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THE KINGDOM OF THAILAND
MINISTRY OF COMMUNICATIONS
DEPARTMENT OF HIGHWAYS

Traffic Safety Plan for Roads in The Kingdom of Thailand

Main Report

JAPAN INTERNATIONAL COOPERATION AGENCY

JANUARY 1985

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PREFACE

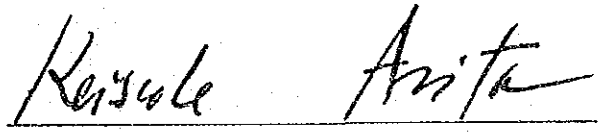
In response to the request of the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a study on the Road Traffic Safety Project and entrusted the study to the Japan International Cooperation Agency (JICA). The JICA sent to Thailand a study team headed by Dr. Yoshitomo Oguri from May 1983 to November 1984.

The team exchanged views on the Project with the officials concerned of the Government of Thailand and conducted a survey in Thailand. After the team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the enhancement of the traffic safety in Thailand and contribute to the promotion of friendly relations between our two countries.

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

January 1985



Keisuke Arita
President

Japan International Cooperation Agency

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GLOSSARY

MOC	-	Ministry of Communications
DOH	-	Department of Highways, MOC
DLT	-	Department of Land Transport, MOC
MOI	-	Ministry of Interior
HPD	-	Highway Police Division, Police Department, MOI
LPs	-	Local Police Stations, Police Department, MOI
TPD	-	Traffic Police Division, Police Department, MOI
LDPD	-	Licenses Division of Police Department, MOI
OCMRT	-	Office of the Committee for the Management of Road Traffic, MOI
BMA	-	Bangkok Metropolitan Administration
NSC	-	National Safety Council, Office of the Prime Minister
MOE	-	Ministry of Education
JICA	-	Japan International Cooperation Agency
ASEAN	-	The Association of Southeast Asian Nations
CIE	-	The International Commission of Illumination
ADT	-	Average Daily Traffic
PCU	-	Passenger Car Unit
cd	-	Candela
KP	-	Kilometer Post
C.S.	-	Control Section

Financial year in Thailand starts on October 1st and ends on September 30th.

1 US$ = 22.90 Baht

Summary

SUMMARY

1. Introduction

As the road traffic accidents have considerably increased in recent years and constitute a serious social problem, the Government of Thailand has given the highest priority to the solution of the problem and requested the Government of Japan for technical assistance to conduct a study on traffic safety plan for the roads administered by the Department of Highways (DOH), Ministry of Communications (hereinafter referred to as the Study).

The Japan International Cooperation Agency (JICA) the official agency responsible for implementation of technical cooperation programs of the government of Japan, has set up a study team (hereinafter referred to as the Team) for consulting services to the Study.

The main activities in the Study are;

- to collect relevant information and data, including reviews on the present DOH practice with regard to traffic accident data collecting systems and data analyses;
- to develop identification methods of hazardous road locations;
- to prepare technical guidelines on road traffic safety;
- to carry out a case-study consisting of road safety planning and experimental works on selected roads; and
- to prepare necessary information for preparation of traffic safety master plan by DOH.

The Study was commenced in May 1983 and completed in January, 1985.

2. Road and Accident

(1) Road Transportation

During the past 20 years, from the beginning of the First National and Social Development Plan (1962 - 1966) up to the present, the transportation system of the country has been remarkably developed and expanded in order to facilitate social and economic developments. As the efforts for such expansion have been primarily directed to the development of the road transportation system, the country's road network has gained an advantage over other transportation modes.

As for domestic transport of good, about 80 percent are transported by road and the remaining 20 percent are by railway. Inland water transportation, which used to be the country's main transport means in the past, now plays much less important role. A road transport also performs an important role in passenger transport. The passenger transport by road in 1977 accounts for 85 percent of the total. Therefore, it can be said that the road transportation is the most important means in domestic transport.

(2) Road Network

Roads in Thailand are classified legally into 7 categories under the Announcement of the Revolutionary Party No. 295 (Highway Law) issued on 1st December, 1972. They are Special Highway, National Highway, Provincial Highway, Rural Road, Municipal Road, Sanitary Road and Concession Road. The total road length in Thailand is approximately 157,000 km.

