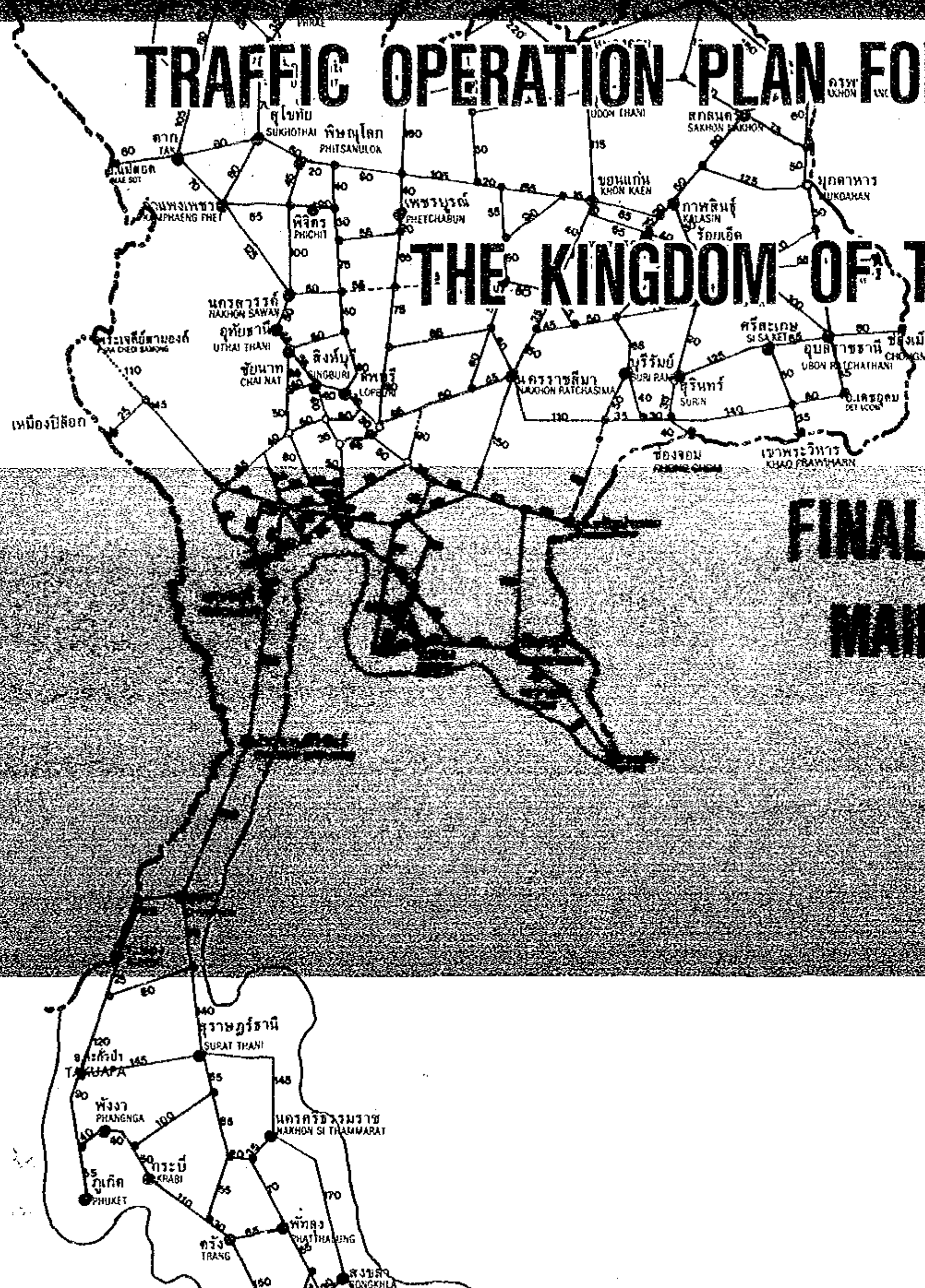
社会開発調査部報告書

TRAFFIC OPERATION PLAN FOR ROADS IN THE KINGDOM OF THAILAND



FINAL REPORT
MAIN VOLUME

JUNE 1990

PLAN FOR ROADS IN THE KINGDOM OF THAILAND FINAL REPORT MAIN VOLUME JUNE 1990

THE STUDY
ON
TRAFFIC OPERATION PLAN FOR ROADS
IN
THE KINGDOM OF THAILAND

FINAL REPORT
MAIN VOLUME

JUNE 1990

JAPAN INTERNATIONAL COOPERATION AGENCY

P R E F A C E

In response to a request from the Government of the Kingdom of Thailand, the Japanese Government decided to conduct a study on the traffic operation plan for roads in the Kingdom of Thailand and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a survey team headed by Dr. Kaoru Ichihara, Central Consultant Inc., composed of members from Central Consultant Inc. and Oriental Consultants Co., Ltd. four times, from February to March 1989, from June to August 1989, from November to December 1989, and from February to March 1990.

The team held discussions with the concerned officials of the Government of Thailand, and conducted field surveys. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

June, 1990

Kensuke Yanagiya

President

Japan International Cooperation Agency

LETTER OF TRANSMITTAL

June, 1990

Mr. Kensuke YANAGIYA
President
Japan International Cooperation Agency
Shinjuku Mitsui Building,
Nishi Shinjuku 2-1,
Shinjuku-ku, Tokyo,
JAPAN

His Excellency,

It is our great pleasure to submit herewith the Report of the Study on Traffic Operation Plan for Roads in the Kingdom of Thailand.

This report is the result of studies carried out by the Study Team consisting of Central Consultant Inc. and Oriental Consultants Co., Ltd. of Japan. During the service period, the Study Team conducted various studies related to the traffic operation for roads under jurisdiction of the Department of Highways in the Kingdom of Thailand.

The Study Team has completed the above service with a firm belief that implementation of above plans will substantially contribute to the improvement of the very serious road traffic problems on roads under jurisdiction of the Department of Highways, in particular the heavy traffic congestion and frequent occurrence of traffic accidents.

Our gratitudes are due to Japan International Cooperation Agency, the JICA Advisory Committee, Ministry of Foreign Affairs, Embassy of Japan in Thailand as well as officials and individuals of Thailand for their assistance extended to the Study Team.

In conclusion, the Study Team sincerely hopes that the study results would contribute to socio-economic development and well being in general and to the future traffic operation in the country.

Yours faithfully,

K. Ichihara

Dr. Kaoru ICHIHARA
Team Leader
The Study on Traffic Operation Plan for Roads in the Kingdom of Thailand
(Central Consultant Inc.)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

GOJ : The Government of Japan
JICA : Japan International Cooperation Agency
GOKT : The Government of the Kingdom of Thailand
MOTC : Ministry of Transport and Communications
DOH : Department of Highways, MOTC
TED : Traffic Engineering Division, DOH, MOTC
MOI : Ministry of Interior
OCMRT : Office of the Committee for the Management of Road Traffic, MOI
BMA : Bangkok Metropolitan Administration
ETA : Expressway and Rapid Transit Authority of Thailand

AADT : Average Annual Daily Traffic
ADT : Average Daily Traffic
CRT : Cathod Ray Tube
GDP : Gross Domestic Product
GRDP : Gross Regional Domestic Product
ITV : Industrial Television
OD : Origin and Destination
PCU : Passenger Car Unit
TIS : Thailand Industrial Standard
VTR : Video Tape Recorder

S U M M A R Y

S U M M A R Y

1 INTRODUCTION

1.1 Background

The road traffic on the highway network is posing one of the serious social problems in Thailand as the degree of difficulties associated with the traffic is increasing at a rapid pace along with the growth of the volume of motor vehicles. Traffic congestion is becoming serious, particularly on the roads under the jurisdiction of the Department of Highways (DOH) in the suburban area of the Bangkok Metropolitan Area and in the areas surrounding the major local cities.

DOH has been aware of the urgent need to improve efficiency of traffic operations on the DOH highway network as well as to increase traffic safety. In this connection, the Study for the Traffic Safety Plan for Roads in the Kingdom of Thailand (the Phase I Study) was carried out by the Japan International Cooperation Agency (JICA) between 1983 and 1985.

The Government of the Kingdom of Thailand (GOKT) requested the Government of Japan (GOJ) to undertake the Study on Traffic Operation Plan for Roads in the Kingdom of Thailand (the Study). The decision was taken by GOJ to undertake the Study in response to the request of the GOKT. JICA has set up a study team (the Study Team) to undertake the Study.

1.2 Objectives of the Study

(1) Objectives of the Study

The objectives of the Study are;

A. To establish an effective traffic operation plan for the existing DOH roads by means of various measures discussed in the Study, namely;

- Physical improvement of roads including installation of traffic control devices.
- Application of traffic information system based on the studies on road inventory system, traffic census system, experimental works for traffic control measures, etc.
- Preparation of engineering specifications for various traffic safety devices and traffic control devices.

B. To perform technology transfer to the DOH counterparts in the course of the implementation of the Study.

(2) Definition of Traffic Operation System and Plan

In the Study, traffic operation is defined in rather narrower sense to cover only those study items specified in 1.3, which is considered to be the minimum requirement for DOH to identify the road sections having traffic problems on their existing road network, and to apply adequate measures for achievement of the objective of traffic operations.

1.3 Study Items

The main study items are classified into the following seven (7) groups taking into account the characteristics of the study items.

1) Review and Preliminary Survey

- Collection of data and information.
- Review of roads and traffic conditions.
- Review of traffic operation systems.

2) Identification of Problem Sections on DOH Roads

- Identification of locations and elements.
- Field survey.

3) Traffic Safety Measures

- Setting up engineering specifications for traffic safety devices

4) Traffic Control Measures

- Setting up guidelines for traffic control devices.
- Setting up engineering specifications for traffic control devices.

5) Experimental Works and Case Study for Traffic Control Measures.

- Field survey.
- Experimental works.
- Case study works.
- Execution of experimental works by DOH.
- Effective assessment of experimental works.

6) Traffic Operation Systems

- Formulation of traffic information system.
- Formulation of road inventory system.

- Formulation of traffic census system.
- Establishment of traffic operation system.

7) Recommendations
   - Recommendation for traffic operation organization.
   - Recommendation for traffic operation plan.

1.4 Reports

The following reports were submitted or are to be submitted to DOH.

- Inception Report	:	February, 1989
- Interim Report (I)	:	July, 1989
- Interim Report (II)	:	December, 1989
- Draft Final Report	:	February, 1990
- Final Report	:	June, 1990

2 CURRENT CONDITION OF DOH'S TRAFFIC OPERATION SETUP

2.1 Present Socioeconomic Condition in Thailand

The total population of the whole country is about 55 million and the population density is 107 person/km^2 in 1988. Bangkok Metropolitan Area has the highest population density (5,437 person/km^2). The population growth rate of the whole country has decreased from 2.4% in 1985 to 2.0% in 1988, except in the Bangkok Metropolitan Area.

The Bangkok Metropolitan Area shows the highest per capita GRDP of about 60,000 Baht, which is almost 3 times as large as that of the whole country. On the other hand, the Northeastern region shows the lowest of about 15,000 Baht, one-forth of Bangkok Metropolitan Area.

2.2 Existing Road Conditions

The total length of roads controlled by DOH is approximately 49,800 km as of 1988. The status of national and provincial highways in 1988 by region indicates the following:

A. The length of paved roads per 1,000 persons is 0.653 km for the nation as a whole. By region, the Southern Region has the highest ratio at 0.963 km.

B. The density of paved roads is 0.07 km/km^2 nationwide. By region, both the Southern Region and the Central Region have the highest density at 0.093 km/km^2.

C. The total length of roads under construction or planned for construction is roughly 8,000 km nationwide. Within these new planned roads, 3,952 km will be constructed in the Northern Region, which has the lowest density of paved roads at present.

2.3 Motor Vehicle Registration

The total number of motor vehicle registrations increased annually by 16.3% from 2.6 million in 1982 to 6.4 million in 1988. Passenger cars have increased annually by 12.9% since 1982 to 816 thousand in 1988, while motorcycles have also increased annually by 18.6% in the same period.

2.4 Current Traffic Conditions

(1) Traffic Volume

Traffic volume on trunk roads in the Bangkok Metropolitan Area are extremely high. Average daily traffic in nearly all sections of major trunk roads within the area exceeds 50,000 vehicles, while traffic volumes in surrounding areas are also generally high at 10,000 - 30,000 vehicles per day. In outlying areas, fairly high volumes are seen on national and provincial highways near major cities, but between cities traffic is light.

(2) Traffic Accident

Traffic accidents in the country rose from about 15,500 in 1982 to 35,000 in 1988 giving an average annual increase of 14%. Particularly, number of traffic accidents drastically increased in 1988. The accident rate on roads managed by the DOH declined from 16.5 in 1981 to 9.2 in 1988.

(3) Current Condition of DOH's Traffic Operation Setup

a) Traffic Conditions

Of the 48,000 km of roads in the nation, only about 450 km mainly in and around the highly-congested Bangkok area are four-lane roads. The rest are two-lane roads. DOH roads experience several problems, as listed below.

- Congestion in and around Bangkok
- Congestion in rural cities
- Congestion caused by motorcycles
- Pedestrian safety

b) Traffic Control and Traffic Safety Facilities

DOH has made great efforts to install traffic control as well as traffic safety facilities on its highways. However, several problems can be pointed out for the following facilities as well as installation methods.

- Traffic signals
- Traffic signs
- Road markings
- Delineators and road studs
- Street Lighting
- Guard fence
- Vehicle detectors

2.5 DOH Budget

Over the past ten years, the DOH budget has doubled. The DOH budget for 1989 is 12 billion Baht, which accounts for 87% of the entire MOTC budget. This large allocation of the MOTC budget to DOH indicates that the highway network under the jurisdiction of the DOH is playing a key role in support of the Thai economy.

The allocation of DOH budget for maintenance of highways has been increasing in recent years. Road maintenance works are predicted to increase more and more in the future. This is due to the expansion of highway network in addition to the improvement of road service level.

2.6 Review of the Phase I Study

(1) Experimental Works

Experimental works in the Phase I Study were implemented at eight hazardous locations of DOH roads in 1984. Considering the present traffic conditions, some counter measures look like rather faded out and further measures were taken at three sites. However, the remaining counter measures taken at five sites still remain effective.

(2) Case Study

In the Phase I Study, total length of 41.4 km (17 locations) sampled from 11 routes was selected as the Case Study roads. Follow-up survey of the case study in the Phase I Study was carried out to make clear how the selected case study sections were improved in compliance with the plans recommended in the Phase I Study.

2.7 Review of the Highway Accident Prevention Project

"Highway Accident Prevention Project" is one of the main projects in "Five years Plan for Construction and Rehabilitation of Highways (1987-1991)". To provide safety to road user, this project started with the total budget of six hundred and five million baht since fiscal year of 1987. According to the investment schedule of DOH, the year- to-year investment amount is quite similar to the investment schedule recommended in the Phase I Study. It indicates that the Phase I Study has been put to practical use.

3 IDENTIFICATION OF PROBLEM SECTIONS ON DOH ROADS

3.1 Basic Concept of Identification of Problem Sections on DOH Roads

Understanding the traffic conditions on the roads, problems and problem sections are comprised of multiple factors, such as the fundamental traffic flow elements consisting of traffic volume, vehicle speed, and density, driving amenity, which is very difficult to be expressed numerically, and also on the minus side the traffic accidents and environmental pollution. Therefore, evaluation of traffic conditions on the roads having a variety of characteristics may change a viewpoint in accordance with the traffic situations on the roads. Generally the main evaluation items are as follows:

- Smoothness
- Safety
- Amenity
- Accessibility
- Economical efficiency
- Environmental protection

The aim of the Study is to understand and evaluate the traffic situation macroscopically and objectively from the viewpoint of the road administrators. In the Study, smoothness and safety are to be evaluated because the related data can be collected and a numerical and reliable analysis is available. The basic concept of the evaluation from the viewpoint of traffic smoothness and traffic safety are described as follows:

(1) Smoothness Evaluation

Smoothness of the traffic is mainly represented by travel speed on the road sections under examination.

