

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

NOVEMBER 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct an After-care Study on 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 study team headed by Dr. Kaoru Ichihara, Central Consultant Inc., composed of members from Central Consultant Inc., and Oriental Consultants Co., Ltd. between April 1991 and September 1991.

The team held discussions with the officials concerned of the Government of the Kingdom of Thailand, and conducted a field survey at the study area. 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.

November 1991



Kensuke Yanagiya
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

November 1991

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 Aftercare 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 gratitude are due to Japan International Cooperation Agency, 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,



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

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DRAFT FINAL REPORT**

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LIST OF ABBREVIATIONS

GOKT	:	Government of the Kingdom of Thailand
JICA	:	Japan International Cooperation Agency
DOH	:	Department of Highways
TED	:	Traffic Engineering Division
TOPR	:	Traffic Operation Plan for Roads in the Kingdom of Thailand
ATOPR	:	Aftercare Study on Traffic Operation Plan for Roads in the Kingdom of Thailand
SIMR	:	The Study on Medium to Long-term Improvement/Management Plan of Road and Road Transport in Bangkok in the Kingdom of Thailand
NESDB	:	National Economic and Social Development Board
DTCP	:	Department of Town and Country Planning
BMA	:	Bangkok Metropolitan Administration
ETA	:	Expressway and Rapid Transit Authority of Thailand
AIT	:	Asian Institute of Technology
GDP	:	Gross Domestic Product
GRDP	:	Gross Regional Domestic Product
ADT	:	Average Daily Traffic
pcu	:	Passenger car unit
RHV	:	Heavy Vehicle Ratio
DIAR	:	Death and Injury Accident Rate
Kp.	:	Kilometre post
w	:	width
km.	:	kilometre
mil.	:	million
hr.	:	hour

SUMMARY

SUMMARY

1. INTRODUCTION

1.1 Background

Traffic volume has increased dramatically in Thailand in the last decade and this has resulted in deteriorating traffic conditions. Past efforts by the Government of the Kingdom of Thailand (GOKT) to deal with traffic problems have been dwarfed by this rapid traffic growth. In recent years, the GOKT has focused on the improvement of road and traffic facilities and this has been supported by a number of programmes. However, traffic problems have persisted, especially in urban areas which suffer from traffic congestion and high accident levels.

In order to find solutions for Thailand's road traffic problems, the Japan International Cooperation Agency (JICA) was requested by the GOKT to conduct a Traffic Operation Plan for Roads in the Kingdom of Thailand (the TOPR Study), from January 1989 to June 1990.

At present, the DOH is preparing the Seventh Highway Development Plan in the Seventh National Economic and Social Development Plan, with reference to the TOPR Study results. As part of the DOH Seventh Plan, JICA has been requested to produce an Aftercare Study on Traffic Operation Plan for Roads in the Kingdom of Thailand (herein referred to as the Study). The Study looks at traffic safety and traffic operation. Within this, the Study provides details and plans to facilitate the progress of the preparation works and the implementation of the Seventh Highway Development Plan.

The decision was taken by the Government of Japan 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 and the Study Area

(1) Objectives of the Study

The Objectives of the Study are:

- a) To formulate the traffic operation plan for reducing road traffic accidents in Thailand, from the engineering point of view;

- b) To recommend a suitable plan for the improvement of roads by applying the Study on the Traffic Operation Plan for Roads in the Kingdom of Thailand (TOPR);
- c) To transfer technology and training to Thai counterpart personnel in the course of the Study.

(2) Study Area

The study area is defined as the roads predominantly under the jurisdiction of the DOH within the area of the Outer Ring Road of Bangkok.

1.3 Study Procedure

The procedure to accomplish the Study objectives, was as follows:

(1) Review and Preparation of the Preliminary Survey

- Review of the TOPR Study;
- Analysis of the Seventh Highway Development Plan;
- Review of road and traffic conditions in the Study Area;
- Review of economic activities and land-use in the Study Area.

(2) Preparation of Improvement Plan

- Collection and analysis of data;
- Identification of traffic problems;
- Selection of Study Sections for the preliminary designs;
- Supplemental surveys;
- Selection of measures for traffic control/safety;
- Preliminary design;
- Cost estimation.

(3) Recommendations for the Traffic Operation Plan

1.4 Reports

The following reports were submitted or is to be submitted to the DOH.

- Inception Report : April, 1991
- Draft Final Report : September, 1991
- Final Report : November, 1991

2. CURRENT CONDITION OF THE DOH'S TRAFFIC OPERATION SET-UP

2.1 Review of the TOPR Study

A review of the TOPR Study was carried out through discussions with the DOH and site investigations. The findings are summarized below.

(1) Technical Guidelines and Engineering Specifications

Technical guidelines, including a warrant, and engineering specifications on the various kinds of traffic safety and traffic control devices, have been prepared in the TOPR Study.

The guidelines and specifications outlined in the TOPR Study, have been used effectively at the DOH for the selection of countermeasures to improve traffic problems. No major problems in the utilization of the above guidelines and specifications have been raised since the submission of the Final Report of the TOPR Study.

(2) Traffic Operation System

In the TOPR Study, basic traffic operation systems were recommended.

After the submission of the TOPR Study Final Report, the DOH has been considering ways of developing these systems based on the results of the TOPR Study. Preparatory work is being carried out to look at the requirements for the introduction and execution of these systems. These include logistical, financial and manpower requirements.