Road Category	Length (Km)
National Highways (Including Special Highways)	15,600
Provincial Highways	28,400
Rural Roads (Including Sanitary Roads and Concession Roads)	106,000
Municipal Roads	6,500
Total	156,500

DOH is responsible for construction and maintenance of the Special Highway, National Highway and Provincial Highway.

(3) Road Traffic

1) Registered Motor Vehicles

In Thailand, the number of registered motor vehicles totals 2.6 million in 1982. One of the features of motor vehicle registration is seen in a high composition rate of motorcycles (53.1% in 1982), followed by trucks (21.5%), passenger cars (15.4%), buses (8.2%) and others (1.8%). The average annual growth rate of registered motor vehicles between 1972 and 1982, was 12.0 percent.

2) Traffic Volume

The traffic volumes on DOH roads vary with the regions and routes. The average traffic volumes on the national highways between major cities are in the range of 1,000 to 3,000, while the average traffic volumes around the major cities count from 3,000 to 5,000 vehicles per day. In particular, the traffic volume around Bangkok is remarkably high with a wide variation ranging from 20,000 to 80,000 vehicles per day.

(4) Road Traffic Accidents

The rapidly expanded road network throughout the country has contributed to the promotion of economic activities and development both in the rural and urban areas. However, adverse effects of traffic accidents have become very serious in spite of the various measures taken on the traffic control and safety. During the period of 1973 to 1982, cases of accidents reported in Thailand increased at an average annual rate of 5 percent from 9,945 to 16,047 cases.

The accident records on DOH roads for the past six (6) years are as follows. The ratios of the accidents on DOH roads to the total of the nation remain almost unchanged during the 6 years, though there are some fluctuations. The number of annual accidents on DOH roads is in the order of 3,000 cases and casualties are about 7,000 to 8,000 persons.

Year	Number of Accidents			Death			Casualties			Length of Road (KM)		
	Thailand	DOH	DOH per Thailand	Thailand	DOH	DOH per Thailand	Thailand	DOH	DOH per Thailand	Thailand	DOH	DOH per Thailand.
1977	16,583	3,924	0.237	2,545	1,927	0.757	11,851	8,356	0.705	N.A.	38,244	
1978	18,669	3,616	0.194	3,952	2,067	0.523	14,520	8,271	0.570	N.A.	41,841	
1979	23,120	2,808	0.121	8,385	1,573	0.188	30,004	7,089	0.238	N.A.	42,805	
1980	17,742	1,727	0.097	4,493	1,169	0.260	17,885	5,092	0.285	N.A.	43,840	
1981	16,361	3,211	0.196	2,760	1,652	0.599	12,057	6,401	0.531	156,497	43,961	0.281
1982	16,047	3,264	0.203	3,091	1,952	0.632	12,431	8,154	0.656	N.A.	43,956	

Source : 1) Figures for all Thailand are based on data from the Research and Planning Division, Police Department.
2) DOH data is from the Traffic Engineering Office, Department of Highways.

It should be noted that the figures for DOH roads in the above table are mostly accidents investigated by the Highway Police Division (HPD), which is responsible for investigation of accident on about 15,700 km of DOH roads (hereinafter referred to as HPD area). In addition some accidents investigated by DOH for its road length of about 28,300 km, for which the Local Police Stations (LPs) are responsible (hereinafter referred to as LPs area), are also included.

(5) Others

1) Vehicle Registration, Vehicle Inspection and Driving License

The Licenses Division of Police Department (LDPD) and the Department of Land Transport (DLT) have full responsibility for registration of motor vehicles, vehicle inspection and issuance of driving licenses according to their respective responsibilities.

2) Traffic Law Enforcement

The traffic laws are enforced by policemen of HPD, Traffic Police Division (TPD) of Police Department (only in Bangkok), each LPs and inspectors of DLT. Most of traffic offences are compoundable, but there are heavy penalties for serious offences.