In the case of evaluating traffic situations on roads using traffic volume, traffic volume to traffic capacity ratio at each road section can be a useful indicator. Traffic volume to traffic capacity ratio not only indicate traffic congestion rate, but also have an advantage of providing some correlation between traffic volume and travel speed. Accordingly, in the Study, traffic congestion rate is to be used as an indicator for traffic smoothness.

(2) Safety Evaluation

If the traffic accidents which occurred during certain periods are recorded in a map of the roads by affixing identifying tags, then similar types of the traffic accidents may be concentrated at specific points. Such frequent traffic accident points on the roads are usually called hazardous locations. In the Study, the hazardous road sections are extracted by identifying the hazardous locations. Accordingly, the traffic accident rate is used as an indicator of traffic safety.

3.2 Identification of Problem Sections through the Traffic Congestion Rate

In the Study, traffic volume to traffic capacity rate, namely, traffic congestion rate is determined to apply as an index of smoothness. DOH roads are classified into non intersection (roadway) and intersection. However, in order that traffic capacity on the intersections may be calculated, the detailed data of operating traffic lane and traffic phase on each intersection are necessary. As it is very difficult to collect completely these data in the Study, the objects of identifying problem sections are determined to apply to only non intersections (roadway sections).

(1) Method of Calculating Congestion Rate

A method applied in Japan is adopted in the Study to calculate traffic capacity for obtaining the congestion rate. The reason for adopting a method applied in Japan is that there is not enough accumulation of data for determining specific traffic capacity applicable to Thai situation and there also is no ground for using values applied in the United States. The method used for calculating congestion rate is illustrated in Figure 1.

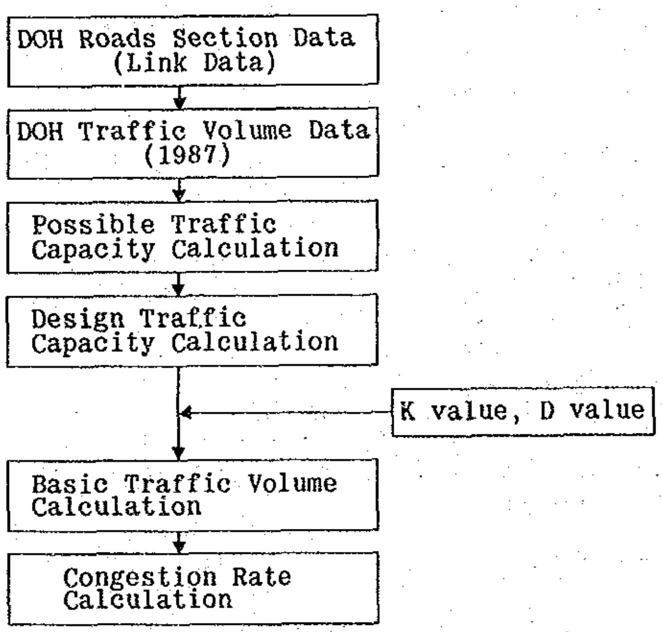


Figure 1 Traffic Congestion Rate Calculation Flow Chart

(2) Identification of Congested Road Sections

The DOH roads' traffic congestion rate is calculated by the methods shown in (1) using the data for 1987. The control sections which were not subjected to actual traffic volume observations were not analyzed. The roadway is broken down to road sections on the following basis:

A. Traffic volume observations which were conducted each year by DOH are carried out basically on one point in each control section. Accordingly, while only one observation point in one control section is set up, it is deemed to be one road section in one control section.

B. In case of one control section which has two and more traffic volume observation points, a central point is deemed to be a road section border.

The calculated traffic congestion rate is shown in Table 1. The followings are understandable from this table.

Table 1 Non Intersection (Roadway) Traffic Congestion Rate (By type of road)

Unit : m

Congestion Rate : a	Primary Highway	Secondary Highway	Provincial Highway	Total
0 ≤ a < 0.25	2,659,721	4,833,936	23,753,546	31,297,205
0.25 ≤ a < 0.50	1,903,668	1,063,911	919,701	3,887,280
0.50 ≤ a < 0.75	376,598	219,951	240,992	837,541
0.75 ≤ a < 1.00	382,923	87,276	31,713	501,912
1.00 ≤ a < 1.25	63,970	6,360	22,608	92,938
1.25 ≤ a < 1.50	19,080	0	13,142	32,222
1.50 ≤ a	74,099	45,853	0	119,952
Total	5,480,059	6,307,289	24,981,702	36,765,050

A. Road sections which show a congestion rate greater than 1.0 amount to a total length of approximately 245km representing 0.7% of total length analyzed.

B. By contrast, road sections which have a congestion rate of less than 0.5 represent a total length of approximately 35,200km or 95.7% of total length analyzed.

C. Road sections which have a congestion rate of more than 1.25 total approximately 150km or about 0.4% of total length analyzed.

D. Traffic congestion rate on Primary Highways appears higher than other road types which were analyzed.

E. Division 410 (Bangkok Highway Division) and Division 430 (Lop Buri Highway Division) which are located in central Thailand show a high traffic congestion rate among the regional observations.

3.3 Identification of Problem Sections through Traffic Accident Rate Analysis

In the Study, hazardous road sections can be defined as sites where traffic accidents occur frequently or a large number of casualties exists indicating some remedial measures are required. However, "hazardous" is always defined relatively and not absolutely.

In the Study, accident rate - traffic volume method, which was recommended in the Phase I Study and which has been adopted at DOH, is used. However, since the existing DOH data on intersections are unavailable, only roadways sections are analyzed through the accident rate - traffic volume method.

(1) Identifying Method for Hazardous Road Locations

Figure 2 shows the process of establishing identification criteria. This diagram describes the flow of the analytical process, data handling and processing to lead to the setting of identification criteria.

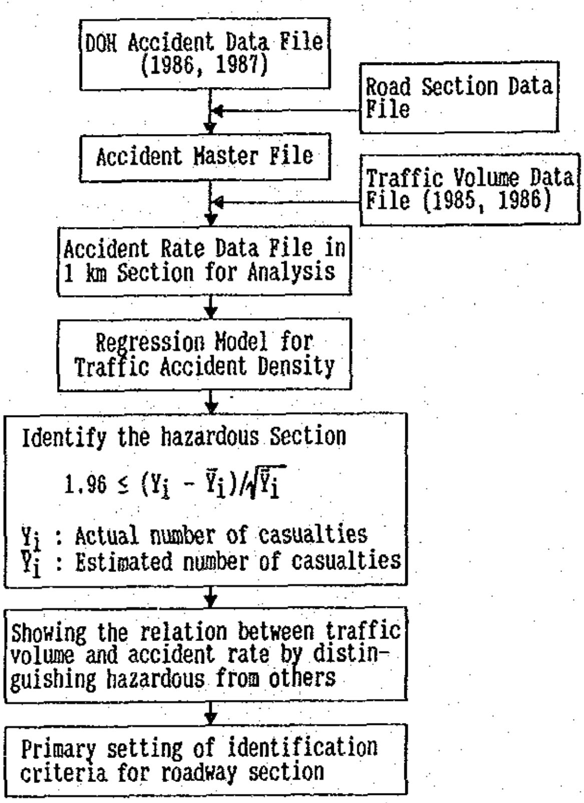


Figure 2 Process of Establishing Criteria

(2) Identification of Hazardous Road Locations

Using the methods previously explained and data of 1986 and 1987 on DOH roads, hazardous sections were identified by classification of roads. Identification of problem sections by the accident rate method was determined comprehensively taking into account the results of interview from district engineers, and the same method as identification of problem sections by the congestion rate.

Table 2 Length of Hazardous Road Locations by Road Classification

Unit : km

Road Classification		1986	1987
Primary Road	Route No. 1 - 4	74.7 (25)	72.5 (24)
	Others	41.6 (14)	38.5 (13)
Secondary Road		35.9 (12)	27.2 (9)
Provincial Road		24.4 (8)	26.5 (9)
Total		176.6 (59)	164.7 (55)

Note : Figures in parentheses indicate number of hazardous road locations.

4 CASE STUDIES AND EXPERIMENTAL WORKS FOR TRAFFIC CONTROL MEASURES

4.1 Objectives of Case Studies and Experimental Works

(1) Objectives of Case Studies

The general procedure to prepare the engineering remedial works at a certain location is as shown below;

A. Selection of location which require remedial works.

B. Collection and analyses of data pertaining to traffic condition and road condition.

C. Identification of major problems from traffic engineering consideration.

D. Determination of traffic control measures applicable to the selected location.

E. Detailed design of traffic control measures.

F. Estimation of improvement cost.

G. Preparation of the implementation program.

In the Study, execution of case studies is planned in order to show some examples of traffic control measures for engineering remedial works prepared according to the procedures outlined above.

(2) Objectives of Experimental Works

The objectives of the experimental works in the Study is to evaluate the effectiveness of the traffic control measures through before-and-after surveys of the experimental works. In the Study, the experimental works are considered to be a part of the case study for the traffic control measures. In addition, execution of the experimental works are fully incorporated with the establishment of the traffic operation system in DOH.

4.2 Selection of Locations for Case Studies and Experimental Works

Since it was almost impossible to pin point certain locations from the huge DOH road network, the representative areas for the Study was determined as follows and several locations from each representative area were selected for the case studies as well as experimental works.

A. Bangkok suburban area

B. Local city area

C. Intercity road section

The final selection of location was made in consideration of the following points;

A. Selected location should be a road section containing typical traffic operational problems in each representative area.

B. Since the case studies and the experimental works must be a kind of demonstration related to the traffic control measures, good effects of improvement should have been expected.

C. For the experimental work locations, it was necessary to consider the DOH's improvement program in the fiscal year 1988, because implementation of experimental works was agreed to be conducted by the DOH's own budget.

As a result, 5 locations and 4 locations were selected for the case study and the experimental work, respectively.

4.3 Supplemental Surveys

Since it was necessary to collect various data related to the site condition and traffic condition at each selected road sections for the case study and the experimental work, topographic surveys and traffic surveys were carried out by the Study Team.

4.4 Preparation of Case Study and Experimental Work Plans

Through the series of site investigations, supplementary surveys and data analyses, existing conditions and major problems were identified for each planning site, and then traffic operational measures for each planning site were planned in order to cope with major traffic operational problems. For the determination of traffic operational measures, the following points were taken into consideration;

A. The proposed measures should be expected to solve the traffic operational problems at each location.

B. The proposed measures should be acceptable in each representative area.

C. The proposed measures should be applicable to other areas in Thailand, where road and traffic condition are similar.

D. The consensus for the proposed measures should easily be obtained from relevant parties, such as drivers and police.

Tables 3 and 4 summarized the selected locations for the case study and the experimental work, and proposed traffic control measures.

4.5 Implementation

The experimental improvement works at four planning sites have been implementing by DOH with DOH budget. The improvement cost for the experimental work are summarized in Table 5.

Table 5 Summary of the Improvement Cost for the Experimental Works

Location	Route No.	Traffic Operational Measures	Improvement Cost (Mill. Baht)
E-1 Laksi Roundabout	R1/R304	- Installation of Signal - Pavement Marking	3.74
E-2 Pathumthani Intersection	R3111/ R346	- Installation of Signal - Provision of Added Lane	0.70 (only signal)
E-3 Khon Kaen	R2	- Provision of Motorcycle Lane	0.55 (only W=1.5m)
E-4 Khon Kaen	R2	- Provision of Passing Lane	3.44

4.6 Effectiveness Evaluation

In the Study, the Study Team decided to adopt before- and after-surveys for the effectiveness evaluation of the experimental works by means of comparison of traffic conditions and traffic accidents between before and after implementation of planned improvement measures.

Unfortunately, the delay of the implementation of experimental works for the Laksi Roundabout and the passing lane in Khon Kaen, mainly because of the budgetary procedure and lacking of contractors, also cause the delay of the after-surveys.

As the result, the effectiveness evaluation of experimental works for the motorcycle lane in Khon Kaen and the improvement of the Pathumthani Intersection were only carried out. The results of these effectiveness evaluation are summarized below.

(1) Motorcycle Lane in Khon Kaen

It was confirmed that the smoothness of vehicle operation as well as the safety condition along this road

Table 3 Summary of Case Study

Location No.	Route No.	Control Section	Section Name	Kilo Post	Area CD	Classified Area	Road Configulation	Major Countermeasure	Remark
C-1	R.34 (R.3, R.3102)	100	Bang Na	0+000- 4+000	411	A	Signalized Intersection (Under elevated road)	* Rehabilitation of pavement * Improvement of visibility of signals * Modification of signal phasing * Extention of left turn lane	
C-2	R.3 (R.315, R.344)	402	Chonburi	92+000- 94+100	422	B	Signalized Intersection Roadway	* Improvement of channelization * Installation of median * Modification of signal phasing	
C-3	R.3	501	Sriracha	95+100	422	B	Signalized Intersection (not operated)	* Improvement of visibility of signal * Channelization * Installation of median * Access control of frontage road	
C-4	R.1 (R.309, R.3189)	202- 301	Wang Noi	65+151 - 167	413	C	Intersection (with partial frontage Rd.)	* Short term plan - Signalization - Improvement of frontage road - Channelization * Long term plan - Grade separation	
C-5	R.344 (R.331)	200	Ban Bung - Klaeng	31+506	422	C	Intersection	* Channelization * Speed control	

Classified Area. A : Bangkok suburban area
B : Local city area
C : Intercity roadways

Table 4 Summary of Experimental Works

Location No.	Route No.	Control Section	Section Name	Kilo Post	Area CD	Classified Area	Road Configulation	Major Countermeasure	Remark
E-1	R.1 (R.304)	100	Laksi	18+567	411	A	Roundabout	* Signalization * Channelization	
E-2	R.346 (R.3111)	100	Pathumthani	12+122	416	A	Intersection (4-leg)	* Signalization * Channelization * Installation of acceleration Lane	
E-3	R.2	1000	Khon Kaen	1+100-3+100	621	B	Roadway	* Motorcycle Lane	
E-4	R.2	1000	Khon Kaen - Nam Phong	14+25-15+500	621	C	Roadway	* Passing Lane	

Classified Area.
A : Bangkok suburban area
B : Local city area
C : Intercity roadways

CLASSIFICATION OF TRAFFIC OPERATIONAL MEASURES IN E/W AND C/S

Intersection

a)	Signalization	Laksi*, Pathumthani*, Wang Noi	3
b)	Improvement of I.S	Ban Bung-Klaeng	1
c)	Improvement of Signalized I.S	Bang Na, Chonburi, Srirach	3
d)	Grade separation	Wang Noi, Laksi	2

Roadway

a)	Access control	Wang Noi, Sriracha	1
b)	Median	Chonburi, Sriracha	2
c)	Adding lane	Khon Kaen*, Pathumthani*	2
d)	Motorcycle treatment	Khon Kaen*	1

* means Experimental Work Sections

section was improved because of segregation of motorcycle traffic from the main traffic flow.

A. 63% of motorcycle used the motorcycle lane, 36% the first lane, and 1% the second lane. Based on the result of traffic volume counting for 12 hours, about 70% of motorcycles used the motorcycle lane.

B. The installation of the motorcycle lane has led to an increased running speed, hence improved smoothness. This tendency is evident particularly on the first lane.

C. The installation of the motorcycle lane helps to substantially reduce a potential danger involved with motorcycles running between cars on the first lane.

D. The central path of the motorcycle lane is most often taken (63% of motorcycles), which is followed by the first lane side path (30%). The video observation also confirmed that motorcycles were running steadily.

E. There was a significant reduction in the number of accidents and casualties, and it has been concluded that the motorcycle lane is serving its purpose well.