In terms of the traffic information system, discussions between the BMA and the DOH have begun on this matter. In addition, the implementation plan for controlling the traffic flow by variable information boards on R34, has been prepared. Following this action, the execution of the case study in Chonburi will be approved in the Seventh Highway Development Plan.

(3) Experimental Works and Case Studies

a) Experimental Works

Experimental works were carried out at four locations to evaluate the effectiveness of traffic control and safety measures.

In general, each traffic operational measure has functioned well.

Motorcycle lanes and passing lanes are newly introduced measures in Thailand and their purpose seems to have been well understood by the road users. At present, there are plans to extend these measures to other sections and to other roads.

b) Case Studies

Case studies were conducted at five planning sections as demonstrations of how to cope with major traffic problems.

In the Study, these case studies were reviewed to determine the status of implementation at each planning section after submission of the Final Report.

Of the five case study sections, implementation work has been completed in 1991 in three planning sections. Implementation of improvement work in the other sections has been approved for 1992 by the DOH. Grade separation has been adopted as the long-term solution at Wang Noi intersection and the plans are being prepared by the DOH.

2.2 Analysis of the Seventh Highway Development Plan

The Seventh Highway Development Plan is now under preparation. The target years are from October 1991 to September 1996. The main framework of this plan is analyzed in the Study.

The total budget of the DOH Seventh Plan will be 94,431 million baht, excluding maintenance work and continued projects in the Sixth Plan. The promotion of traffic safety is one of the main policies of the DOH Seventh Plan and the investment for the traffic safety project is 2,000 million baht.

Traffic safety measures, such as signs, signals, street lighting, pedestrian overpasses, guard fences, etc., for 619 locations, will be constructed under the traffic safety project. Construction of passing and climbing lanes, and the installation of information facilities for the locations selected by the TOPR Study will also be included in this project. Grade separations and railway crossings will be implemented under the construction project. The bicycle lanes program will be changed to the motorcycle lane program and constructed under the road maintenance project.

The results of the Study will be presented in the Seventh Highway Development Plan.

2.3 Review of Road and Traffic Conditions in the Study Area

(1) Road Conditions

The total length of roads controlled by the DOH was approximately 52,300 km. in 1990. Of these, the central region covering the Study Area had the length of roads at approximately 12,900 km. and the totalled length of roads within the Study Area is approximately 714 km.

Regarding the status of the national and provincial highways in 1990 by region, the total length of roads under construction, or planned for construction nationwide, was roughly 6,900 km. with approximately 1,300 km. scheduled for the central region.

(2) Traffic Conditions

Current traffic conditions in the Study Area indicate the following:

- A. The traffic volume growth factor between 1987 and 1990 was 1.73 for the Study Area as a whole. Traffic volume growth factors between 1987 and 1990 are greater than 2.0 on Route 303, 304, 340, 3035, 3104, 3110, 3111, 3215 and 3242;
- B. The daily traffic volume on Route 31 was approximately 180,000 vehicles per day, while Routes 1, 3, 34, 302, 304, 308, 346, 3113 and 3344 had more than 50,000 vehicles per day;
- C. The average peak-hour factor in the Study Area is approximately 7.2%;
- D. The average vehicle type composition on roads in the Study Area in 1990 indicates that passenger cars made up 47% of all vehicle types, buses comprised 11%, trucks 35%, and motorcycles (including bicycles) 7%.

(3) Accident Conditions

Current accident conditions in the Study Area indicate the following:

- A. The national total figure of accidents recorded in 1989 was approximately 42,500 cases and the national total figure of casualties was approximately 20,000 persons. The Bangkok Metropolis accounted for 85% (approximately 36,000 cases) of all accidents and 62% (approximately 12,500 persons) of all casualties;
- B. The total number of accidents that occurred in the Study Area in 1988 was 4,925, which caused 2,365 casualties and an accident rate of 28.5 persons/100 million vehicle-kilometers.

2.4 Review of Economic Activities and Land-Use in the Study Area

(1) Socioeconomic Conditions

The total population of Thailand was 55.9 million and the population density was 109 persons/km² in 1989. Bangkok Metropolitan Area, which covers the Study Area, has the highest population density (3,727 persons/km²).

Per capita gross domestic product (GDP) was 32,043 Baht in 1989. By region, the Bangkok Metropolitan Area had the highest per capita gross regional domestic product (GRDP) of approximately 72,000 Baht in 1987.

(2) Land-Use

Urban areas have developed mainly in the south-eastern and north-eastern directions during the recent rapid economic boom in Thailand. The main urbanized areas in the south-eastern direction are along route 3 and 34. The establishment of factories and residential areas are underway along these roads. On the north-eastern direction along route 1, the development of industrial estates and residential areas has progressed rapidly.

(3) Motor Vehicle Registration

The total number of motor vehicle registrations in Thailand increased annually by 14.9%, from 2.1 million in 1981 to 6.5 million in 1989. Of these, bus registration has increased annually by 18.9% and motorcycles registration has increased annually by 17.2%.

In the Bangkok Metropolitan Area, the total number of registrations increased annually by 11.5% from 0.72 million in 1981 to 1.72 million in 1989. The percentage growth rate for buses is the highest at 31.1%.

3. SELECTION OF TRAFFIC OPERATIONAL MEASURES IN THE STUDY SECTIONS

3.1 Methodology of Traffic Operation Planning

In order to formulate and enforce an effective traffic operation plan, the following procedures should be observed:

- A. Selection of section locations;
- B. Identification of traffic problems and problem sections;
- C. Selection of traffic operation measures (preparation and comparative evaluation of alternative measures);
- D. Implementation of traffic operation plan;
- E. Implementation of follow-up survey.

