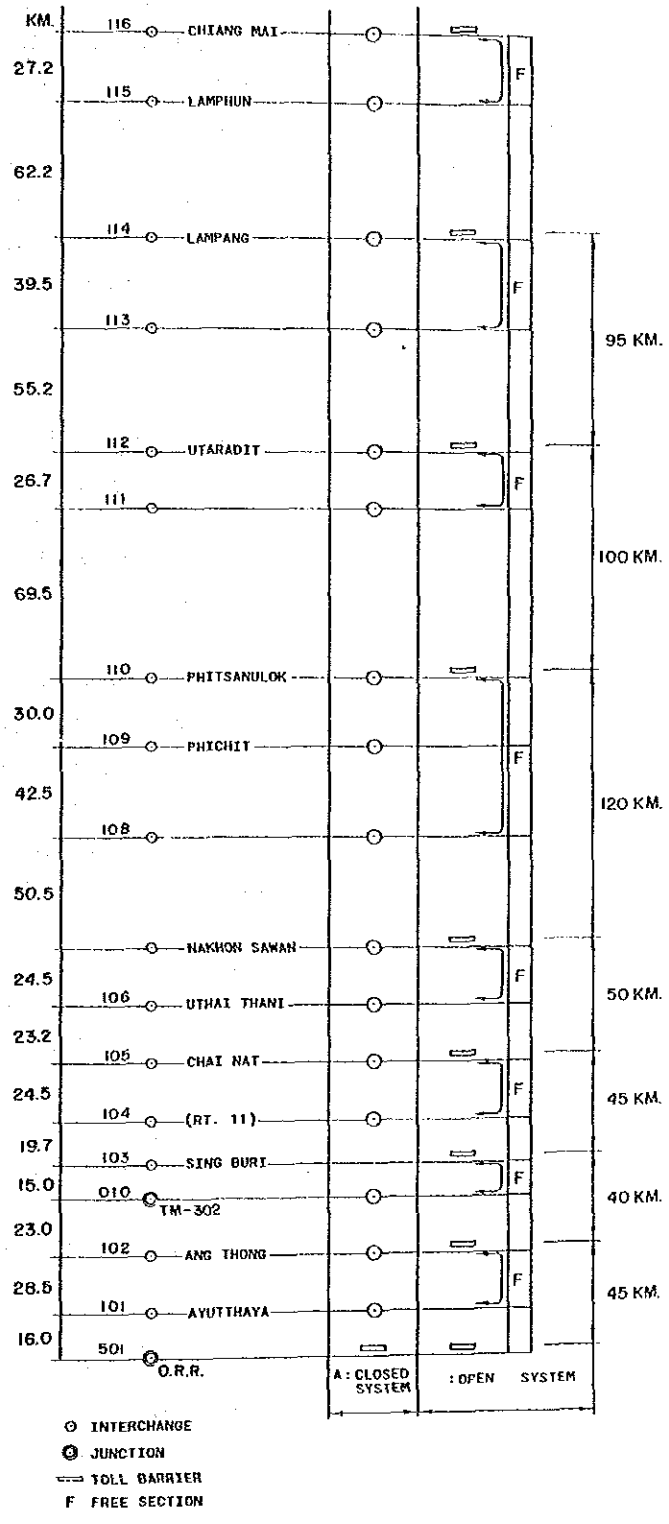


Figure 9.6 EXAMPLE FOR TOLL COLLECTION SYSTEM

3) Pool Payment System

The pool payment system in which profit from highly redeemable motorway sections is used to compensate loss from non-redeemable sections would be recommendable for the nationwide motorways formation. It is because motorway sections in less-developed areas are usually not redeemable while those in developed areas are highly redeemable.

This kind of pool system has been functioning successfully in Japan, Italy, France and other countries to implement motorways in less-developed areas.

4) Concession System

Concession system is also adopted in many countries as shown in Table 9.1. The major objective is almost the same in the meaning, i.e. aiming to promote motorway implementation under the appropriation of limited government budget.

In some sections of motorways in Italy, France, Indonesia and Malaysia, concession system seems to work well. So, the Study would like to suggest the Government to consider the concession system to be adopted together with financial measures such as special fund which is mainly based on tax revenue related to road users. This special fund would turn out to be government subsidies to make concession system viable.