F. Most of users think that the installation of a motorcycle lane contributes significantly to reduced travel time, improved mobility and reduced accidents. 74% of motorcycle riders think the width of the motorcycle lane is adequate.

(2) Pathumthani Intersection

It was confirmed that the traffic smoothness as well as the safety level at the intersection were improved because of segregation of traffic flows by installation of traffic signals.

A. Results of the traffic behavior survey indicate the increase of running speed at the intersection by 10-25% after installation of traffic signals.

B. Total number of conflicts were reduced from 65 to 11, with the reduction rate of 83%. Particularly, conflicts between through vehicles and right turn vehicle were drastically reduced.

C. Number of accidents were reduced from 5 to 4, while side collisions were reduced from 4 to 0. All accident patterns after installation of traffic signals were rear-end collisions, but those collisions were not severe.

5 TRAFFIC CENSUS SYSTEM

5.1 General Traffic Volume Survey

The General Traffic Volume Survey consists of a Traffic Volume Survey and a Travel Speed Survey. The Traffic Volume Survey has been conducted by DOH since 1962 and it is desirable to improve the survey step by step. On the other hand, a Travel Speed Survey has not been implemented systematically so far. It is recommended to introduce this survey since it is very useful in identifying bottlenecks on DOH roads.

Travel Speed Survey is to be conducted annually on major routes by following the survey method proposed in the Study. The routes to be surveyed initially will be those with many control sections having high congestion levels as shown in the Report. Table 6 shows selected routes which need to be surveyed.

Table 6 Proposed Route for Travel Speed Survey

Route No.	Survey Section (Control Section)
Route 1	0001 0100 (Bangkok) - 0001 1202 (Nakhon Sawan)
Route 2	0002 0101 (Sara Buri) - 0002 1201 (Udon Thani)
Route 3	0003 0100 (Bangkok) - 0003 1200 (Chanthaburi)
Route 4	0004 0100 (Bangkok) - 0004 1100 (Prachuap - Khiri Khan)
Route 31/32	0031 0100 (Bangkok) - 0032 0802 (Chaint)

5.2 Motor Vehicle Origin-Destination Survey

Even though its value is unquestioned, it is very difficult to conduct an OD survey on a nation - wide basis. In Japan, when OD surveys were first introduced, it was only done in major city groups. At present, it is judged impossible to obtain enough survey staff to conduct a nation wide OD survey in Thailand. Therefore, for the time being, DOH should conduct OD survey locally and wait until a future time before conducting a survey on a nation-wide scale.

There are two ways to conduct OD survey locally.

1) Structure a city group with a major core city
2) Divide the country into blocks.

DOH is in control of all major trunk roads throughout the country and it is important that DOH is aware of nation-wide traffic flows. In the light of such an objective, method 1 is not recommended since it tends to focus on some major cities and may fail to reflect nation-wide traffic flows. Also such a grouping method has been employed by the Department of Town and Country

Planning. It is suggested, therefore, that DOH should divide the country into 4 blocks, namely, North block, North-East block, Center block, South block and conduct the OD survey by the block.

Since traffic demand is expected to grow rapidly due to the dramatic economic growth of the country, it is better to conduct the survey as often as possible to maintain the validity of data. However, in view of the fact that traffic volume survey has been conducted directly by the Traffic Engineering Division, it is practical that the OD survey be conducted every 5 years. In summary the suggested OD survey to be conducted by DOH is as follows:

A. The country is to be divided into 4 blocks, i.e. North block, North-East block, Center block, South block and the Survey is to be conducted within each block.

B. The survey is to be conducted annually in each block. For the nation-wide data, the accumulated data in each block are to be combined every 5 years to prepare nation-wide OD Table .

At present, the Traffic Engineering Division directly conducts the survey. However, it should be considered to entrust such survey with some external organization. If it is judged impossible to conduct the survey in a certain block in a single day, the block can be further divided into sub-blocks to obtain the data.

5.3 Continuous Traffic Volume Observation Survey

DOH conducts traffic volume surveys every year. Among these, a Control Count Survey is conducted at 35 points on the National Highway 4 times a year for 7 days (3 days for certain time range) to measure traffic on 24-hour basis and to identify changes in traffic volume by season or by time of a day. It is unfortunate, however, that this is not sufficient basic data required for traffic engineering analysis, and it is suspected that day-to-day traffic management suffers because of this lack of basic data.

A Continuous Traffic Volume Observation Survey employs vehicle detectors and can collect data on a 24-hour basis all year round. This method will not only collect basic data for traffic engineering analysis but also can provide useful data for improving reliability of the traffic census. Therefore it is recommended to conduct the Continuous Traffic volume Observation Survey.

The amount of data to be collected by the Continuous Traffic Volume Observation Survey should be about the same as the amount collected by the control count survey. It is desirable that the travel speed of passing vehicles are also measured at the same time. Taking that into consideration, the vehicle detectors to be used for this survey should be at about the same level as the ones installed along Route 31 by DOH. Table 7 describes the functions of vehicle detectors installed along Route 31.

It is expected that it will take some time before all 35 control count survey stations are equipped with such detectors. Referring to the analysis results, priority of early installation of equipment should be given to those stations with higher congestion levels. In installing detectors, it is also important that vehicle detectors are installed equally throughout the country.

Table 7 Functions of Vehicle Detectors on Route 31

Items	Functions
Types	- Small-Size truck - Large-size truck - Bus
Output data	- Number of monitoring lane; 6 lanes max - Recording method; paper tape punch - Recording time intervals; 5 min, 30 min, 1 hour - Recording data; traffic volume, average speed, occupancy

6 TRAFFIC INFORMATION SYSTEM

6.1 Data-Gathering Devices and Their Placement

Assuming that traffic information is to be provided actively in Thailand in the future, data-gathering devices required for present include:

1) Vehicle detectors
2) Traffic surveillance cameras

The criteria for selecting the locations of the above-mentioned devices should be considered in the following;

1) Congestion

Bottlenecks, occur at fixed points within a road network, and can be expected to occur most frequently, with respect to ordinary roads at signalized intersections.

2) Diverging traffic flow

For example, locations where detours or alternative routes are available.

3) Alteration of road network

For example, locations where changes in the road network due to the construction of a bypass or a new road occur.

4) Alteration of geometric element

For example, locations where changes in the road capacity due to the alterations in the geometric configuration of a road, such as an improvement of an intersection or road widening occur.

5) Change in demand

For example, locations where changes in the quantity and quality of traffic demands due to the development of a housing area, factory or some other facility occur.

6.2 Informational Devices and Their Placement

Assuming that traffic information is to be provided actively in Thailand in the future, informational provision equipment required for the time being, in addition to the ordinary radio equipment already available, include variable-message signs and a telephone service system.

Location of variable-message signs should be determined in accordance with the following guidelines:

A. Well in advance of points or areas where congestion occurs frequently, in order to give drivers sufficient time to respond to congestion information.

B. Near intersections where route changes are possible, in order to allow drivers to respond to detour information.

C. When a variable-message sign is to be placed near an intersection, it should be placed at a point upstream from the intersection, in order to give drivers sufficient time to change lanes or make other necessary movements.

Concerning the telephone service system, it is necessary for the organization responsible for road management to work together with the telecommunication company in promoting the system.

6.3 Case Study Plan in Chonburi Area

(1) Software Configuration

Traffic information obtained from vehicle detectors will be used as primary data, and those obtained from ITVs, patrol cars, telephones and monitors will serve as patrol cars, telephones and monitors will serve as supplements. Data on traffic volume and time occupancy will be obtained from vehicle detectors, and travelling speed will be calculated from the traffic volume and occupancy thus obtained. While it is possible to have detectors input information at intervals of 30 seconds, 1 minute, 5 minutes or 15 minutes, the interval assumed for the subject system is 5 minutes, in consideration of such factors as the scattering of data.

(2) Hardware Configuration

Terminal equipment consists of vehicle detectors, message signs, and ITVs. Since the ultrasonic vehicle detector is superior in terms of ease of construction and maintenance, this type is suggested for the subject system. A pattern-selection message sign instead of a, free-pattern sign is proposed for the subject system, since only a few kinds of information are to be provided, added to the fact that the messages to be transmitted are relatively fixed. Overhead message signs will be provided at major locations and roadside signs at supplementary locations.

7 ROAD INVENTORY SYSTEM FOR DOH ROAD

7.1 Inventory System for Traffic Engineering

Through the discussion with DOH staff in detail in view of traffic operation, management, planning and administrative works in TED, more than three hundred data items for the road inventory database were determined in detail for traffic engineering use. The database sufficiently covers the existing road database and is designed in such a way that no inconsistencies occur between them.

In the Study, in order to achieve improved traffic operation using the new database system as soon as possible, ten computerized database were recommended as shown in Figure 3. Meanwhile, considering the current data volume to be input into database, written inventory sheets in a form of table were also recommended for daily management works on traffic sign and road lightings in the district offices.

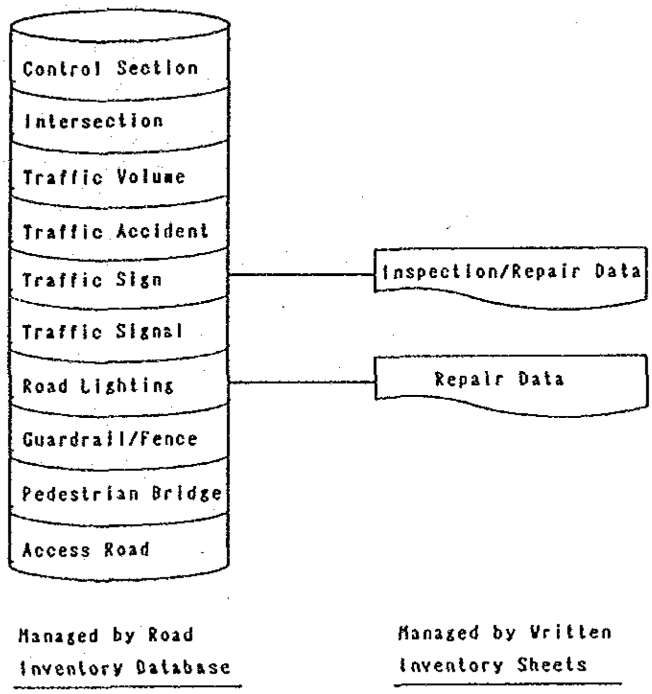


Figure 3 Road Inventory Database

The number of data items and of estimated records are summarized in Table 8. Total data volume is estimated at approximately 10 MB after collecting data for the whole national highway system in Thailand. The main frame computer of model B-A3K has a capacity sufficient enough to accommodate all data for the road inventory database without hindrance in load of the other system to the computer.

Table 8 Database Files for Road Inventory System

Name of Database	No. of Items	Record Length (Bytes)	No. of Records	Data Volume (KB)	Remarks
Control Section	62	236	11,000	2,600	to be added data on major rural/municipal roads in the future.
Intersection	39	110	9,600	1,100	ditto.
Traffic Volume	31	138	3,000	400	ditto. (/year)
Traffic Accident	29	72	3,000	200	(/year)
Traffic Sign	47	150	22,000	3,300	
Traffic Signal	18	60	5,500	300	
Road Lighting	21	74	5,500	400	
Guardrail/Fence	23	211	5,500	1,200	
Pedestrian Bridge	22	116	2,200	300	
Access Road	16	71	5,500	400	
Total	308	——	——	10.2 MB	——

Note; Number of records is based on the assumation considering in the current data condition and identification method.

7.2 Data Collection

In order to demonstrate the collection methods of inventory database and to make easily implementing the initial data collection, coding sheets for ten database files are prepared.

8 TECHNICAL GUIDELINES AND ENGINEERING SPECIFICATIONS ON TRAFFIC SAFETY AND TRAFFIC CONTROL DEVICES

In the Study, technical guidelines and engineering specifications on the following traffic safety and traffic control devices have been prepared and they are presented in the separate volume of this report "Technical Guidelines and Engineering Specifications".

1) Median Divider, Facilities for Channelization and Added Lane in the Neighborhood of an Intersection

- Median divider
- Facilities for channelization
- Added lane in the neighborhood of an intersection

2) Climbing Lane, Passing Lane and Motorcycle Lane

- Climbing lane
- Passing lane
- Motorcycle lane

3) Traffic Signal

- Warranting conditions
- Method to determine the signal phase and timing
- Concept for coordinated signal control
- Design of traffic signal control
- Installation of signal equipment
- Management of traffic signal operation

4) Traffic Sign

- Material of traffic sign
- Reflective material
- Illumination equipment
- Structure of traffic sign board
- Post of traffic sign
- Foundation and installation
- Inspection and Maintenance of traffic sign
- Traffic sign data book

5) Pavement Markings

- Basic requirement for the material
- Classification of materials and application method

6) Crossing Facility for Pedestrians

- Crosswalk
  * Warranting condition
  * Planning methods
  * Basic concept for designing a crosswalk
- Refuge island

  * Warranting condition
  * Planning method
- Pedestrian overpass
  * Warranting condition
  * Standard for pedestrian overpass design
  * Maintenance of pedestrian overpass

7) Sidewalk and Bicycle Path

- Warranting condition
- Minimum width of pathway
- Shoulder
- Vertical clearance
- Separation method
- Pavement of sidewalk
- Treatment for handicapped people
- Treatment of bicycle path at intersection

8) Street Lighting

- Warranting condition
- Lighting apparatus
- Lighting Pole
- Other equipments
- Installation process of street lighting
- Design of street lighting
- Design of wiring
- Installation
- Inspection
- Cleaning and maintenance
- Record

9) Delineator

- Post delineator
  * Warranting condition
  * Reflector
  * Supporting post
  * Installation
  * Routine inspection
  * Cleaning and maintenance
- Raised pavement marker
  * Warranting condition

10) Guard Fence

- Warranting condition
- Classification of guard fence
- Color
- Anti-corrosive treatment
- Installation method
- Inspection
- Maintenance
- Record

11) Pavement Treatment

12) Other Facilities
- Vehicle detector
- Road information system
- Bus stop facility
- Grade separation at railway crossing

9 TRAFFIC OPERATION PLAN

9.1 Traffic Operation System

(1) Traffic Obstacles in Thailand

This undertaking is concerned with DOH roads. DOH roads and related roads seem to have the following obstacles to traffic:

1) Traffic accident
2) Road disaster
3) Road improvement work
4) Abnormal weather
5) Traffic congestion

Accidents, disasters and improvement work represent traffic obstacles common to all roads,not limited to DOH roads. Abnormal weather poses a traffic obstacle accompanied mostly by torrential rain, sometimes with fog. Traffic congestion is caused by the concentration of traffic in the metropolitan area of Bangkok and other major cities across the nation at morning and evening peak hours. The traffic congestion is a constant occurrence.

(2) Traffic Operation Measures

The actual objectives of the traffic operation for countermeasures to the traffic obstacles mentioned above on DOH and related roads are as follows:

1) Easing of traffic congestion
2) Securing traffic handling capability in a state of traffic obstacles.
3) Effective road use.

Easing traffic congestion is to prevent or reduce traffic congestion. Securing traffic handling capability is to utilize detours to cope with traffic obstacles such as traffic accident. Effective road use is aimed at proper distribution of traffic volume on road network so as to avoid a localized concentration of traffic volume. These objectives should be achieved by application of the traffic operation methods.

(3) Traffic Operation System

The basic considerations in implementing the proposed traffic operation may be systematized in Figure 4.