3) Road Safety Education

In Thailand, several agencies conduct road traffic safety education for pupils, drivers, motor vehicle operators and the public by their own budgets. The National Safety Council (NSC), established in 1982, is trying to coordinate activities related to the road traffic safety educations of various agencies.

4) Insurance

It is not compulsory for the motor vehicle owners to be covered by insurance for third party liabilities in Thailand. Therefore, the number of motor vehicles covered by insurance is extremely low. In 1982, the average insurance coverage was ฿ 250,000/person for fatality.

3. Data Collection and Compilation

(1) Investigation

HPD is responsible for accidents on the major DOH roads outside the municipal areas (about 15,700 km), while LPs have responsibility for the major DOH roads in the municipal areas and all minor DOH roads with a total road length of about 28,300 km.

DOH also investigates and records traffic accidents on DOH roads. As the main objective of the investigation by DOH is to record damages of road properties, the investigation does not necessarily cover all accidents occurred on the roads.

(2) Recording and Reporting

Since the main purposes of the three agencies, i.e., HPD, LPs and DOH are different, they have their own accident recording forms. The records filled in by sub-district offices of DOH are sent to the Traffic Engineering Office and the Maintenance Division of DOH headquarters.

The traffic accident records by the inspector offices of HPD are prepared both in HPD's form and DOH's form. Then these records are forwarded to their headquarters. At the headquarters of HPD, DOH's form are sent to DOH regularly.

Each LPs records traffic accidents in their own form which contains detailed information, in particular, those which are necessary for prosecution. At the same time, LPs also prepare records briefing each accident and send them to Police Department headquarters. There is no established system for DOH to receive the accident data from LPs.

The Traffic Engineering Office of DOH stores traffic accident data from HPD and DOH's sub-district offices in the mainframe computer in DOH. In practice, the accident data in the mainframe computer of DOH are limited only to those on the roads in HPD area, and accident data which occurred on the roads in the LPs area and were investigated by DOH sub-district offices.

(3) Traffic Volume and Road Data

Since 1962, DOH has been conducting a nationwide traffic volume survey at a total of 1,834 counting stations on the national and provincial highways. There are two counting methods in the present system, that is, control count and coverage count.

The control count is to establish both seasonal and daily characteristics of traffic volume. For the control count traffic volume is surveyed at 35 major counting stations on the national highways.

The coverage count is conducted at 444 stations on the national highways and at 1355 stations on the provincial highways. The objective of the coverage count is to estimate average daily traffic (ADT) for each road control section which is a unit road section for the execution of road management by DOH.

In the past, a comprehensive road inventory had been prepared for DOH roads, but the inventory is now out of date, because no revisions were made ever since. Since 1983, the Programming Section of DOH has been collecting road data for the whole DOH road network to complete the Road Data Base scheme.

(4) Supplemental Data Collection by the Team

The traffic accident data available at DOH is virtually limited to the accidents occurred in HPD area except those investigated by DOH. Road data, which are indispensable for preparing traffic safety plans from engineering approaches, are not available at present from DOH. To acquire minimum basic data required for the Study, the Team collected supplemental data on traffic accidents in LPs areas and road data as mentioned below.

1) Accident Data

The team collected the accident data by visiting each Lps office where original accident records containing information to indicate accident location are kept. Since this collection procedure was supposed to be time consuming, about 430 km* in the Lps area of six (6) Changwats out of seventy three (73) Changwats and a part of Bangkok Metropolitan were chosen for the supplemental data collection.** The selected Changwats

---

* 360 km in 6 Changwats and 70 km in Bangkok.

** Most accidents in Lps area of 6 Changwats where DOH roads total about 2,100 km occurred on roads of 360 km which are located in urban area.

are Saraburi, Chonburi, Nakhon Ratchasima, Khon Kaen, Chiang Mai and Songkhla.

2) Road Data

In order to conduct detailed analyses of traffic accidents on the Study Roads, the Team collected road data for the Study Roads by the site investigation as well as the observation with a video tape recorder. These road data were assorted by one kilometer section and utilized for the preparation of safety plans in the case study.