The terms of conditions of concession agreement should be carefully prepared so as to attract the interest of the possible firms.

Experiences in some countries suggest that The Financial Internal Return Rate (FIRR) for 30 years redemption period should be high enough to attract the attention of the interested companies.

In order to maintain FIRR the viable value, the following measures should be taken into considerations, as shown by the foreign examples:

1) Government subsidies to capital fund and for some of interest cost of the Bonds.

2) Introduction of low interest rate government guaranteed loan from overseas financial institutions.

As mentioned above, the concession system is very useful to promote motorway implementation under limited government budget. However, since a major objective of private companies is to pursuit profit, the concession system is apt to apply for only highly redeemable motorway sections. If the pool payment system is not introduced in this case, implementation of motorway sections in less-developed area will be interrupted because benefit gained from the profitable section is not appropriated to these sections.

9.2 MANAGEMENT SYSTEM

9.2.1 Proposed Execution Bodies

As seen in Table 9.2, the executing body of toll motorways may be broadly divided into four categories.

Table 9.2 EXECUTING BODIES OF MOTORWAYS

Bodies	Description	Example
Government	Central or Regional	Taiwan
Public Corporation	Established by Government and Public Authority	Japan Italy (Autostrade) Korea (KHC) Indonesia (IHC) Malaysia (MHA)
Third Sector	Capital Investment by Public and Private Institutions	France (SEM) Italy (19 Companies)
Private Companies	Concessionaire Companies	France (ASFA) Italy (2 Companies)

In general, motorways which have been implemented and operated by governments are free of toll, and toll motorways have been

implemented by public corporations or concession companies. The experiences in various countries suggest that nationwide toll motorways have to be implemented and operated by public corporation or concession company as the main execution body.

As for the number of executing bodies involved, in some cases, it is one, while more than one in some others, as in Italy, it is 25 companies. Generally, the executing body will be only one when it is a public corporation, and in the case of private companies.

Since each procedure has its advantages and disadvantages as shown below, it is hard to say which one is the better. But when viewed from a long-term standpoint for completing the nationwide motorway network, it is better that the executing body be one, and a public corporation as well.

a. Single executing body
(Japan, Korea, Indonesia and Malaysia)

Advantages are:

- Offering uniform services (structural standard, toll level, etc.)
- Ease of reinforcing a management system
- Ease of introducing a pool payment system

Disadvantages are:

- Losing flexibility in management by growing into an excessive scale.

b. Multi-executing bodies
(France and Italy)

Advantages are:

- Early implementation with competition among executing bodies.

Disadvantages are:

- Different toll rates according to executing bodies
- Relief by the government of defective companies

This may be more clearly understood by looking at the history of toll motorways of France. At the first stage the motorways were constructed by a couple of semi-governmental corporations. Then at the second stage, many private companies took part in the construction. Yet, because of resulting business depression of these companies, the Government took action to consolidate them and to increase government involvement.

The advantages of a public corporation are as follows:

Trustworthiness

The trustworthiness as a public corporation is one of the important factors to acquire the investment funds from various resources, not only from international financial institutions such as IBRD but from the private sector as well.

The above funds will be acquired as loans and will be repaid with toll revenues. The public corporation will act, in principle, as a self-supported organization. The government provides the public corporation with the capital funds (this portion is to be also repaid to the government) and attached guarantees to the above internal and external loans.

Maneuverability and Flexibility

The other advantages of the public corporation from the management point of view are:

- to adjust the scale of organization flexibly to match the volume of works.
- to manage the toll motorways effectively by checking the account separately from the government account.
- to promote the toll motorway business by making the organization smaller than the government for quicker response.

Applicability of the Pool Repayment System

As concession companies tend to be reluctant to extend the toll network from high profitable sections/routes to lower profitable ones, it is considered to be difficult to promote the nationwide motorways only by the BOT method. The private sector has, originally, no incentives to construct a toll road unless it contributes to raising profits. A high traffic density area like BMA may be applicable to the BOT method. For the formation of the nationwide motorway network, it is desirable to concentrate the implementation works on the single public corporation through the pool payment system.

As mentioned above, the Study recommends that a public corpora-