Figure 1 shows the standard process of traffic operation planning.

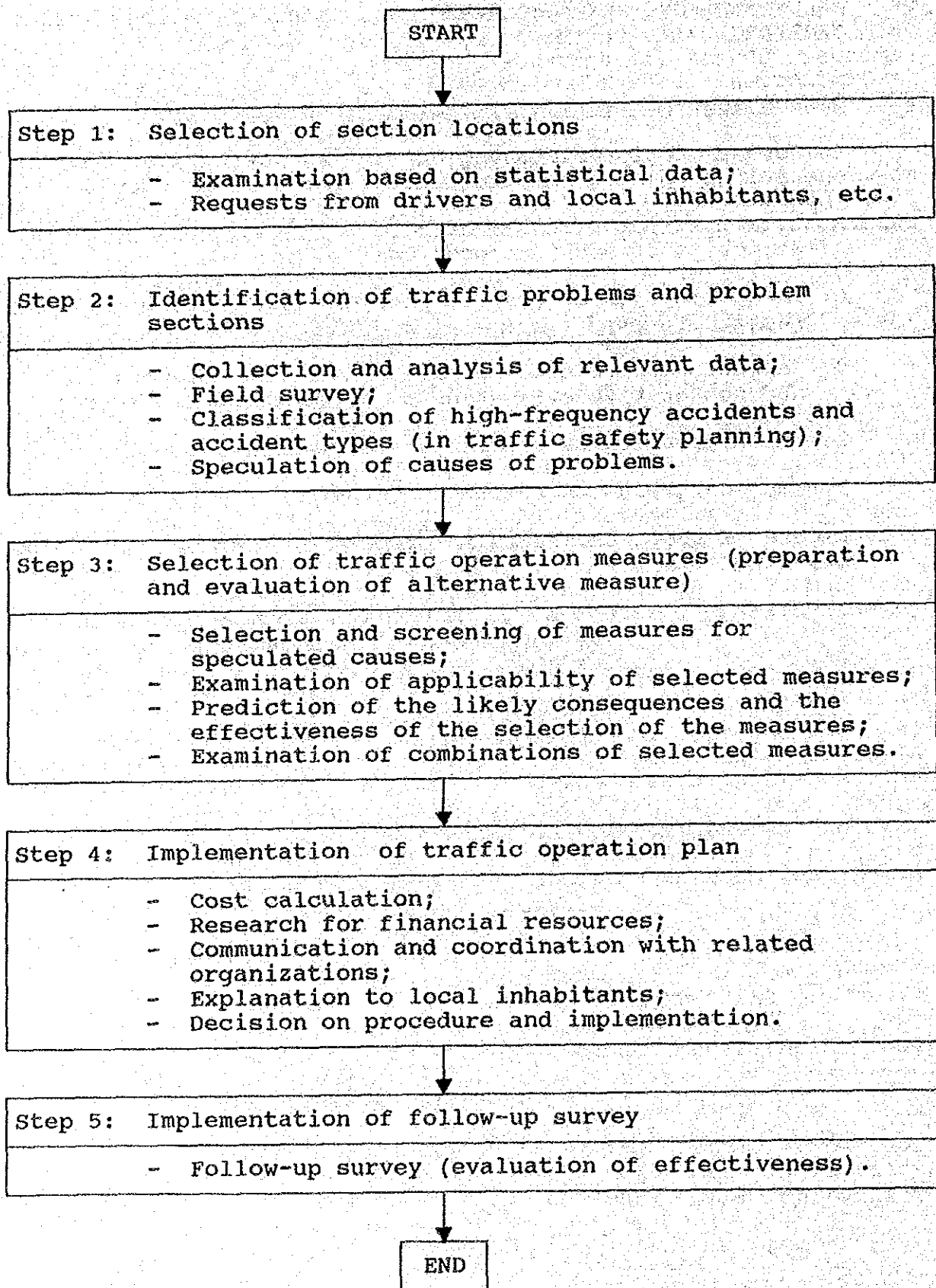


Figure 1 STANDARD PROCESS OF TRAFFIC OPERATION PLANNING

3.2 Selection of Study Sections

For the purpose of selecting Study Sections, a number of proposed sections, which met the following conditions, were screened:

- A. Sections whose inclusion in the Study Area was strongly desired by road administrators, users and neighbouring inhabitants;
- B. Sections considered highly susceptible to accidents from the analysis of various data, including traffic accident data;
- C. Sections considered needy of improvement for better traffic operation using on-site data.

The final selection of the Study Sections was made after consultation with the DOH.

The Study Section selected are shown in Table 1 (in section 3.4). Of a total of 59 selected Study Sections, 24 required intersection improvements, 6 required improvements to the general road sections, and 29 needed improvements to provide greater safety for pedestrians.

3.3 Traffic Data Analysis

(1) Analysis of Traffic and Accident Data

Traffic accident analyses at each Study Section were carried out based on traffic accident data in 1988.