(5) Data Compilation for Analysis

From the information items in the accident data (in the years of 1981 and 1982) stored in the DOH computer, necessary information items have been selected and compiled in two forms of files, i.e. Accident Master File and Road Section File together with traffic volume data. The supplemental data collected by the Team have been also compiled in the same way.

In the Accident Master File, the selected information from the accident data, and traffic volume data have been assorted by traffic accident.

In the Road Section File, the same information in the Accident Master File has been assorted by road section so that all information can be retrieved on the basis of each road section. For intersections, a Road Section File with 1 km section as unit length, were produced separately from that of roadway with 3 km section, as an intersection should be assessed by spot rather than by section.

(6) Traffic Accident Analysis

1) Type of Accident

In HPD area, the vehicle-vehicle type of accident stands the highest both in number of accident (49%) and fatality (64%). In LPs area, the vehicle-vehicle type of accident also shows the highest rate (70%), followed by vehicle-pedestrian type (21%).

2) Collision Pattern

In HPD area, as to the vehicle-vehicle accidents, frequency of head-on collision (34%) and rear-end collision (32%) are high on roadway, while

side collision during crossing (37%) and right turn (26%) shows higher frequency at intersection. In LPs area, rear-end collision (32%) and head-on collision (18%) occurred frequently.

3) Cause of Accident

The major causes of accidents in HPD area are speeding (41%), improper passing (21%), failure to yield right of way (13%) and failure to signal of way (11%).

(7) Recommendation on Data Collection System

Based on the experiences obtained through the Study some recommendations on the present data collection and compilation have been proposed. The major recommendations are as follows.

1) Accident Data from Police

- To establish a data transfer system from LPs to DOH as being the case with HPD.
- To request LPs to produce adequate accident records containing necessary information for traffic safety planning.
- To request HPD to indicate the precise accident locations in the records by reference to kilometer post.
- To avoid the duplication of accident data stored in the computer of DOH.

2) Accident Record Format

- To include land use around the accident location, existence of safety devices and traffic regulation, and to modify the classification of accident cause in the present DOH accident record format.
- To modify the style of the DOH format by introducing more multiple-choice method.

3) Data Compilation

- To prepare the accident master files and the road section files.
- To prepare accident location histograms, accident location maps and collision diagrams.

- To indicate the old control section number together with a new control section number in accident records, when there will be any change of control section number.

4. Method for Identification of Hazardous Road Locations

(1) Identification Method

Although the definition of hazardous road locations is relative and not an absolute account, in this study, the road locations, where a relatively high frequency of traffic accidents or a large number of casualties exist and some remedial measures are required, are defined as hazardous locations.

There are various methods to identify hazardous road locations. To propose the identification methods applicable to DOH roads, extensive reviews on the following methods were made;

- accident number method,
- accident density method,
- accident rate method,
- number-rate method,
- rate-volume method, and
- statistical method.

After thorough reviews, rate-volume method for roadway (road segment between intersections) and accident number method for intersections were selected for DOH roads. The identification criteria in the above two methods were determined in the following manners.

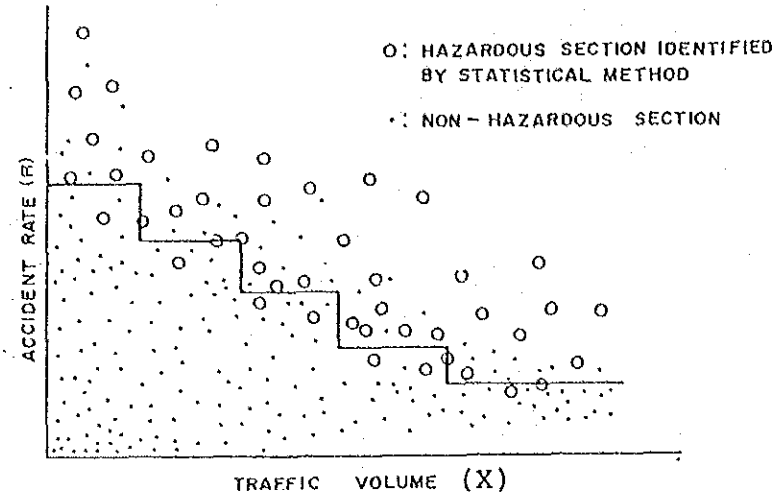
(2) Criteria for Roadway

Statistical approach was adopted to determine the criteria for the rate-volume method, and its concept is as follows:

a) To determine road sections which are judged to be hazardous by using the statistical method,

b) To plot the results on a rate-volume diagram. The circled points show the "hazardous sections" identified by the statistical method, and

c) To determine the criterion line for each traffic-volume-rank in such a way that they can separate the sections between hazardous road sections and non-hazardous road sections.



The judgement whether "hazardous" or "non-hazardous" can be made by the following formula.

$$H_i = (Y_i - \bar{Y}_i) / \sqrt{\bar{Y}_i}$$

where, Y_i: Actual number of casualty at section (i)

$\bar{Y}_i$: Estimated number of casualty at section (i)

The sections of roadway of which H_i values exceed 1.96 could be assumed hazardous. The above diagram can be drawn plotting the values of accident rate (R_i) ($R_i = Y_i/X_i$ x section length (3 km) x 10^8) where X_i stands for daily traffic volume at section (i).

The estimation of casualty's number ($\bar{Y}_i$) is usually made applying regression models. Several factors such as road environment and traffic characteristics enter as explanatory variable in a regression model. However, in this study inventory data were not available. After analyses, the following equation was obtained.

$$\bar{Y}_i = 0.56 \times X_i^{0.196}$$

where, $\bar{Y}_i$: Estimated number of casualties at traffic volume X_i

X_i: Average daily traffic volume

The determined criteria by the categories of average daily traffic are as follows.

Average Daily Traffic	Identification Criteria (rate)*
- 500	not defined
501 - 1,000	400
1,001 - 2,000	300
2,001 - 3,000	250
3,001 - 5,000	200
5,001 - 10,000	150
10,001 - 15,000	100
15,000 -	100

* Accident Rate (Casualty/10^8veh. km.)

The number of hazardous road sections of roadway and casualties for the road network of the HPD area where traffic accident data are available are as follows.

Area	Road Length (km)	Number of Sections	Number of Hazardous Sections	Number of Casualties
HPD area	15,700	4,844	375	4,470*

* This figure consists of 1,037 killed and 3,433 injured. 4,470 persons is 61% of total casualties (7,277 persons, annual average for 1981 and 1982) on DOH roads.

(3) Criterion for Intersection

The approach to determine the criteria for roadway can not be ruled out in the case of intersections. However, most intersections have their own specific characteristics in traffic movements, configurations and structures, thus it is obvious that the mechanisms of accidents at intersections are more complex than those of roadways, and require more explanatory variables to formulate any regression model.

At present, there are virtually no road inventory data as to intersections and even traffic volumes of the crossing roads are not available when the crossing roads are administered by other agencies than DOH. Therefore, in the study, the criterion for intersections was determined by an empirical approach.

The district engineers of DOH were requested to select hazardous intersections by their own judgements and to report them to the headquarters of DOH together with other data and information. It is a possible way to determine a criterion such a way that all intersections selected by district engineers would be identified as hazardous.

But, as the definition of "hazardous" is always relative and subjective matter, it can be assumed that there might be some extremely biased ones among the district engineers judgements. To maintain the reliability of identification criterion, close examinations and analyses on their judgements were made. The average number of casualties ($\overline{X}$) and standard deviation (σ) for all intersections as well as those by intersections classified by traffic volumes were calculated. The results of calculations revealed that the difference in average number of casualties among the classified intersections is negligible.

In this study, the standard deviation was considered as a threshold of confidence in the engineers' judgements. In other words, the value of ($X-\sigma$) could be an identification criterion for intersections. X and σ came out 6.2 and 2.1, respectively. For practical purpose, the identification criterion has been decided at 4 casualties per year. The number of hazardous intersections and casualties on DOH roads in HPD area are as follows.