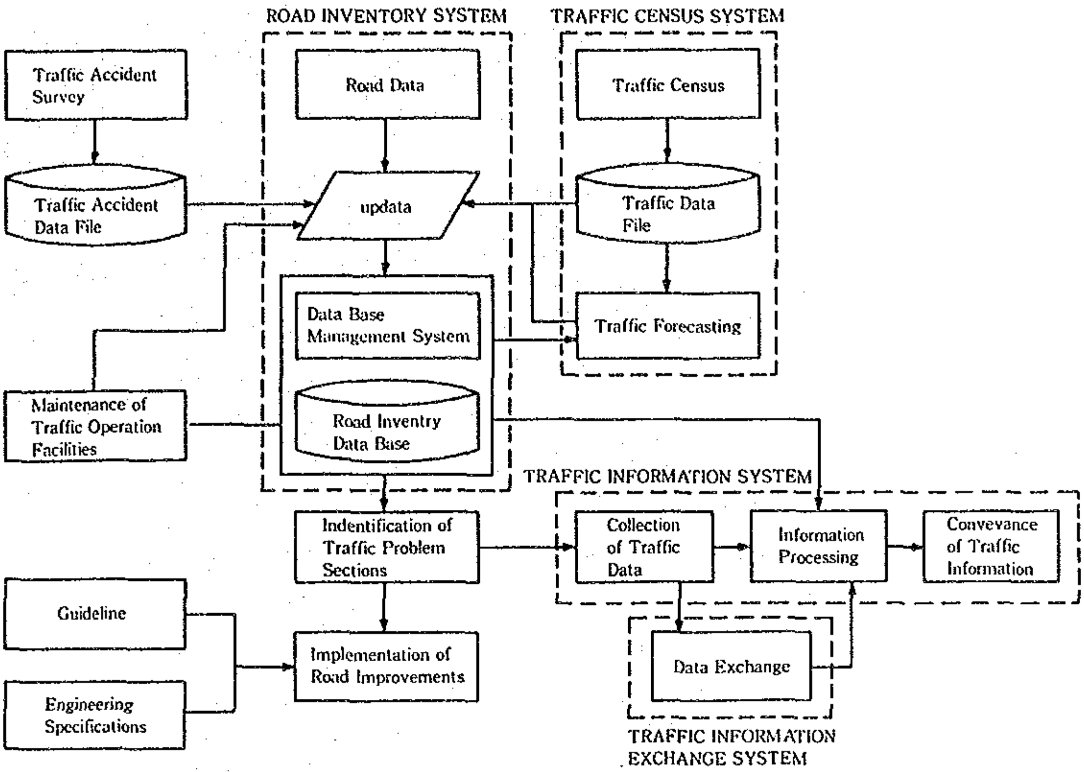


Figure 4 Traffic Operation System

9.2 Traffic Operation Plan

(1) Basic Concept of Traffic Operation Plan

There is no established definition as to traffic operation plan for achievement of safe, efficient and convenient travel of motor vehicles. The definition shall varies according to the purposes of the plan. In a broad sense, the plan for traffic operation is not only to formulate the direct and immediate measures and applications for traffic control by means of various devices, but also shall include the improvement of all the existing traffic functions comprising all the road facilities, traffic regulations and organizations, etc.

In the Study, however, the traffic operation plan is discussed on those physical measures to be applied on road facilities, such as motorcycle lane, passing lane and grade separated intersection, and traffic information system, which shall be implemented in a certain time span.

It is also to be mentioned that this report does not aim to present a plan itself, but the information needed for formulation of a traffic operation plan, and indication of the process to work out a plan through case study. From the planning period, the plan can be classified into two types, namely; masterplan with the time span of about five to ten years, and action plan with shorter planning period with detailed scheme of implementation. The Study deals with a macroscopic masterplan on traffic operation.

(2) Method for Development of Traffic Operation Plan

The process and steps to formulate a traffic operation plan macroscopically are described as follows;

A. to select road sections or locations having traffic problems by identification methods with criteria by congestion degree and accident rate.

B. to classify the selected section or locations by road patterns and measure types.

C. to prepare standardized improvement measures corresponding to road patterns.

D. to apply each standardized measure to each classified road sections or locations, and to map out a macroscopic improvement plan for traffic operation.

E. to quantify the volume of the unit work for each type of improvement plan, and to estimate the cost required for implementation of the plan.

F. to sum up each type of improvement plan and to integrate to be a complete traffic operation plan.

G. to evaluate the formulated plan for traffic operation from the engineering viewpoint as well as from economic viability such as net benefit and benefit/cost ratio, together with the available financial resources.

As to the evaluation on the effectiveness of the formulated plan, it is possible to a certain extent to convert the benefit accrued from the investment such as saving of travel time, reduction in vehicle operation cost, saved life, prevented injury and property damage, etc., to monetary values, but it would be advisable to make a final decision in consideration of other factors like national policy and interest, development and improvement policy and strategy of road transportation and also DOH's policy and strategy for encouragement of traffic operations.

For formulation of a traffic operation plan, it is also important to verify the quantity and conditions of the existing traffic control and safety devices, and to work out the budget needed for replacement, repair and maintenance of such devices.

(3) Macroscopic Improvement Works Planning

In order to draw out a masterplan for traffic operation systematically and macroscopically, 64 selected road sections have been classified into four typical road patterns by road and traffic conditions for which four types of standardized improvement measures can be effectively adopted respectively.

As described in the preceding sections, there are four types of improvement work proposed in the Study;

A. Installation of motorcycle lane

B. Installation of passing lane

C. Provision of grade separated intersection

D. Provision of traffic information system

Therefore, the criteria for classification of road sections having various traffic problems to fit into four types of improvement work on traffic operation have been set forth as the following:

A. Congestion rate exceeding 0.50

B. Hazardous section selected by statistical method

C. Type of traffic problem to be congestion

D. Cause of traffic problem by ;

- Motorcycle ....Motorcycle lane
- Slower vehicle ....Passing lane
- Heavy traffic volume at intersection.........Grade separation
- Heavy traffic volume on road network ....Traffic information system

E. Degree of problem to be very high endorsed by district engineers of DOH.

F. Number of lane to be 1 lane each for both directions in cases of motorcycle and passing lane.

G. The selected road section is on roadway or the road section between intersections, for traffic information system.

With aforesaid criteria, 64 selected problem sections have been classified and fit into four types to which four proposed improvement works are to be adopted, namely; 20 sections for installation of motorcycle lane, 15 sections for installation of passing lane, 12 sections for provision of traffic information system, and 17 sections for provision of grade separated intersections.

(4) Effectiveness Evaluation

In the Study, the masterplan for traffic operation was evaluated by economic analysis in terms of net benefit (B - C) and benefit/cost ratio (B/C). In particular, it was made by the comparative assessment of the accrued total benefit by implementation of the masterplan in accordance with the implementation schedule spread over the period of 10 years, against the required installation cost and operating/maintenance cost distributed yearly according to the implementation schedule.

The conditions and assumptions for this evaluation were set as follows;

A. Evaluation period is assumed to be 20 years from the viewpoint of nature of the plan, its scale in work volume and cost, and the time required for completion.

B. The calculation was practiced with the constant prices at 1989 for costs and benefits with the assumption that price escalation rate is same for both costs and benefits. Also, for practical convenience, costs and benefits calculation was made without application of discount rate to achieve the net benefit and benefit/cost ratio.

C. The traffic volume and the number of casualties adopted for this evaluation was fixed at 1989 level for the practical convenience, although it might be possible to adopt those based on projection with annual increase for the plan period.

The economic evaluation reveals that by implementation of the masterplan for traffic operation, about 990 million Baht of net benefit (B - C) can be yielded with the benefit/cost ratio of 1.43 with the evaluation period of 20 years, justifying that this masterplan is economically feasible.

The result of economic evaluation from the first to 20th years are summarized in Table 9.

Table 9 Summary of Economic Evaluation

Year	Fiscal Year	Benefit (Mill. Baht)	Cost (Mill. Baht)	B-C (Mill. Baht)	B/C
1	1990	11.09	81.04	-69.95	0.14
5	1994	232.93	680.11	-447.18	0.34
10	1999	1,064.49	1,807.48	-738.99	0.59
15	2004	2,177.66	2,052.03	125.63	1.06
20	2009	3,286.83	2,296.58	990.25	1.43

(5) Summary of Traffic Operation Masterplan

The total amount of investment required for the masterplan for proposed traffic operation has been estimated at approximately 1,800 million Baht at 1989 prices, comprising 1,570 million Baht for installation/construction and 230 million Baht for replacement and operating/maintenance. This estimation was made on the condition that the masterplan were to be implemented over the period of 10 years from 1990 to 1999.

There are four types of improvement works proposed in the masterplan, namely; motorcycle lane would be installed at 20 road section, passing lane be installed at 15 sections, 12 traffic information systems would be provided at the selected road sections and 17 grade separated intersections be provided at the selected locations.

9.3 Traffic Operation Organization

(1) Internal Organization Mainly Aimed at Traffic Operation

Proposed improvement plan for divisions under control of the Deputy Director General for Engineering is shown in Figure 5.

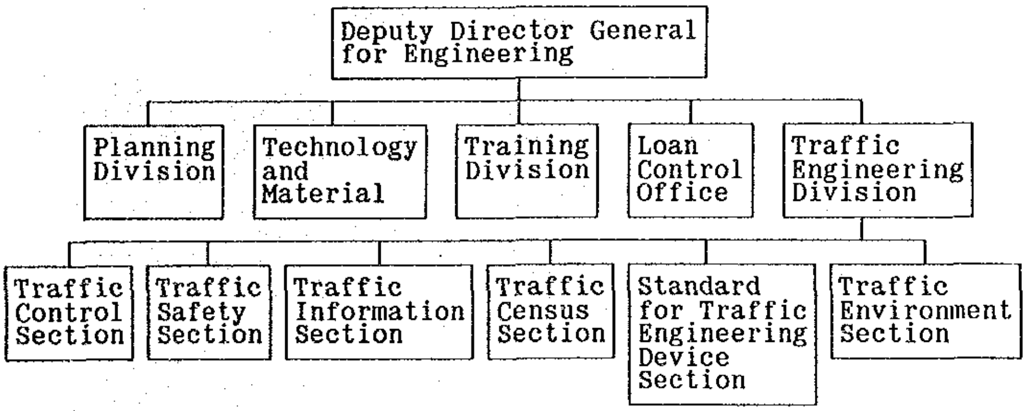


Figure 5 Proposed Traffic Operation Organization

(2) External Organization

In order to cope with advanced and complicated technology as well as to aggressively respond to the social requirement, it is desirable to establish the Research Laboratory and the Traffic Information Center as external bodies of DOH.

a) Traffic and Highway Research Laboratory

Proposed organization chart of the Traffic and Highway Research Laboratory is shown in Figure 6. In addition, expansion of this organization is desirable to be done gradually.

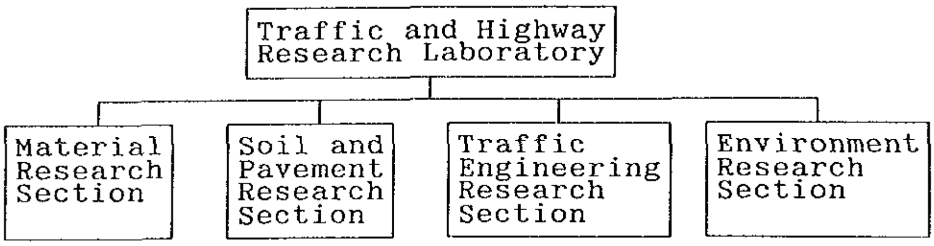


Figure 6 Proposed Organization Chart of the Traffic and Highway Research Laboratory

b) Traffic Information Center

The organization chart of proposed Traffic Information Center is shown in Figure 7. According to increase of tasks in the future, the organization is necessary to be expanded.

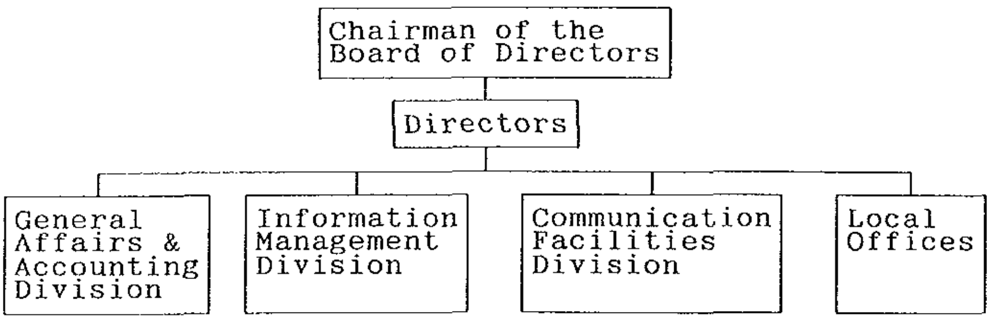


Figure 7 Organization Chart of Proposed Traffic Information Center

CHAPTER 1 INTRODUCTION

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1.1 BACKGROUND

The trunk highway network in Thailand totaling 49,800 km in length is under the jurisdiction of the Department of Highways (DOH). The road traffic on the highway network is posing one of the serious social problems in Thailand as the degree of difficulties associated with the traffic is increasing at a rapid pace along with the growth of the volume of motor vehicles. This trend is indicated by the increase of the number of road traffic accidents in recent years.

Smoothness of road traffic is also deteriorating. Traffic congestion is becoming serious, particularly on the DOH roads in the suburban area of the Bangkok Metropolitan Area and in the areas surrounding the major local cities.

Recognizing the serious socioeconomic problems caused by road traffic accidents and congestions, the Government of the Kingdom of Thailand (GOKT) has given the highest priority to the solution of these problems.

The Study for the Traffic Safety Plan for Roads in the Kingdom of Thailand (the Phase I Study) was carried out by the Japan International Cooperation Agency (JICA) between 1983 and 1985. The Phase I Study mainly aimed at:

A. To collect relevant information and data, including review on the DOH practices with regard to traffic accident data collecting systems and data analyses.

B. To develop identification methods of hazardous road locations.

C. To prepare technical guidelines on road traffic safety.

D. To carry out a case study consisting of road safety planning and experimental works on selected roads.

E. To prepare necessary information for preparation of traffic safety master plan by DOH.

Subsequently, the Highway Accident Prevention Project was prepared by DOH on the basis of the results of the Phase I Study. This project was put into effect during 1987 and has been implemented up to the present time with the financial assistance of the World Bank.

DOH has been aware of the urgent need to improve efficiency of traffic operations on the DOH highway network as well as to increase traffic safety. It is deemed necessary to establish and put into practice a comprehensive road traffic operation program in order to ensure a more effective utilization of the existing DOH highway network.

Consequently, GOKT requested the Government of Japan (GOJ) to undertake the Study on Traffic Operation Plan for Roads in the Kingdom of Thailand (the Study).

The decision was taken by GOJ to undertake the Study in response to the request of the GOKT. The scope of work to be undertaken was agreed in September 30, 1988, based on the findings of meetings and discussions held between the JICA's Preliminary Study Team and DOH.

JICA, the official agency responsible for the implementation of technical cooperation programs by the Government of Japan, has set up a study team (the Study Team) to undertake the Study.

The Study commenced February 1, 1989 with the arrival of the Study Team members, together with the JICA advisory committee members and a coordinator from JICA. Subsequently, the Inception Report was submitted on February 2, 1989 to DOH.

Following to the first stage of the study works both in Thailand and Japan, the progress of the Study by the end of June, 1989 was compiled in the Interim Report (I) and it was submitted on July 10, 1989 to DOH.

After completion of major study works in Thailand, the progress of the Study was compiled in the Interim Report (II) and it was submitted on December 4, 1989 to DOH.

The Draft Final Report comprised all the outcomes of the Study executed under the Scope of Works, including the recommendation for the traffic operation plan, and it was submitted on February 20, 1990 to DOH.

The contents of the Draft Final Report were reviewed after the submission to DOH mainly based on comments from DOH and the Final Report is compiled.

The Final Report consists of the <u>Summary</u>, the <u>Main Volume</u>, the <u>Technical Guideline and Engineering Specification</u>, the <u>Drawings</u> and the <u>Manuals</u>.