The traffic accident conditions at each Study Section indicate the following:

- A. The death and injury accident rate (DIAR) in the entire Study Area was 35.2 casualties/100 mil. vehicle kilometers. Study Sections where the casualty rate was especially higher than this average are S-16 (R34), S-17 (R34), S-29 (R304), S-30 (R304), S-31 (R304), S-39 (R306), S-49 (R340) and S-51 (R3119);
- B. Pedestrian-vehicle collisions totalled 141 cases in the entire Study Area (12.2% of all accidents). Sections where the frequency of this type of collision is relatively high are S-1, S-16 and S-17;

C. Vehicle-vehicle collisions include many side, passing and rear-end collisions. There were 208 cases of side-swiping accidents for the entire Study Area (18.0% of all accidents), and they occurred most frequently on sections S-1, S-6, S-16, S-17, S-25, S-27, and S-46. Rear-end collisions totalled 341 cases for the entire Study Area (29.4% of all accidents), and their frequency was high on sections S-1, S-16, S-17, S-25, S-27, S-28 and S-47.

(2) Supplemental Traffic Survey

The traffic surveys were carried out by the Study Team in order to obtain data on the traffic control and safety measures at selected Study Sections.

Traffic surveys are divided into: a vehicle count survey at intersections; a vehicle count survey at roadsides; and a road crossing pedestrian count survey.

3.4 Formulation of Measures

(1) Procedure

The selected countermeasures were examined on the basis of the technical guidelines and the engineering specifications in the TOPR Study. In particular, they were examined according to the flow chart shown in Figure 2.

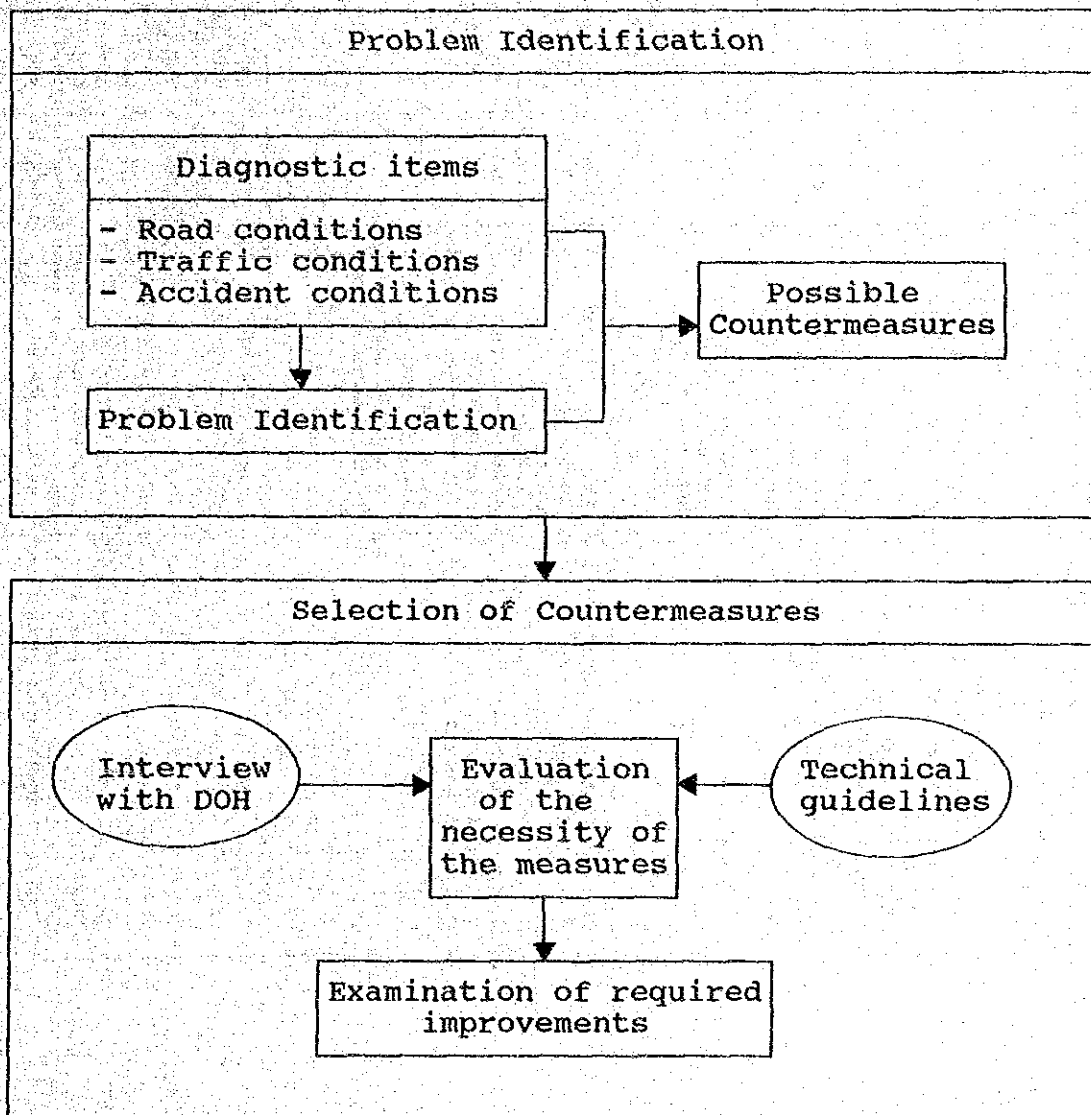


Figure 2 FLOW CHART FOR EXAMINING COUNTERMEASURES

(2) Problem Identification and Selection of Countermeasures

Table 1 shows traffic operation problems and the countermeasures considered effective in resolving these for each Study Section, together with the justification of such countermeasures.