Area	Total Length (Km)	Number of Hazardous Intersections	Number of Casualties
HPD area	15,700	78	341*

* This figure consists of 58 killed and 283 injured. 341 persons is 76% of total number of casualties at intersections on DOH road in HPD area (15,700 km).

5. Technical Guidelines on Traffic Safety Devices

Technical guidelines are proposed in regard mainly to the warranting conditions and installation planning of major safety devices listed below:

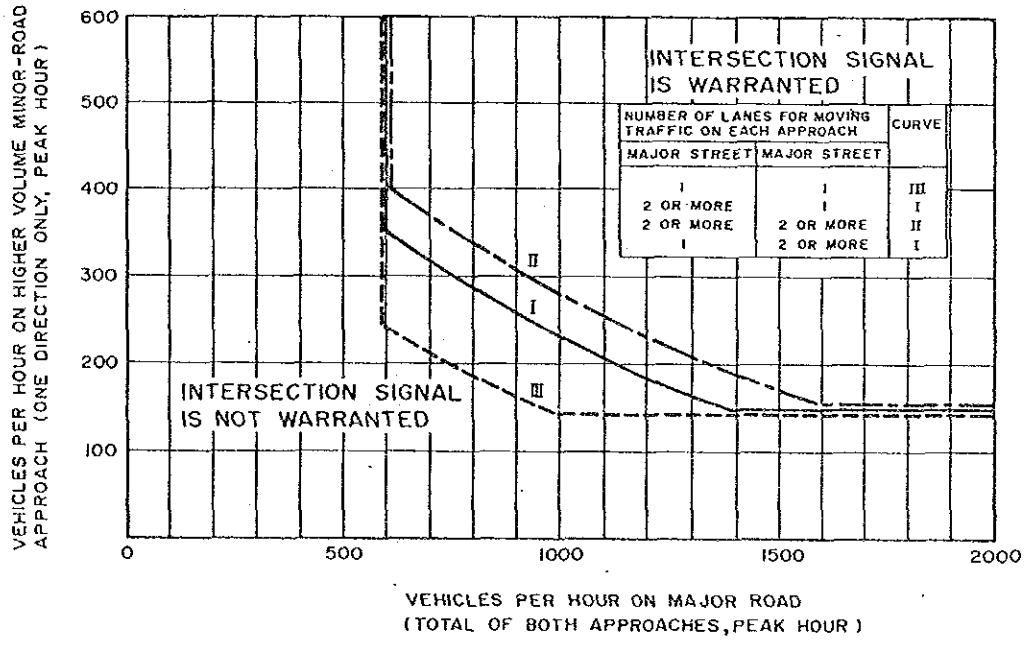
- Traffic signal,
- Guidefence,
- Lighting,
- Delineator,
- Sidewalk and bicycle path, and
- Crossing facility for pedestrian.

A review has been made on the guidelines for traffic signs and marking developed by DOH.

5.1 Warrants of Traffic Signal

Warrants on installation of traffic signals are proposed for the following three types of signal systems: i.e., (1) pretimed signal, (2) semi-traffic-actuated signal, and (3) pedestrian signal. A criterion of installing signals for accident prevention is also proposed.

(1) Pretimed Signal



(2) Semi-Traffic-Actuated Signal

	Vehicle per hour on major road (total of both approaches)	Vehicle per hour on higher-volume minor road approach (one direction only)
Peak hour traffic volume	900 or more	100 or more

(3) Pedestrian Signal

	Vehicle per hour on the street (total of both directions)	Pedestrian per hour on the crosswalk crossing the road
Peak hour traffic volume	650 or more	200 or more

(4) Traffic Accident Prevention by Traffic Signal

	Accidents Preventable by Traffic Signals
Number of Accidents within a 12-month Period	5 or more