1.2 OBJECTIVES OF THE STUDY

1.2.1 Objectives of the Study

The objectives of the Study are;

A. To establish an effective traffic operation plan for the existing DOH roads so that the motor vehicular traffic can be;

- Ensured safe and comfortable trip

- Avoided reduced traffic capacity on road network.

- Prevented unexpected delay by congestion.

by means of various measures discussed in the Study, namely;

- Physical improvement of roads including installation of traffic control devices.

- Application of traffic information system based on the studies on road inventory system, traffic census system, experimental works for traffic control measures, etc.

- Preparation of engineering specifications for various traffic safety devices and traffic control devices.

B. To perform technology transfer to the DOH counterparts in the course of the implementation of the Study.

1.2.2 Definition of Traffic Operation System and Plan

Traffic operations generally cover quite a wide range of traffic measures to solve and improve the various traffic problems for achievement of safe, efficient and convenient movement of motor vehicles. These measures include not only various control devices like signals, signs, markings and channelization, but also traffic regulations and ordinances, traffic information systems and physical improvement of roads. In addition, traffic census systems and road inventory systems also support traffic operations.

However, in the Study, traffic operation is defined in rather narrower sense to cover only those study items specified in the following para. 1.3 (Study Flow), which is considered to be the minimum requirement for DOH to identify the road sections having traffic problems on their existing road network, and to apply adequate measures for achievement of the objective of traffic operations.

1.3 STUDY FLOW

The general flow chart of the works to accomplish the Study Objectives is shown in Figure 1.1. The main study items are classified into the following seven (7) groups taking into account the characteristics of the study items.

1) Review and Preliminary Survey (Item 3.1)

   - Collection of data and information.
   - Review of roads and traffic conditions.
   - Review of traffic operation systems.

2) Identification of Problem Sections on DOH Roads (Item 3.2).

   - Identification of locations and elements.
   - Field survey.

3) Traffic Safety Measures (Item 3.3)

   - Setting up engineering specifications for traffic safety devices

4) Traffic Control Measures (Item 3.4).

   - Setting up guidelines for traffic control devices.
   - Setting up engineering specifications for traffic control devices.

5) Experimental Works and Case Study for Traffic Control Measures.

   - Field survey.
   - Experimental works.
   - Case study works.
   - Execution of experimental works by DOH.
   - Effective assessment of experimental works.

6) Traffic Operation Systems (Items 3.6 - 3.9)

   - Formulation of traffic information system.
   - Formulation of road inventory system.
   - Formulation of traffic census system.
   - Establishment of traffic operation system.

7) Recommendations (Items 3.10 & 3.11).

   - Recommendation for traffic operation organization.
   - Recommendation for traffic operation plan.

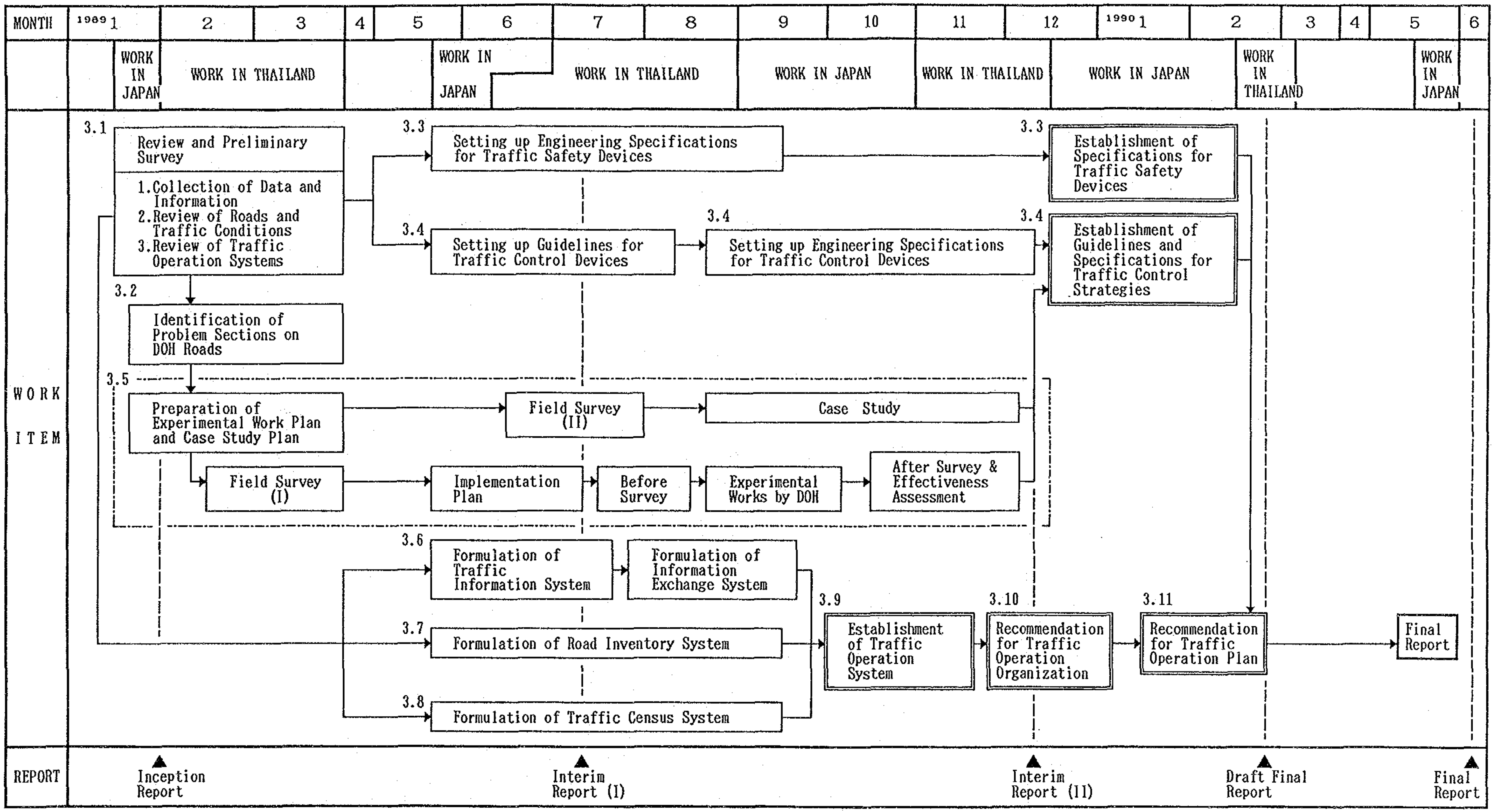

Figure 1.1 Study Flow Chart

1.4 STUDY ORGANIZATION

The agencies directly concerned with the Study are DOH and JICA. The schematic organization chart during implementation of the Study is shown in Figure 1.2.

The Study is being carried out by the Study Team, headed by Dr. Kaoru ICHIHARA. The Study Team is comprised of eight (8) experts, who are performing their consulting services in close collaboration with DOH through its counterpart personnel. The Advisory Committee consisting of Japanese Government officials, organized by JICA, monitors the progress of the Study and gives advice, when necessary.

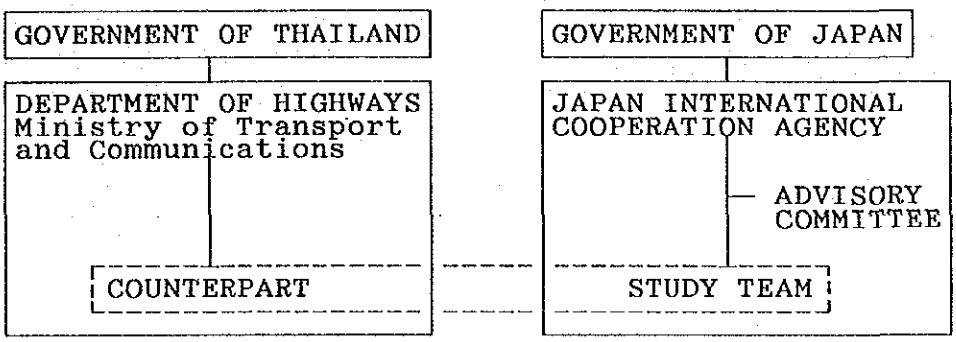

Figure 1.2 Organization Chart

(1) Japanese Side

a) Members of JICA Study Team

Kaoru ICHIHARA	:	Team Leader
Kenjiro MATSUMOTO	:	Deputy Team Leader/ Traffic Operation Planner
Koji WADA	:	Traffic Control Planner
Masashi OSHITARI	:	Traffic Safety Planner
Koji SUZUKI	:	Highway Planner
Hikaru NISHIMURA	:	Specification Expert
Surapong LAOHA-UNYA	:	System Analyst
Toshio SUZUKI	:	Economist
Shin KOKUBO	:	Economist

b) Members of Advisory Committee

Makoto MIZOGUCHI (Chairman) (Former Member)	:	Senior Officer for Road Conservation, Road Bureau, Ministry of Construction
Kenjiro IZUMI (Chairman)	:	Senior Officer for Road Conservation, Road Bureau, Ministry of Construction

Yoshitaka MOTODA (Traffic Planner) (Former Member)	:	Head, Traffic Safety Division, Road Department, Public Works Research Institute, Ministry of Construction
Namio NISHIOKA (Traffic Planner)	:	Senior Researcher, Traffic Safety Division, Road Department, Public Works Research Institute, Ministry of Construction
Mitsuru MASUKATA (Traffic Planner)	:	Senior Traffic Engineer, Traffic Engineering Section, Laboratory, Japan Highway Public Corporation

c) JICA

Toshiichi MINATANI (Coordinator) (Former Member)	:	First Development Division, Social Development Study Dept. JICA
Shingo SAITOU (Coordinator)	:	First Development Division, Social Development Study Dept. JICA

(2) Thai Side

a) Project Officer

Kitipol ASAPARPORN	:	Director, Traffic Engineering Division, Department of Highways

b) Counterpart Team

Jinda MONGKHOLSAWASDI	:	Member
Mongkhol PAISALWATANA	:	Member
Montri THARESUWON	:	Member
Vorasih PRADITBATHUGA	:	Member
Kittipan PANCHAN	:	Member
Anucha WATCHARASIN	:	Member
Poowanai PAIBULSIN	:	Member
Yada PRAPONGSANA	:	Member
Pranee VARIYACHAI	:	Member
La-ed TONGBAI	:	Member
Isaranee SIRITHALA	:	Member

CHAPTER 2 CURRENT CONDITION OF DOH'S TRAFFIC OPERATION SETUP

CHAPTER 2 CURRENT CONDITION OF DOH'S TRAFFIC OPERATION SETUP

2.1 PRESENT SOCIOECONOMIC CONDITION IN THAILAND

2.1.1 Area, Population and Population Density

The regional area, population and population density in Thailand are shown in Table 2.1. The total population of the whole country is about 55 million and the population density is 107 person/km² in 1988. The Northeastern and the Northern regions have the largest areas and populations in comparison to the other regions.

However, Bangkok Metropolitan Area has the highest population density (5,437 person/km²), followed by the Central region. Both regions are the industrial centers in Thailand.

The regional growth rates of population are shown in Table 2.2. The population growth rate of the whole country has decreased from 2.4% in 1985 to 2.0% in 1988. In accordance with this decreasing population growth rate, all regions recorded a drastic decreased population growth rate in 1988 with the exception of the Bangkok Metropolitan Area. This indicates a movement of the population concentration into the Bangkok Metropolitan Area from other regions.

Table 2.1 Area, Population and Population Density by Region

Region	Area (km²)	Population (1988) (Thousand)	Population Density (Person/km²)
Northern Region	169,644.3	10,731.6	63
Northeastern Region	168,854.3	19,254.1	114
Central Region*	18,741.6	2,791.9	149
Bangkok Metropolitan Area	1,565.2	8,509.5	5,437
Eastern Region	37,506.6	3,595.2	96
Western Region	46,087.8	3,217.4	70
Southern Region	70,715.2	6,861.1	97
Whole Kingdom	513,115.0	54,960.8	107

Note * : Excluding Bangkok Metropolitan Area
Source : Registration Div., Dept. of Local Administration, Ministry of Interior.

Table 2.2 Growth Rates of Population by Region

Unit : 1000 persons

Region	1985		1986		1987		1988	
	Population	Growth Rate (84/85)	Population	Growth Rate (85/86)	Population	Growth Rate (86/87)	Population	Growth Rate (87/88)
Northern Region	10,391	1.1%	10,490	0.9%	10,585	0.9%	10,732	1.4%
Northeastern Region	18,061	2.4%	18,552	2.7%	18,884	1.8%	19,254	1.9%
Central Region*	3,553	3.6%	3,651	2.8%	3,724	2.0%	2,792	-25.0%
Bangkok Metropolitan Area	5,363	3.6%	5,469	2.0%	5,609	2.6%	8,509	51.7%
Eastern Region	3,963	3.6%	4,107	3.6%	4,223	2.8%	3,595	-14.9%
Western Region	4,023	2.3%	4,091	1.7%	4,131	1.0%	3,217	-22.1%
Southern Region	6,441	2.2%	6,608	2.6%	6,716	1.6%	6,861	2.1%
Whole Kingdom	57,796	2.4%	52,969	2.3%	53,873	1.7%	54,961	2.0%

Note * : Excluding Bangkok Metropolitan Area
Source : Same as Table 2.1.

2.1.2 Gross Domestic Product

The trend of the Gross Domestic Product (GDP) of Thailand is shown in Table 2.3.

Table 2.3 Trend of GDP of Thailand

Item	Year	1984	1985	1986	1987	1988*
GDP (Current Market Prices)	GDP (Million Baht)	973,412	1,014,399	1,094,679	1,234,030	1,465,736
	Per Capita GDP (Baht)	19,193	19,287	20,790	23,020	26,876

Note * : Estimated figure.
Source : NESDB

The per capita GRDP of each region in 1986 is shown in Table 2.4. The Bangkok Metropolitan Area shows the highest per capita GRDP of about 60,000 Baht, which is almost 3 times as large as that of the whole country. On the other hand, the Northeastern region shows the lowest of about 15,000 Baht, one-forth of Bangkok Metropolitan Area.

Table 2.4 Per Capita GRDP by Region in 1986

Region	Per Capita GRDP (Baht)
Northern Region	13,112
Northeastern Region	8,321
Central Region*	17,082
Bangkok Metropolitan Area	59,885
Eastern Region	30,483
Western Region	21,481
Southern Region	15,542
Whole Kingdom	20,790

Note * : Excluding Bangkok Metropolitan Area
Source : NESDB

2.2 EXISTING ROAD CONDITIONS

2.2.1 Road Classification

Roads in Thailand are divided into the following eight classes for administrative purposes:

1) Special highways
2) National highways
3) Provincial highways
4) Rural roads
5) Municipal roads
6) Sanitary roads
7) Concession highways
8) Expressways

As a basic rule, the first three classes listed above are under the control of the DOH. Figure 2.1 shows the network of special and national highways, which serve as major transportation axes in the country.

2.2.2 Road Length and Density

Table 2.5 gives the length of roads in Thailand by class. Of these, the total length of roads controlled by the DOH is approximately 49,800km as of 1988.

Table 2.6 shows the status of national and provincial highways in 1988 by region. The table indicates the following:

A. The length of paved roads per 1,000 persons is 0.653 km for the nation as a whole. By region, the Southern Region has the highest ratio at 0.963 km.

B. The density of paved roads is 0.07 km/km^2 nationwide. By region, both the Southern and the Central Regions have the highest density at 0.093 km/km^2.

C. The total length of roads under construction or planned for construction is roughly 8,000 km nationwide. Within these new planned roads, 3,952 km will be constructed in the Northern Region, which has the lowest density of paved roads at present.