Table 1 Basic Conception for Measure (1)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Results of Examination	
					Measures	Necessary Grounds of Necessity
1.	1	Saphan Mai Market	19+000 - 21+500 (2.5)	<ul style="list-style-type: none"> Traffic volume exceeds the capacity of stop-controlled intersection. Confusion from vehicles making U-turn (in 19.8 kp). Dangerous condition of pedestrian crossing in front of Saphan Mai Market. 	<ul style="list-style-type: none"> Installation of pre-timed signals. 	<ul style="list-style-type: none"> Satisfies criteria for improvement.
2.	1	Phumiphol Adulyadet Hospital	23+000	<ul style="list-style-type: none"> Decline in smoothness of traffic flow between 19.0 kp and 21.5 kp. Confusion from entering/exiting vehicles and vehicles making U-turns in front of hospital. 	<ul style="list-style-type: none"> Alternative 1 Installation of pedestrian signal coordinated with adjacent signals. Alternative 2 Installation of pedestrian signal coordinated with adjacent signals. Coordinated signal control in control segment. Installation of pre-timed signals set to be simultaneously offset with nearby signals (this signal is operated only during hospital opening hours and it is left flashing during closing hours). 	<ul style="list-style-type: none"> Satisfies criteria for improvement. Satisfies criteria for improvement. Pedestrian signals coordinated with adjacent signals are not feasible because of the heavy pedestrian volume. Satisfies criteria for improvement. Satisfies criteria for improvement.
3.	1	Ko No 25	25+500	<ul style="list-style-type: none"> Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> Installation of pedestrian overpass. 	<ul style="list-style-type: none"> Satisfies criteria for improvement.
4.	1	Sorakan Rithiron School	26+000	<ul style="list-style-type: none"> Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> Installation of pedestrian overpass. 	<ul style="list-style-type: none"> Satisfies criteria for improvement.
5.	1	ANNEX	26+200	<ul style="list-style-type: none"> Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> Installation of pedestrian overpass. 	<ul style="list-style-type: none"> Satisfies criteria for improvement.
6.	1	Chun Sin	26+600	<ul style="list-style-type: none"> Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> Installation of pedestrian overpass. 	<ul style="list-style-type: none"> Satisfies criteria for improvement.
7.	1 (3312)	Thupe Teepee Stadium	27+600	<ul style="list-style-type: none"> Traffic volume exceeds the capacity of stop-controlled intersection (R1-R3312). 	<ul style="list-style-type: none"> Installation of pre-timed signals coordinated with signals installed at 27 kp. 	<ul style="list-style-type: none"> Satisfies criteria for improvement.

Table 1 Basic Conception for Measure (2)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Results of Examination	
					Measures	Necessary
8.	1	Si Muang Muang Market	28+000 - 29+000 (1.0)	- Cars drop into depressed medium.	- Installation of grade fence.	No - Not warranted. No accidents from cars dropping into depressed medium.
9.	1 (3214)	Khlong Luang	40+454	- Users from R3214 feel inconvenienced when going straight or turning right because of closed median. - Difficulty of making U-turns at the near median opening due to heavy traffic volumes travelling at speed.	- Installation of signals. - Channelization for U-turns. - Installation of U-turn signals.	No - Not warranted enough, No clear need for measure. Yes - Providing U-turn facilities. - Cannot handle U-turn volume without signal.
10.	1	Ent. AIT	41+500	- Difficulty of turning right and making U-turns due to heavy traffic volumes travelling at speed and the partial expanded lanes.	- Reduction of number of lanes to match ordinary lane numbers. - Providing U-turn facilities.	Yes - Although traffic volumes are low, the road conditions warrant the measures.
11.	1	Kawanakorn	46+200	- Users from the industrial estate feel inconvenienced because of the lack of signals.	- Installation of signal.	Yes - Satisfies criteria for improvement.
12.	3	Crocodile Farm	29+000	- Traffic volume is near saturation levels for a stop-controlled intersection (Leading to crocodile farm).	- Installation of pre-timed signal. - Installation of semi-actuated traffic signal.	No - Not warranted because of low traffic volume. Yes - Satisfies criteria for improvement. (traffic volume from crocodile farm is low).
13.	3	Bang Poo	29+250 - 51+150 (21.9)	- Number of night-time accidents are higher than on other sections especially the number of vehicles and motorcycle accidents.	- Installation of continuous lighting (Kp. 29.5-kp. 37).	Yes - Satisfies criteria for improvement. - There are residential areas and market facilities between 29.5 kp and 37.0 kp. - There are no facilities far from 37.0 kp.
14.	4 (3091) (3414)	Oam Noi	24+950	- To make a signal control plan with intersection improvement.	- Examination of traffic signal control.	Yes - DOH approved.

Table 1 Basic Conception for Measure (3)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Measures	Results of Examination	
						Necessary	Grounds of Necessity
15.	4	Samanchan Palace	58+580	<ul style="list-style-type: none"> - Traffic volume exceeds the capacity of the stop-controlled intersection. - Difficult to make U-turns due to the heavy traffic volumes on the major road. 	<ul style="list-style-type: none"> - Installation of traffic signals at the intersection. - Installation of U-turn traffic signals at the median opening - Channelization at the intersection. 	Yes	<ul style="list-style-type: none"> - Satisfies criteria for improvement. - Can treat U-turn volume without signal control. - Road conditions warrant the measure.
16.	34	Prapha Montri School	1+500	<ul style="list-style-type: none"> - Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	Yes	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
17.	34	Nuan Thong School	2+300-500	<ul style="list-style-type: none"> - Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	Yes	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
18.	302 (1)	Kaset Sat	0+000	<ul style="list-style-type: none"> - Saturated signalized intersection. 	<ul style="list-style-type: none"> - Widening of R302. - Channelization on R1 - Improvement of traffic signal phasing. 	Yes Yes Yes	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
19.	302 (306)	Khae Rai	6+333	<ul style="list-style-type: none"> - Saturated signalized intersection. 	<ul style="list-style-type: none"> - Grade separation based on the widening plan of R302 (R302 will cross over R306). 	Yes	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
20.	302	Ratanathibet	6+333 - 10+800 (4.5)	<ul style="list-style-type: none"> - Number of night-time accidents are higher than on other sections. 	<ul style="list-style-type: none"> - Installation of continuous lighting. 	Yes	<ul style="list-style-type: none"> - It is better that continuous lighting be installed between 6.3 kp and 10.8 kp, since continuous lighting already exists on R3110. - Existing traffic volume is about 19,000 veh./day, continuous lighting should be installed when volume exceeds 25,000 veh./day.
21.	302	Wat Saima	13+400	<ul style="list-style-type: none"> - Traffic volume exceeds the capacity of the stop-controlled intersection. - Confusion from U-turning vehicles. 	<ul style="list-style-type: none"> - Installation of signals. - Channelization to providing a U-turn lane. 	No Yes	<ul style="list-style-type: none"> - Not warranted because of low traffic volume. - Road conditions warrant the measure.

Table 1 Basic Conception for Measure (4)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Results of Examination	
					Measures	Necessary Grounds of Necessity
22.	303 (3104)	Prapadaeng	11+198	- Reduction of road capacity and confusion of traffic owing to parked vehicles, short right-turn lane, bus movement and poor shoulders.	- Improvement of signal phasing after widening of R3104 to 4 lanes. - Prohibition of parking. - Extension of storage lane length for right-turn on R303. - Provision of bus bay.	Yes - Satisfies criteria for improvement.
23.	304	Ent. Army	4+800	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	No - Pedestrian volume is low.
24.	304 (BMA)	Khlong Prapa	4+800 - 5+600 (0.8)	- Difficult to U-turn and weave due to the heavy traffic volumes of through and right-hand turning traffic on R304.	- Alternative A (Improving BMA road): Signalization of intersection with the BMA road (widening of BMA road and R304 will be required). - Alternative B (not improving BMA road): Traffic signal at the median openings on both sides in order to handle U-turning vehicles, without improving the intersection with the BMA road.	Yes - Satisfies criteria for improvement.
25.	304	Ram Inthra Post Office	0+000 - 0+200 (0.2)	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes - Satisfies criteria for improvement.
26.	304	Army Golf Club	1+000 - 1+200 (0.2)	- Dangerous condition of pedestrian crossing. - Confusion from entering/exiting vehicles to army golf club.	- Installation of pedestrian overpass. - Operation of signal control (not operated at present).	Yes - Satisfies criteria for improvement. No - Not warranted because of low traffic volumes.
27.	304	Ram Indra Center	2+000	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes - Satisfies criteria for improvement.
28.	304	Km. 4 Market	4+000	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes - Satisfies criteria for improvement.
29.	304	Air Police	4+800	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	No - Pedestrian volume is low.

Table 1 Basic Conception for Measure (5)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Results of Examination		
					Measures	Necessary	
30.	304	Mai Ya Lap	5+200	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
31.	304	Wacharaphon	5+600	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
32.	304	Nopparat Ratchathani Hospital	11+900 - 12+000 (0.1)	- Confusion from entering/exiting vehicles in the front of hospital.	- Installation of signals (simultaneous-type).	Yes	- Satisfies criteria for improvement.
33.	306	Sattri Nontaburi School	1+500	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
34.	306	Pongsawat Commercial School	3+270	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
35.	306	Wat Lanna Boon	5+500	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	No	- Pedestrian volume is low.
36.	306	Pinrapakom	7+700	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
37.	306	Suang Og Hospital	8+210	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
38.	306	Thai Farmer Bank	9+100	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
39.	306	Tansamrit Pattana	9+538	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
40.	306	Samak Ki	11+251	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
41.	306	Amphan Paisan School	16+300 - 16+500 (0.2)	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
42.	306	Ha Yaek Pakket	13+450	- Dangerous condition of pedestrian crossing.	- Installation of pedestrian overpass.	Yes	- Satisfies criteria for improvement.
43.	307 (3035) (3111)	Pathum Wilai	10+813	- Traffic volume exceeds the capacity of stop-controlled intersection. - Confusion caused by unclear traffic priority.	- Signalization of intersection. - Provision of right-turn lanes, except on R3111.	Yes Yes	- Satisfies criteria for improvement. - Satisfies criteria for improvement.