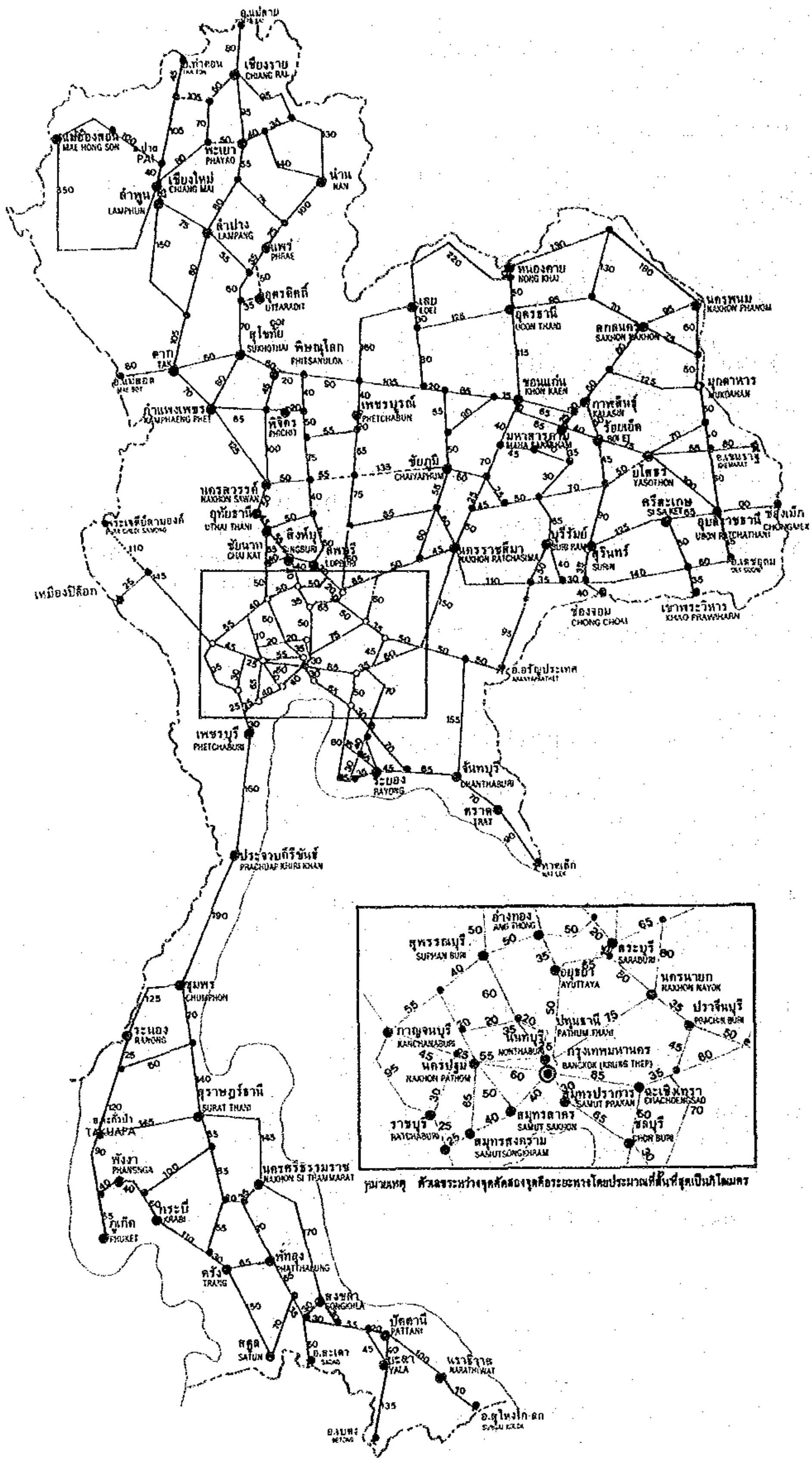

Figure 2.1 Highway Network in Thailand

Table 2.5 Length of Highway Network in Thailand by Road Class

Unit : km

Road Class	1981	1982	1983	1984	1985	1986	1987	1988
1. Special Highway (DOH)	84.0	84.0	84.0	84.0	193.4	193.4	193.4	193.4
2. Expressway (ETA)	8.9	8.9	16.8	16.8	16.8	16.8	27.1	27.1
3. National Highway (DOH)	15,172.0	15,511.0	15,497.0	15,499.0	15,507.6	16,329.6	16,378.6	16,504.6
4. Provincial Highway (DOH)	28,660.0	28,361.0	28,714.0	28,951.0	29,457.0	30,026.0	32,034.0	33,170.0
5. Rural Roads	103,528.6	105,039.6	106,401.6	107,567.6	108,716.8	109,821.6	110,788.6	110,788.6
- The Office of Accelerated Rural Development	15,717.0	16,582.0	17,392.0	17,951.0	18,551.2	19,066.0	19,506.0	19,506.0
- The Royal Irrigation Dept.	3,563.0	3,893.0	4,203.0	4,602.0	4,872.0	5,173.0	5,200.0	5,200.0
- Public Works Department	2,598.0	2,914.0	3,156.0	3,364.0	3,643.0	3,932.0	4,432.0	4,432.0
- Others	81,650.6	81,650.6	81,650.6	81,650.6	81,650.6	81,650.6	81,650.6	81,650.6
6. Municipal Roads	8,541.7	8,541.7	8,541.7	8,541.7	8,544.4	10,174.4	14,709.0	14,709.0
- BMA	1,152.3	1,152.3	1,152.3	1,152.3	1,155.0	2,785.0	2,785.0	2,785.0
- Others	7,389.4	7,389.4	7,389.4	7,389.4	7,389.4	7,389.4	11,924.0	11,924.0
Total	155,995.2	157,546.2	159,255.1	160,660.1	162,436.0	166,561.8	174,130.7	175,392.7
Total Length of DOH Highway	43,916.0	43,956.0	44,295.0	44,534.0	45,158.0	46,549.0	48,606.0	49,868.0

Source : DOH

Table 2.6 Status of National and Provincial Highways in 1988

Item	North	Northeast	Central	South	Total
Area (km^2)	169,644	168,854	103,902	70,715	513,115
Population (1000 person)	10,731	19,254	18,115	6,861	54,961
Density (person/km^2)	63.2	114.0	174.3	97.0	107.1
National Highway (km)					
- Paved	3,366	4,597	4,754	3,105	15,822
- Unpaved	16	34	20	7	77
- Under Construction	360	90	310	39	799
Sub-total	3,742	4,721	5,084	3,151	16,698
Provincial Highways (km)					
- Paved	6,117	5,538	4,893	3,504	20,052
- Unpaved	1,424	2,056	1,390	973	5,843
- Under Construction	3,592	1,548	1,396	739	7,275
Sub-total	11,133	9,142	7,679	5,216	33,170
Total (km)					
- Paved	9,483	10,135	9,647	6,609	35,874
- Unpaved	1,440	2,090	1,410	980	5,920
- Under Construction	3,952	1,638	1,706	778	8,074
Sub-total	14,875	13,863	12,763	8,367	49,868
Density (km/km^2)					
- Paved	0.056	0.060	0.093	0.093	0.070
- Unpaved	0.008	0.012	0.014	0.014	0.012
- Under Construction	0.023	0.010	0.016	0.011	0.016
Sub-total	0.088	0.082	0.123	0.118	0.097
Length (km/1000 person)					
- Paved	0.881	0.526	0.533	0.963	0.653
- Unpaved	0.134	0.108	0.078	0.143	0.108
- Under Construction	0.368	0.085	0.094	0.113	0.147
Sub-total	1.386	0.720	0.705	1.220	0.907

Source : DOH

2.3 MOTOR VEHICLE REGISTRATION

2.3.1 Past Trend of Motor Vehicle Registration

The number of motor vehicle registration in Thailand has been increasing at a rate comparable with the development of the Thai economy. The total number of motor vehicle registrations increased annually by 16.3% from 2.6 million in 1982 to 6.4 million in 1988. Passenger cars have increased annually by 12.9% since 1982 to 816 thousand in 1988, while motorcycles have also increased annually by 18.6% in the same period. Specifically, there was a particular increase of numbers of vehicle registrations in 1988. The past trend of motor vehicle registration by vehicle type is shown in Table 2.7.

Table 2.7 Past Trend of Motor Vehicle Registration in Thailand

Year / Vehicle Type	1982	1983	1984	1985	1986	1987*	1988	Average Annual Increase Rate
Passenger Car	394,189	411,982	541,419	545,369	572,107	n.a.	816,693	12.9%
Motorcycle	1,399,470	1,716,175	1,911,633	1,816,286	1,958,029	n.a.	3,894,824	18.6%
Motor Tricycle	8,923	11,704	11,529	13,220	12,524	n.a.	28,017	17.0%
Bus	196,719	221,015	229,979	256,213	271,611	296,590	428,366	17.8%
Van & Truck	533,601	568,822	597,674	601,883	631,705	720,864	994,407	10.9%
Others	47,293	47,680	49,947	50,620	76,085	n.a.	214,868	28.7%
Total	2,580,195	2,977,378	3,342,181	3,283,591	3,522,061	n.a.	6,377,175	16.3%

Note * : 1987 data of several vehicle type were lost during transference of vehicle registration administration from the Police Dept. to the Land Transport Dept.
Source : Licenses Division, Police Department
Land Transport Department

On the other hand, the production volume of motor vehicles in Thailand has also been increasing at a remarkable rate, as shown in Table 2.8. This increasing trend of motor vehicle production is considered to have accelerated at a drastic pace between 1987 and 1988.

As most economists predict, the scale of the sales markets for motor vehicles in Thailand has reached a level of between 130,000 - 140,000 in 1988, whereas it used to be at a level of 80,000 in both 1985 and 1986.

Table 2.8 Trend of Motor Vehicle Production in Thailand

I t e m	1986	1987	1988 (Jan-Jun)	1988* (Jan-Dec)
Passenger Car	21,046	29,333	22,240	44,480
- Up to 1200 cc	266	42	0	0
- 1201 - 2000 cc	19,744	26,752	20,572	41,144
- Over 2000 cc	1,036	2,539	1,668	3,336
Truck	52,203	68,447	44,990	89,980
- Up to 5 tons	47,419	60,465	40,097	80,194
- 5 - 10 tons	2,625	4,124	2,326	4,652
- Over 10 tons	2,159	3,858	2,567	5,134
Others	913	368	704	1,408
Total	74,162	98,148	67,934	135,868
Index	100.0	132.3		183.2

Note * : Figures for 1988 (1 year) were calculated by doubling the figures of the first half of 1988.
Source : "1988 Year-End Economic Review", Bangkok Post.

2.4 CURRENT TRAFFIC CONDITIONS

2.4.1 Traffic Volume

According to traffic counts on national highways conducted periodically by the DOH, traffic volumes on trunk roads in the Bangkok Metropolitan Area are extremely high, with the most congested sections experiencing volumes in excess of 100,000 - 150,000 vehicles per day. Average daily traffic in nearly all sections of major trunk roads within the area exceeds 50,000 vehicles, while traffic volumes in surrounding areas are also generally high at 10,000 - 30,000 vehicles per day.

In outlying areas, fairly high volumes are seen on national and provincial highways near major cities, but between cities traffic is light. For example, average daily traffic is only 1,000 - 6,000 vehicles on Route 1 in the Northern Region (Nakhon Sawan-Chiang Mai), 2,000 - 8,000 vehicles on Route 2 in the Northeastern Region (Saraburi-Nong Khai) and 1,000 - 2,000 vehicles on Route 41 in the Southern Region (Chum Phon-Hatyai). A traffic flow map of major roads are shown in Appendix 2.1.

2.4.2 Traffic Accident

Figure 2.2 shows the total number of traffic accidents which occurred on all roads in Thailand between 1977 and 1988. The figure indicates that traffic accidents in the country rose from about 15,500 in 1982 to 35,000 in 1988 giving an average annual increase of 14%. Particularly, number of traffic accidents drastically increased in 1988.

As shown in Figure 2.3, the accident rate (number of accidents per 1 million vehicle-kilometers) on roads managed by the DOH declined from 16.5 in 1981 to 9.2 in 1988. This decline is assumed to be the result of accident prevention measures effected by the various agencies concerned in 1978.

Table 2.9, which compares Bangkok's traffic accident statistics in 1988 with those of the nation as a whole, indicates that Bangkok has a high incidence of accidents.

The Fifth Socioeconomic Development Plan (1982 - 1986) addressed the problem of accident prevention, while annual decreases of 3% in the accident rate and 1% in the fatality rate have been targeted in the past. Accident prevention is also one of the issues discussed in the Sixth Socioeconomic Development Plan.

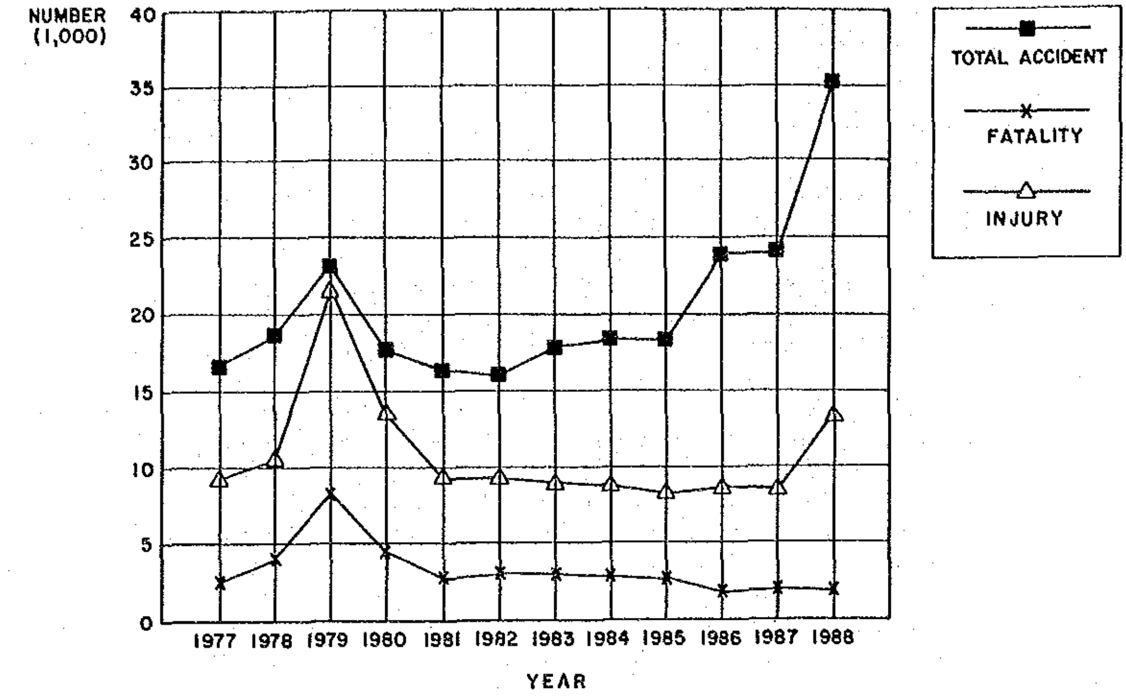

Figure 2.2 Traffic Accidents in Thailand (1976-1988)

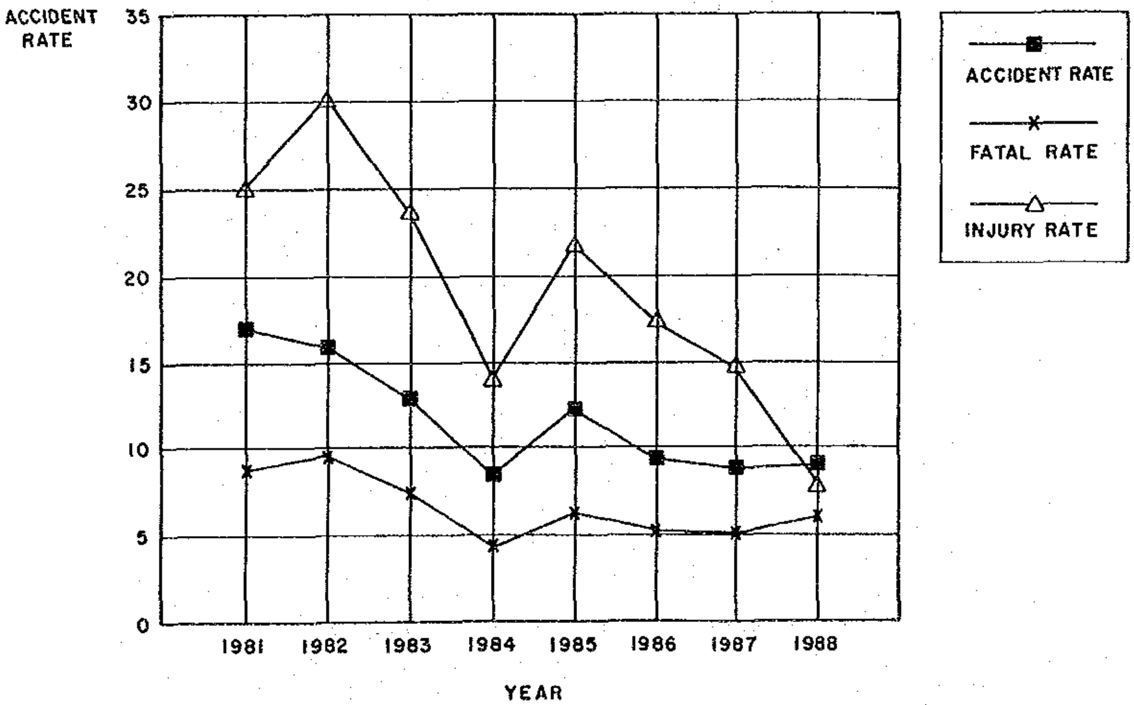

Figure 2.3 Traffic Accident Rate on DOH Highways (1981-1988)

Table 2.9 Traffic Accidents in Thailand and Bangkok in 1988

Item	Bangkok	Thailand Excluding Bangkok	Whole Thailand
No. of Accidents	31,175 (88.3)	4,114 (11.7)	35,289 (100)
No. of Fatality	817 (40.5)	1,198 (59.5)	2,015 (100)
No. of Injury	9,565 (70.8)	3,939 (29.2)	13,504 (100)
Property Damage (Million Baht)	76.4	-	-

Source : Research and Planning Div., Police Department
Note : Figures in parenthesis indicate percentages.

2.4.3 Current Condition of DOH's Traffic Operation Setup

(1) Traffic Conditions

Of the 49,800 km of roads in the nation, only about 450 km mainly in and around the highly-congested Bangkok area are four-lane roads. The rest are two-lane roads. Owing to the low volume of traffic and small number of traffic signals, fast and comfortable driving is possible on two-lane inter-city trunk roads. However, DOH roads experience several problems, as summarized below.

a) Congestion in and around Bangkok

Congestion is particularly pronounced in certain road sections and intersections on trunk roads in the Bangkok Metropolitan Area. In addition, roads in surrounding areas often become congested during the morning and evening commuting hours owing to traffic flowing into and out of Bangkok, respectively.

b) Congestion in Rural Cities

In rural cities such as Chiang Mai that serve as regional centers, congestion occurs during the morning and evening peak hours in surrounding areas owing to commuting traffic. Congestion is said to be particularly severe on bridges and at points where radial roads enter the cities.

c) Congestion Caused by Motorcycles

As mentioned above, motorcycles account for a large proportion of vehicular traffic in Thailand. Because of this, the traffic flows on major carriageways frequently confuse due to higher composition rate of motorcycles, which cause the traffic congestion.

d) Pedestrian Safety

Although crosswalks are provided at various points, pedestrians frequently cross roads at locations other than crosswalks. This is thought to be due to the improper placement of PEDESTRIAN CROSSING signs, as a result of which vehicles do not decelerate when passing a crosswalk and accordingly pedestrians find it difficult to cross at a crosswalk.

To ensure the safety of pedestrians, it is necessary to consider such measures as provision of sidewalks, additional pavement markings, adequate traffic signs, pedestrian bridges or pedestrian signals. For intersections, provision of zebra crosswalk markings, stop lines, and instructions to turning vehicles should be considered.

(2) Traffic Control and Traffic Safety Facilities

DOH has made great efforts to install traffic control as well as traffic safety facilities on its highways. However, several problems can be pointed out regarding these facilities as well as installation methods. The following summarize these problems.

a) Traffic Signals

A. Installation of traffic signals is mainly confined to major intersections in Bangkok, Bangkok suburban area and major cities in regions, while no signals are installed at major intersections in rural areas, even at an intersection between major trunk roads.

B. Number of engineers who can design signal systems are very limited in DOH.

C. Visibility of traffic signals installed is insufficient mainly due to small diameter of lens and low level of illumination.

b) Traffic Signs

A. Traffic signs are frequently stolen because material utilized for traffic signs are aluminum plates. Therefore, it is necessary to produce cheaper signs such as those made of steel plates.

B. The reflective sheets used for traffic signs are costly since they must be imported.

C. The DOH currently employs a number of different standards, which causes confusion in the procurement of materials.

c) Road Markings

Pavement edge lines are only provided on DOH highways. Since illumination is virtually nonexistent on DOH highways in rural areas except at intersections, provision of edge marking is desirable to ensure the visual guidance related to the pavement edge.

d) Delineators and Road Studs

A. Many guideposts made of concrete have reflectorized paint on the top and are installed along curves and approaches to bridges. Reflective paint used for this type of guidepost produces a retro-directive reflecting surface that appears luminous at night under the light from vehicle headlamps. However, reflectance of the guidepost is often reduced by dirt, and reflectance is also lowered in the rain.

B. Road studs of various shapes and sizes are used to guide traffic at curves and other locations in conjunction with crosswalk markings. However, the effectiveness of road studs has not been ascertained.

e) Street Lighting

Street lighting is relatively well provided on DOH highways. However, the high maintenance cost due to the high level of illumination and the collision of motor vehicles with street light supports or poles are major problems at present.

f) Guard Fence

Guard fences provided along DOH highways apparently consist of only a single type of guardrail. Disregarding the fact that they are corrugated, the guardrails are more or less the same as the Type C guardrails used in Japan and are believed to have the same performance level. Type C guardrails are designed to withstand collision speeds of up to 35 km/h and are used on roads ranked below trunk roads in Japan. However, the speed limit on DOH trunk roads is 90 km/h, and the actual speed is even higher. If a heavy vehicle collides with the guardrail, it would not be able to prevent the vehicle from breaking through even if it functions as designed.

g) Vehicle Detectors

All traffic counters currently in Thailand are imported (made in Europe), and it is difficult to obtain spare parts.

2.5 DOH BUDGET

Over the past ten years, the DOH budget has doubled, as shown in Table 2.10. The DOH budget for 1989 is 12 billion Baht, which accounts for 87% of the entire MOTC budget. This large allocation of the MOTC budget to DOH indicates that the highway network under the jurisdiction of the DOH is playing a key role in support of the Thai economy if this is compared with other transport modes, such as railway, air or sea/inland water transport.

Table 2.10 Trend of DOH Expenditure Budget

Year	National Budget (A) (Mill. ฿)	DOH Budget (B) (Mill.฿)	A/B (%)	Subdivision of DOH Budget					
				Administ-ration (C) (Mill. ฿)	C/B (%)	Construc-tion (D) (Mill. ฿)	D/B (%)	Mainte-nance (E) (Mill. ฿)	E/B (%)
1979	92,000.0	6,177.4	6.7	919.6	14.9	4,392.1	71.1	865.7	14.0
1980	114,556.5	7,263.7	6.3	1,475.4	20.3	4,759.2	65.5	1,029.1	14.2
1981	140,000.0	8,781.7	6.3	1,453.1	16.5	6,100.5	69.5	1,228.1	14.0
1982	161,000.0	8,892.0	5.5	1,457.5	16.4	5,571.8	62.7	1,862.7	20.9
1983	177,000.0	9,201.2	5.2	1,695.2	18.4	5,633.3	61.2	1,872.7	20.4
1984	192,000.0	9,088.2	4.7	1,706.7	18.8	5,267.3	58.0	2,114.2	23.3
1985	213,000.0	9,317.6	4.4	1,729.5	18.6	5,179.3	55.6	2,408.8	25.9
1986	218,000.0	8,928.2	4.1	1,757.3	19.7	4,867.8	54.5	2,303.1	25.8
1987	227,500.0	8,562.3	3.8	1,809.3	21.1	4,231.5	49.4	2,521.8	29.5
1988	243,500.0	10,037.8	4.1	1,983.3	19.8	5,208.2	52.0	2,815.8	28.1
1989	285,500.0	11,794.5	4.1	2,057.2	17.4	6,940.1	58.8	2,797.1	23.7

Source : DOH, Financial Division

It is notable upon inspection of the subdivision of the DOH budget that the allocation of budget for maintenance of highways has been increasing in recent years. Road maintenance works, including road improvement works, are predicted to increase more and more in the future. This is due to the expansion of highway network in addition to the improvement of road service level, which now has to cater for an increase in the volume of vehicles including high speed cars and larger size trucks.

2.6 REVIEW OF THE PHASE I STUDY

A review of the Phase I Study was carried out to get information on the measures taken by DOH after submission of the Phase I Study Report, to observe present condition and identify problems of DOH roads.

2.6.1 Experimental Works

Experimental works in the Phase I Study were implemented to confirm the effectiveness of the following counter measures for traffic safety at eight hazardous locations of DOH roads in 1984.

A. Improvement of lane line marking.

B. Improvement of a sub-standard curve by visual guidance.

C. Safeguard of pedestrian.

D. Improvement of turning traffic by signalization.

E. Intersection improvement by channelization.

In this study, a follow-up survey was conducted at each experimental work site and findings are shown in Table 2.11.

The increasing trend of traffic volume growth was very sharp after the Phase I experimental works in 1984, throughout the country especially in the great Bangkok area. The same tendency was observed at all experimental work sites.

Considering the present traffic conditions, some counter measures taken at that time look like rather faded out and further measures were taken to accommodate the increasing traffic problems at three sites out of the eight. Newly adopted main measures are road expansion, installation of pedestrian overpass, and installation of traffic signals.

However, the fact that the remaining counter measures taken at 5 sites still remain effective in spite of the drastic change of traffic circumstances and that these same counter measures have been adopted at other sites by DOH after the Phase I Study, show definitely the counter measures taken at that time were effective.

Table 2.11 Results of Follow-up Survey on Experimental Works of Phase I Study

Route No.	Experimental Works		The Status Quo		Remarks
Location (KP)	Safety Measure	Contents	Measures by Phase I Study	Additional Measures by DOH	
Route 1 (48+000-49+000)	Improvement of Lane Line Marking	Widening Width of Line Marking	Original wide lane marking is disappeared		Edge line making system is generally adopted
Route 306 (2+900-3+200)	Improvement of a Sub-standard Curve by Visual Guidance	- Delineator - Chatter-Bar - Pavement Marking	- Most of delineators remain in use - Chatter-Bars remain in use	- A pedestrian overpass (A cross walk was removed) - Parking prohibition was lifted - Chatter-Bars at adjacent section	Traffic volume seems unchanged
Route 306 (13+500-14+000)	Safeguard of Pedestrian	Sidewalk - Curb Pedestrian Crossing - Refuge Island - Marking - Warning Sign	- Curb remains in part - Refuge Island remains in use - Marking remains - Warning Sign remains	- A pedestrian overpass - Bus bays at both sides - Flashing traffic signals - Removal of curb	Traffic volume increased considerably Remaining Curb and a refuge island are about to be removed
Route 336 (2+700-3+000)	Improvement of Turning Traffic by Signalization	Signalization - Signals for Vehicle Traffic - Signals for Pedestrians	- Signals for vehicle traffic and pedestrians were removed to Route 302 - Median closure was removed - Pedestrian crossings remain in use - Right-turn lanes remain in use	- Shortening of right-turn lanes - Additional leading line markings at the intersection	Traffic conflicts are often observed at the intersection
Route 336 (3+900-4+300)	ditto	ditto	- All signals are working - Pedestrian crossings remain in use - One median closure remain - Another median closure was removed	- A pedestrian overpass at 200 m distance - The structure of median closure was changed from an oil drum barricade to a sodded island - Shortening of right-turn lanes - Additional leading line markings at the intersection - Lane number of a main leg was changed from three to four (raised bars were removed)	
Route 1141 (1+331)	Intersection Improvement by Channelization	- Channelized Island - Marking	- Traffic islands remain in use - Most of traffic signs were removed except for stop signs	- Chatter bars	Under construction for widening the road in all directions
Route 1141 (1+550)	ditto	ditto	- Marking is disappearing - Traffic islands were removed	- Traffic signals for vehicles	ditto
Route 302	Improvement of Turning Traffic from University by Signalization	Signalization - Signals for Vehicle Traffic - Signals for Pedestrians		- All traffic signals are working	Signals for vehicle traffic and pedestrians were moved from Route 336 (2+700 - 3+000) intersection

2.6.2 Case Study

In the Phase I Study, total length of 41.4 km (17 locations) sampled from 11 routes was selected as the Case Study roads.

The criteria for selecting "Case Study sections" were:

A. High frequency of accidents.

B. Sub-standard alignments and disorderly traffic flow.

C. Concerns expressed by relevant parties.

In the Study, follow-up survey of the case study in the Phase I Study was carried out to make clear how the selected case study sections were improved in compliance with the plans recommended in the Phase I Study. Detail of the recommended counter measures and actual counter measures at each location are shown Table 2.12.

Table 2.12 Results of Follow-up Survey on Case Study of Phase I Study (1/2)

Route No.	Section No.	Road Classification by Type	Main Countermeasures in Case Study	Actual Countermeasures	Remarks
1	S1	Roadway; Tangent Small Intersection	Installation of pedestrian bridge Installation of guard fence Restriction of parking Provision of stop line marking	Installation of pedestrian bridge in 1989	
	S2	Large Intersection	Construction of frontage-road Securing of bus-stop space Installation of traffic signals Provision of right turning lane		Construction of Interchange is planned in 1989
	S3	Roadway; Tangent	Installation of wide lane and edge line marking	Materialized as an Experimental Work Installation of pedestrian bridge	
32	S4	Small Intersection	Provision of marking Installation of chatter-bar Paving of shoulder		Overlaid
304	S5	Roadway; Tangent/ Crest Small Intersection	Prohibition of overtaking Installation of warning sign Paving of crossing road Provision of marking		
323	S6	Large Intersection	Installation of traffic signals Provision of crosswalks	Installation of traffic signals Provision of crosswalk	
302	S7	Roadway; Tangent	Construction of frontage road Installation of median Installation of pedestrian bridge	Installation of pedestrian bridge	

Table 2.12 Results of Follow-up Survey on Case Study of Phase I Study (2/2)

Route No.	Section No.	Road Classification by Type	Main Countermeasures in Case Study	Materialized Countermeasures	Remarks
306	S8	Medium Intersection	Reduction of intersection in size Provision of right and left turning lanes Installation of pedestrian crossing Installation of guardrail Provision of marking		Installation of traffic signals is requested by BMA
	S9	Roadway; Curve	Installation of delineator Installation of chatter-bar Restriction of parking	Materialized as an Experimental Work	
	S10	Roadway; Tangent	Installation of refuge islands Installation crosswalk marking Installation of sidewalk by curb Installation of warning sign and marking Construction of bus bays	Materialized as an Experimental Work	After E/W, a pedestrian bridge and bus bays were installed
336	S11	Roadway; Tangent Medium Intersection	Installation of signals for vehicular traffic Installation of signals for pedestrian Installation of pedestrian crossing Coordination of traffic signals Restriction of turning vehicles at median-openings	Materialized as an Experimental Work	
3113	S12	Roadway; Tangent	Construction of sidewalk Installation of pedestrian bridge Installation of parking-lane Installation of chatter-bar Installation of guard fence		Road rehabilitation is planned
11	S13	Medium Intersection	Provision of bicycle ways		
1141	S14	Medium Intersection	Channelization at T-shaped intersection and Installation of traffic signals Installation of right-turning lanes	Materialized as an Experimental Work	Road widening is underway
2	S15	Large Intersection	Installation of samlor lane Installation of side walk Installation of pedestrian crossing Installation of guardrail Installation of chatter-bar		Road improvement is planned
	S16	Medium Intersection	Installation of traffic signals Installation of pedestrian, samlor and bicycle crossing		Road rehabilitation is underway
205	S17	Roadway; Tangent/ Narrowing	Installation of marking		

2.7 REVIEW OF THE HIGHWAY ACCIDENT PREVENTION PROJECT

"Highway Accident Prevention Project" (referred to as the Project hereinafter) is one of the main projects in "Five Years Plan for Construction and Rehabilitation of Highways (1987-1991)". To provide safety to road user, the Project started with the total budget of six hundred and five million baht since fiscal year of 1987. In the Study the program and the progress of the Project was investigated.