Table 1 Basic Conception for Measure (6)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Results of Examination	
					Measures	Necessary Grounds of Necessity
44.	325	Daimoen Sadauk	53+705 - 38+215 (4.5)	<ul style="list-style-type: none"> - Conflict between ordinary automobiles and motorcycles. - Improper super-elevation and poor pavement markings. 	<ul style="list-style-type: none"> - Installation of motorcycle lane. - Improvement of curvature section. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
45.	338	Pra Pin Village	2+200	<ul style="list-style-type: none"> - There is no facility for pedestrian crossing between 1.1 kp and 3.3 kp on R338. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
46.	338	Suan Pak	2+952 - 5+900 (3.0)	<ul style="list-style-type: none"> - Conflict in the merging section. 	<ul style="list-style-type: none"> - Extending merging section. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
47.	338	Buddha Monthon Sai 7	28+609.5	<ul style="list-style-type: none"> - Conflict in the crossing section. 	<ul style="list-style-type: none"> - Channelization. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
48.	340 (BMA)	Bang Maek	3+725	<ul style="list-style-type: none"> - Traffic volume is beyond the capacity of stop-controlled intersection. 	<ul style="list-style-type: none"> - Creation of grade separation for the long-term. - Installation of pre-timed signal, and installation of forewarning guide signs for short-term. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement. - Satisfies criteria for improvement.
49.	340 (3242)	Eakka Chai	29+300	<ul style="list-style-type: none"> - Drivers make illegal U-turns. 	<ul style="list-style-type: none"> - Installation of guide signs (figure type). 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
50.	340	Wat Si Boon Rueng	10+500	<ul style="list-style-type: none"> - Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
51.	3119 (BMA)	Minburi	0+450	<ul style="list-style-type: none"> - Traffic volume beyond the capacity of stop-controlled intersection. 	<ul style="list-style-type: none"> - Installation of pre-timed signal. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.

Table 1 Basic Conception for Measure (7)

No.	Route No.	Name of Location	Kp. Start-End (Length)	Major Problems	Results of Examination	
					Measures	Necessary Grounds of Necessity
51.	3119 (BMA)	Onn Much - 3119	11+003	<ul style="list-style-type: none"> - Priority of R3119 is unclear depending on the T-shaped interchange and this causes confusion. - Traffic volume is beyond the capacity of stop-controlled intersection. 	<ul style="list-style-type: none"> - Signalization. - Channelization to provide left-turn and right-turn lane. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
52.	3202	Indra Luk Market	3+000 - 4+000 (1.0)	<ul style="list-style-type: none"> - Drivers from the soi feel inconvenienced when going straight or turning right because of closed median. - Difficult to U-turn at the near median opening due to the heavy traffic volumes. 	<ul style="list-style-type: none"> - Installation of signal. 	<ul style="list-style-type: none"> - Not warranted enough. No clear need established. - Provides U-turn facility.
53.	3202	Indra Luk Market	3+000 - 4+000 (1.0)	<ul style="list-style-type: none"> - Drivers from the soi feel inconvenienced when going straight or turning right because of closed median. - Difficult to U-turn at the near median opening due to the heavy traffic volumes. 	<ul style="list-style-type: none"> - Channelization to handle U-turns. - Installation of U-turn signal. 	<ul style="list-style-type: none"> - Cannot treat U-turn volume without signal.
54.	3202	Nuan Chan	5+300 - 5+500 (0.2)	<ul style="list-style-type: none"> - Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
55.	3256 (BMA)	Onn Much - 3256	11+719	<ul style="list-style-type: none"> - Traffic volume is beyond the capacity of stop-controlled intersection. 	<ul style="list-style-type: none"> - Installation of pre-timed signal. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
56.	3278	Wat Phichai	1+100	<ul style="list-style-type: none"> - Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
57.	3278	Bangchan Industrial Estate	7+800	<ul style="list-style-type: none"> - Dangerous condition of pedestrian crossing. 	<ul style="list-style-type: none"> - Installation of pedestrian overpass. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
58.	3278	Government House	1+039	<ul style="list-style-type: none"> - Traffic volume is beyond the capacity of stop-controlled intersection. 	<ul style="list-style-type: none"> - Installation of pre-timed signal. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
59.	3278	Saha Khan Kan Kaha	3+744	<ul style="list-style-type: none"> - Traffic volume is beyond the capacity of stop-controlled intersection. 	<ul style="list-style-type: none"> - Installation of pre-timed signal. 	<ul style="list-style-type: none"> - Satisfies criteria for improvement.
Total Study Sections			59			

As seen in the Table 1, the proposed countermeasures can be broadly classified as follow:

a) Intersection Improvement

- grade separation;
- installation of traffic signals;
- improvement of intersection configuration;
- channelization of traffic.

b) Improvement of Pedestrian Facilities

- construction of pedestrian overpass;
- installation of pedestrian crossing.

c) Improvement of Night-time Traffic Safety Facilities

- installation of street lighting.

d) Improvement of Roadway Section

- installation of motorcycle lane;
- installation of guard fence;
- installation of guide sign;
- traffic flow channelization in open sections of median strip.

The selection of countermeasure was examined on the basis of the technical guidelines and the engineering specifications.

In considering U-turn traffic in the median opening, the installation of U-turn signals was proposed and the necessity of such new signals was evaluated on the basis of the installation standards shown in Figure 3.