2.7.1 The List of Safety Program Measure

Following six works are listed as comprising the safety program.

1) Highway improvement

Construction and revision of highways and installation of safety equipment, including the various traffic signs.

2) Installation of street lighting

3) Installation of traffic signals

Installation of traffic signals, construction of traffic islands to enable the installation of traffic signal posts, provision of crosswalks and installation of traffic signs required.

4) Installation of guard rails/walls.

Installation of guard rails or walls to prevent fatal accidents due to vehicle's swerving from their normal paths including the provision of light-reflecting tape and painting or signs to guide traffic during the night time.

5) Construction of bicycle lanes/foot paths.

Construction of new bicycle lanes or foot paths to enable bicycles or pedestrians to travel safely from one point to another.

6) Construction of pedestrian overpass/underpass

Construction of pedestrian overpasses or underpasses to enable pedestrians to cross safely from one side of the road to the other, including all works contributing to the above objective, e.g. bus stops, protective walls for overpass pillars, traffic signs showing clearance height and illuminating lights, etc.

Performed and planned works classified by nature of work are shown in Table 2.13.

Table 2.13 Amount of Work Performed and Planned Classified by Nature of Work

Unit : locations

Fiscal Year	1987	1988	1989
Road Improvement	6	12	26
Light & Signal	14	68	133
Guard Rail	55	87	158
Bicycle Lane	3	3	3
Pedestrian Bridge	0	1	18
Total	78	171	338
Remarks	executed	executed	under way

Source : DOH

The fact that the works are dispersed to all divisions of DOH (15 divisions), shows the program is proceeding throughout the country.

2.7.2 Amount of budget

In the Phase I Study, investment schedule for "Highway Accident Prevention Project" was recommended as shown in the second column of Table 2.14. These figures were estimated under the assumptions shown below.

A. Growth rate of National budget : 10% per annum

B. MOTC Budget : 6% of National budget.

C. DOH Budget :
Share against MOTC budget is reduced from 82.0% in 1985 to 70% in 1993 and thereafter.

D. DOH Maintenance Budget :
Share against DOH Budget is from 22% in 1985 to 25% in 1988 and thereafter.

DOH has started the Project in 1987 and its investment schedule, budget and expenditure are shown from third to fifth column of Table 2.14.

According to the investment schedule of DOH, the year-to-year investment amount is quite similar to the recommended investment schedule. It shows that the Phase I Study has been put to practical use.

Table 2.14 Budget and Expenditure for "Highway Accident Prevention Project"

Unit : Million Baht

Fiscal Year	Recommended Investment Schedule In Phase I Study	DOH's Investment Schedule	Budget	Expenditure	Finance Source
1987	82	109	45	52.9	DOH's own budget
1988	109	115	120	89.5	DOH's own budget 50% IBRD loan 50%
1989	130	121	207	-	ditto
1990	139	127	-	-	-
1991	159	133	-	-	-

Source : DOH

CHAPTER 3 IDENTIFICATION OF PROBLEM SECTIONS ON DOH ROADS

CHAPTER 3 IDENTIFICATION OF PROBLEM SECTIONS ON DOH ROADS

3.1 BASIC CONCEPT OF IDENTIFICATION OF PROBLEM SECTIONS ON DOH ROADS

Road administration is generally carried out by the following procedures:

1) Understanding the traffic conditions on the roads
2) Understanding problems and problem sections
3) Provision of countermeasures (alternatives)
4) Evaluation and screening of the alternatives
5) Implementing the countermeasures
6) Inspecting the effect of countermeasures

The objective phenomena under the above items (1) Understanding the traffic conditions on the roads and (2) Understanding problems and problem sections are comprised of multiple factors, such as the fundamental traffic flow elements consisting of traffic volume, vehicle speed, and density, driving amenity, which is very difficult to be expressed numerically, and also on the minus side the traffic accidents and environmental pollution. Therefore, evaluation of traffic conditions on the roads having a variety of characteristics may change a viewpoint in accordance with the traffic situations on the roads. Generally the main evaluation items are as follows:

- Smoothness
- Safety
- Amenity
- Accessibility
- Economical efficiency
- Environmental protection

In the above items, amenity covers smoothness, safety and comfortable driving and visibility which depend on the driver's subjective evaluation.

Accessibility is a feature of the road network.

Economical efficiency represents macroscopic items such as an energy consumption of road traffic and the investment effect of road improvement.

Environmental protection covers the evaluation of roadside inhabitants.

The aim of the Study is to understand and evaluate the traffic situation in each road section macroscopically and objectively from the viewpoint of the road administrators.

In the Study, smoothness and safety are to be evaluated because the related data can be collected and a numerical and reliable analysis is available. The basic concept of the evaluation from the viewpoint of traffic smoothness and traffic safety are described as follows:

(1) Smoothness Evaluation

Smoothness of the traffic is mainly represented by travel speed on the road sections under examination. Travel speed is a unique traffic situation indicator and most drivers will evaluate the traffic situation by travel speed. In the light of these facts, travel speed is an excellent indicator of the traffic situation; however, travel speed data collected through the traffic census survey which is observed once a day are limited and inapplicable to the varied traffic situations on the roads from hour to hour. Traffic density can also be one of the indicators related travel speed.

However, because of the difficulty of data collection, traffic density for the specified road sections has not been applied except for the special case in which the detailed data models of the traffic situations are built up from the estimated traffic situations such as estimated congestion, estimated travel speed, etc.

Traffic volume is a basic data item collected through traffic surveys. In the case of evaluating traffic situations on roads using traffic volume, traffic volume to traffic capacity ratio at each road section can be a useful indicator. Traffic volume to traffic capacity ratio not only indicate traffic congestion rate, but also have an advantage of providing some correlation between traffic volume and travel speed. Accordingly, in the Study, traffic congestion rate is to be used as an indicator for traffic smoothness.

(2) Safety Evaluation

Even in cases where drivers are to blame for traffic accidents (i.e. driving, while intoxicated etc.), there are occasional cases found in which the traffic circumstances force a driver to make an error or delay judgment. Under this situation the driver is required to make many instant decisions or makes errors of judgment.

If the traffic accidents which occurred during certain periods are recorded in a map of the roads by affixing identifying tags, then similar types of the traffic accidents may be concentrated at specific points. These points as compared with the others come under traffic circumstances mentioned above.

Such frequent traffic accident points on the roads are usually called hazardous locations. In the Study, the hazardous road sections are extracted by identifying the hazardous locations. Accordingly, the traffic accident rate is used as an indicator of traffic safety.

3.2 IDENTIFICATION OF PROBLEM SECTIONS THROUGH THE TRAFFIC CONGESTION RATE

Generally, in the case of low traffic volume, drivers are able to drive their vehicles without paying undue attentions to the other vehicles in front and behind. They are able to be freely adjust their speed within allowable scope of road alignment and speed limit. However, with an increase in traffic volume, driving speed as a whole is under the constraint of other vehicles and if traffic volume on the roads reaches a certain degree, traffic can not increase beyond the limit. This limitation of traffic volume is known as the traffic capacity.

Although, traffic capacity is calculated on the basis of characteristic on each road section, traffic capacity itself exhibits considerable fluctuation. It is merely an average value whether many actual sampling data are used or not and there are occasions when congestion occurs with less traffic volume than the calculated capacity or at other large times a traffic volume than calculated is observed.

However, in micro terms, a few problems in relation with traffic volume and traffic capacity may appear, but from a macroscopic viewpoint, smoothness at each road section is shown to some extent. In the Study, traffic volume to traffic capacity rate, namely, traffic congestion rate is determined to apply as an index of smoothness. DOH roads are classified into non intersection (roadway) and intersection. However, in order that traffic capacity on the intersections may be calculated, the detailed data of operating traffic lane and traffic phase on each intersection are necessary. However, as it is very difficult to collect completely these data in the Study, the objects of identifying problem sections are determined to apply to only non intersections (roadway sections).

3.2.1 Method of Calculating Congestion Rate

Calculation of traffic capacity to obtain congestion rate is described in detail in the Highway Capacity Manual prepared by the Transportation Research Board of the United States. Traffic Capacity based on the Manual reflects conditions of roads and traffic in the United States, however, and, at the time of application, collection and analysis of various data of traffic capacity are required. There are not many records of research conducted on traffic capacity in Thailand it is not at present appropriate to calculate traffic capacity reflecting conditions of roads and traffic in Thailand.

A method applied in Japan is adopted in the Study to calculate traffic capacity for obtaining the congestion rate. The reason for adopting a method applied in Japan is that there is not enough accumulation of data for determining specific traffic capacity applicable to Thai situation and there also is no ground for using values applied in the United States.

In the Study the method used for calculating congestion rate appears in Figure 3.1.

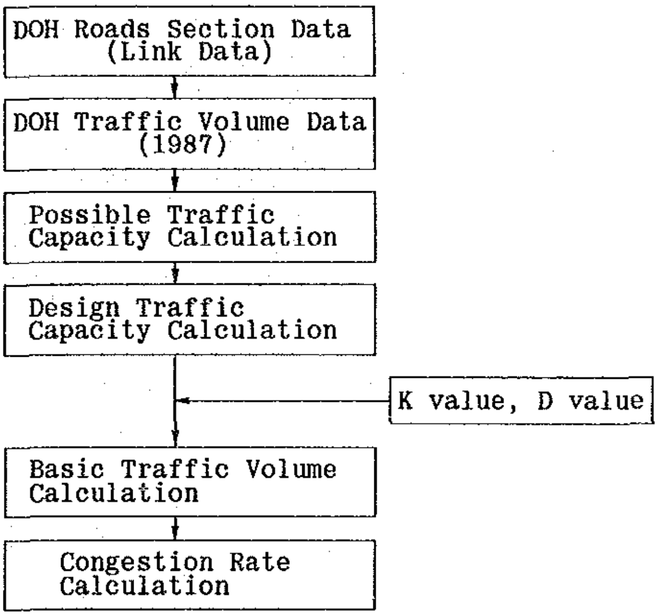

Figure 3.1 Traffic Congestion Rate Calculation Flow Chart

(1) Equation for Calculating Possible Traffic Capacity Volume

The following equation to calculate possible traffic capacity volume may be applied to general roads without signalized intersection and further, each correction rate calculating equation is shown in Table 3.1.

(Single Lane Road)

$$C = \frac{600}{(5.5 - 3.5)} (W - 3.5) + 50 \qquad (3.5m < W < 5.5m)$$

$$C = 50 \qquad (W < 3.5m)$$

W : Lane width

(Double Lane Road)

$$C = 2200 * \gamma_L * \gamma_C * \gamma_N * \gamma_I * 2 \text{ (pcu/hour)}$$

(one direction)

$C = 2500 * \gamma_L * \gamma_C * \gamma_N * \gamma_I$ (pcu/hour)
(two directions)

γ_L : correction rate by lane width
γ_C : correction rate by lateral clearance
γ_N : correction rate by mixed with two wheeled vehicles
γ_I : correction rate by roadside situation (parking)

(Multi Lane Road)

$C = 2200 * \gamma_L * \gamma_C * \gamma_N * \gamma_I * N$

N : number of traffic lane

Table 3.1 Correction Rate of Traffic Capacity on Roadway Section

<table>
<tr><td>Corrected by Lane Width
γ_L</td><td>$\gamma_L = 1.0 \quad (W_L \geqq 3.25m)$
$\gamma_L = 0.24W_L + 0.27, \quad (W_L < 3.25m)$
γ_L : Correction rate by lane width
W_L : Lane width (m)</td></tr>
<tr><td>Corrected by Lateral Clearance
γ_C</td><td>$\gamma_C = 1.0 \quad (W_C \geqq 0.75)$
$\gamma_C = 0.18W_C + 0.86 \quad (W_C < 0.75)$
γ_C : Correction rate by lateral clearance
W_C : Lane width (m)</td></tr>
<tr><td>Corrected by Mixed with Two-Wheeled Vehicle
γ_N</td><td>$\gamma_N = \frac{100}{100+\alpha \cdot P_m+\beta \cdot P_B} = \frac{1}{1+\alpha \cdot P_m/100-\beta \cdot P_B/100}$
γ_N : Correction rate by congestion of two-wheeled vehicle
α : Passenger car equivalent of motor two-wheeled vehicle
P_m : Motor two-wheeled vehicle Ratio (%)
β : Passenger car equivalent of bicycle
P_B : Bicycle ratio (%) to be consistent with P_m</td></tr>
<tr><td>Corrected by Roadside Situation
γ_N</td><td>Correction rate by roadside situation γ_N
<table>
<tr><th>roadside situation / number of traffic lane</th><th>Two lane and below</th><th>Multi lane</th></tr>
<tr><td>Motor way</td><td>1.00</td><td>1.00</td></tr>
<tr><td>Mountain area</td><td>0.90</td><td>0.95</td></tr>
<tr><td>Plain area</td><td>0.85</td><td>0.90</td></tr>
<tr><td>Urban area</td><td>0.70</td><td>0.75</td></tr>
</table></td></tr>
</table>

All data in relation to lane width and other characteristics on the roads use the DOH data base (link data); however, since much of collected data on lane width from the above data were incomplete and incorrect, lane width data were inapplicable and a correction rate for traffic mixed with two wheeled vehicle was applied as follows:

the vehicle conversion rate on the local roads (Motor two wheeled vehicle=0.75, Two wheeled vehicle=0.5), and the correction rates for a road side situation are applied uniformly at a ratio of 0.90.

(2) Equation for Calculating Design Traffic Capacity

Design traffic capacity is calculated by multiplying the possible traffic capacity which was calculated at (1) by a diminution rate according to level of service as shown in following table.

$$CD = C * \gamma_P$$

where, CD : Design traffic capacity (pcu/hour)
C : Possible traffic capacity (pcu/hour)
γ_P : Diminution rate

Level of Service	Diminution Rate γ_P	
	Rural Area	Urban Area
1	0.75	0.80
2	0.85	0.90
3	1.00	1.00

(3) Equation for Calculating Evaluation Basic Traffic Volume

Basic traffic volume is calculated using design traffic capacity, K value and D value. Basic traffic volume is calculated on the basis of multi lane road, single lane road, two lane road and one way road respectively and the equations are as follows:

$$CE = \frac{CD/2}{(K/100)*(D/100)} = CD * \frac{5000}{K*D} \quad \text{(multi-lane road)}$$

$$CE = \frac{CD}{K/100} = CD * \frac{100}{K} \quad \text{(single lane road, two-lane road and one way road)}$$

where; CE : 24 hour basic traffic volume (pcu/24 hours)
CD : Design traffic volume (pcu/hour)
K : 30th traffic hour volume ratio (%) against annual average 24 hours traffic volume
D : Peak hour heaviest directional traffic ratio (%)

The K and D values are as follows:

The applied K value is 10.3% peak ratio on a basis of the Car-OD survey results around Bangkok Metropolitan Area. (Applied hour 9:00 - 10:00)