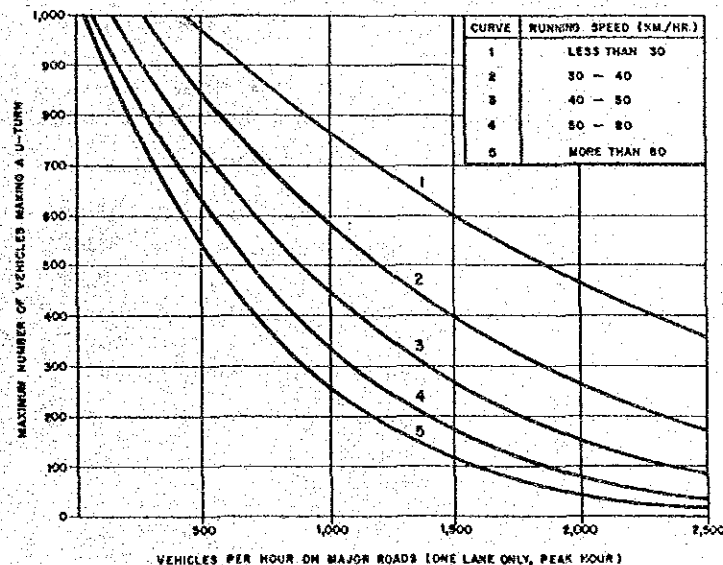


Figure 3 MAXIMUM NUMBER OF VEHICLE MAKING A U-TURN

Where it is difficult to estimate the number of crossing pedestrians, the average spacing between existing pedestrian overpasses on major highways in central Bangkok (500 m) was used as a criteria for determining the necessity of pedestrian overpass construction.

4. PREPARATION OF IMPROVEMENT PLAN

4.1 Objectives

In the Study, improvement plans were carried out at the preliminary design level in order to show some examples of traffic control and safety measures for engineering remedial works.

A study of other improvement plans, and a look at their effectiveness, is useful for the preparation and design of the optimum improvement plan for the remedial works. The sample of improvement plans are also useful guides for the future preparation of improvement plans by the DOH.

4.2 Selection of Preliminary Design Sections

The selection of the ten Study Sections, from the fifty-nine Study Sections put forward for the preliminary design, was carried out through discussions with the DOH. In the selection of the Study Sections the results of the data analysis and the site investigations were reviewed and sites exhibiting the following points were chosen:

- A. Sections which would experience effective improvement of congested hazardous conditions from the improvement plan;
- B. Sections which revealed typical traffic problems, and whose improvement plans were applicable to other sections;
- C. Sections which required detailed plans for the explanation of the countermeasures put forward by the improvement plans.

The preliminary design sections have been classified into five categories, by traffic safety and control measures, as follows:

- A. Improvement of roadway section : S-44
- B. Improvement of signalized intersection : S-18, S-22
- C. Grade separation : S-19, S-48
- D. Improvement of intersection and median openings : S-10, S-15, S-24
- E. Signalization and channelization : S-43, S-52 (S-48)

4.3 Supplemental Topographic Survey

Topographic maps were used for the preliminary design of the improvement plans of each Section. The maps had to be of a sufficiently small scale to reveal the existing conditions at the sites and to enable traffic control and safety measures to be devised to deal with these.

In the Study, the topographic maps are at a scale of 1:500 and they were prepared based on the results of the topographic survey conducted by the Study Team.

4.4 Preliminary Design

Through a series of site investigations and supplementary surveys, as well as by data analysis, existing conditions and major problems were identified for each planning site. Traffic control and safety measures were then planned to cope with the major traffic problems.

Preliminary designs were conducted primarily based on topographic maps with a scale of 1:500.

Each Study Section is looked at in turn and the existing conditions and the main problems at the site are discussed. Several alternative countermeasures are presented and the main proposed countermeasure is outlined.

The outline of each location and the proposed traffic controls and safety measures are summarized in Table 2.

4.5 Cost Estimation

Based on the results of the preliminary designs, the work quantities and improvement cost were estimated. The results are useful for the selection of the traffic control/safety measures and for preparing future improvement plans. The unit cost for the cost estimation was determined through discussions with the DOH officials based on the recent improvement projects implemented by the DOH.

Table 2 Outline of Preliminary Design Section

No.	Route No.	Location Name	Kilopost Cont. Sec. No.	Type of Road	Lane No.	Strategies and Measures
10.	1	Ent. AIT	41+500 201	Roadway section with entrance and median openings	4	- Channelization to minimize the size of the intersection. - Provision of U-turn facility to deal with the U-turn traffic.
15.	4	Sanamchan Palace	58+580 203	four-leg intersection with median opening	4x2	- Signalization and/or U-turn facility to ensure smooth traffic flow at the intersection and median openings.
18.	302 (1)	Kaset Sat	0+000 100	three-leg signalized intersection	4x4(8)	- Channelization and modification of the signal phasing to increase the capacity of the intersection.
19.	302 (306)	Khae Rai	6+333 100	four-leg signalized intersection	4x4(8)	- Grade separation to deal with the heavy traffic volume.
22.	303 (3104)	Prapedang	11+198 100	three-leg signalized intersection	4x2(4)	- Channelization and modification of the signal phasing to increase the capacity of the intersection. - Improvement of the road-side to ensure smooth traffic flow.
24.	304 (BMA)	Khlong Prapa	4+800-5+600 101	four-leg intersection with median openings	4x2(4)	- Signalization to ensure smooth traffic flow at the intersection and median openings.
43.	307 (3035) (3111)	Pathum Wilai	10+813 100	four-leg intersection	2x2	- Signalization and channelization to solve the confusion at the intersection.
44.	325	Damnoen Saduak	33+705-38+215 200	Roadway section	2	- Installation of motorcycle lanes to avoid mixing traffic. - Improvement of curvature section.
48.	340 (BMA)	Bang Haek	3+725 100	four-leg intersection	4x2	- Signalization to deal with turning traffic at the intersection as a short-term plan. - Grade separation as a long-term plan.
52.	3119 (BMA)	Omn Nuch-R.3119	11+003 100	three-leg intersection	2x2	- Signalization and channelization to ensure the smooth traffic flow at the intersection.

No. of Lane
() : Improvement Plan