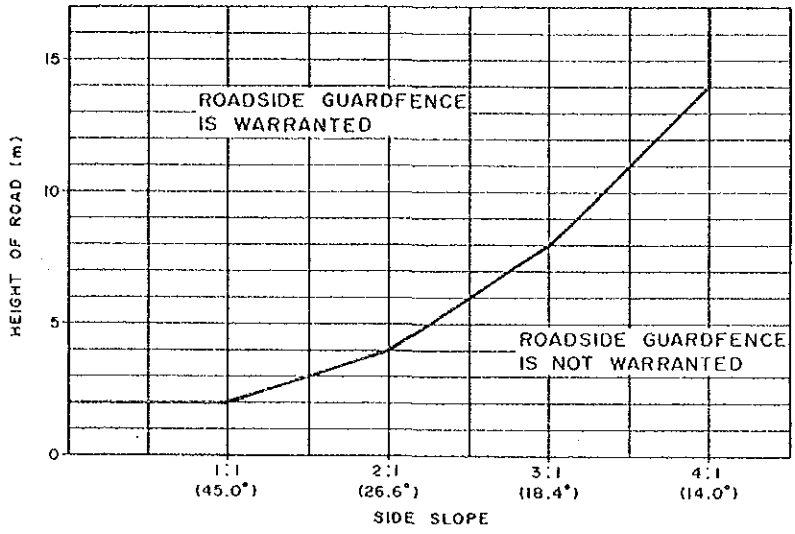
5.2 Warrants of Guardfence

Warrants of guardfence are proposed for roadside guardfence, median guardfence and sidewalk guardfence.

(1) Roadside Guardfence

A. Sections having roadside hazards

1. Road sections where the combination of height and side slope fall above the line in the following diagram.



NOTE : "SIDE SLOPE" MEANS LATERAL LENGTH CORRESPONDING TO VERTICAL HEIGHT WHICH IS ASSUMED 1.

2. Road sections where there are obstacles like big trees, houses, within 2m-zone adjacent to the carriageway.

3. Sections along the water hazards such as sea, lake, pond, river, ditch, etc. of which depth is more than 1.5m.

B. Low-standard design sections

1. Curves with radius of 200m or less.

2. Downgrades of 4% or more.

3. Sections where the roadway width or number of lanes is reduced abruptly.

C. Proximities to bridges, culverts, etc.

1. Approaches to bridges or culverts.

2. Sections where pier, retaining wall or other rigid structure exists within 2m-zone adjacent to the carriageway.

D. Sections where off-carriageway accidents are frequent

1. Sections where considerable number of run-off-carriageway accidents happened or are suspected to happen.

(2) Median Guardfence

A. Sections where the median width is less than 10 meters

1. Sections where 85 percentile speed is 80km/hr or more and meet one of the following conditions:
   a. longitudinal gradient is 3% or more.
   b. curve radius is 750m or less.
2. Sections where median guardfence installation is justified because of high vehicle speed.

B. Sections where the median width is more than 10 meters

1. Sections which conform to warrants of roadside guardfence.

(3) Sidewalk Guardfence

A. Guardfence to restrain the errant vehicle

1. Sections where vehicles are suspected to run into pedestrians on sidewalks due to poor horizontal alignment.
2. Sections where prevailing speed is considerably high and safeguard of pedestrians or bicycles is considered to be requisite.

B. Guardfence to discourage pedestrian from crossing the carriageway

1. Sections where roadway crossing by pedestrian should be prohibited.

C. Guardfence to prevent pedestrian or cyclist from dropping off

1. Sections along the roadside hazard such as ditch, river or big falling.

5.3 Warrants of Lighting

(1) Continuous Lighting (in urban area only)

1. ADT is 25,000 vehicles or more.
2. Adjacent area has a high illumination level, which interferes with driver's visibility.

3. Pedestrian traffic at night is considerably high.

4. Road segment shorter than 1km which is sandwiched by two lighted sections.

(2) Lighting for Specific Road Locations

1. Intersection where traffic signal is warranted and installed.

2. Crosswalk where pedestrian signal is warranted and installed.

3. Sections where cross section abruptly changes.

4. Sharp bend or steep slope.

5. Toll plaza and its approaches.

6. Sections where the ratio of night to day accident rate is more than 2.0.

7. Sections where a study indicates that lighting may be expected to significantly reduce nighttime accidents.

5.4 Warrants of Delineator

(1) Post Delineator

1. Curve sections of which radius is 400m or less, and approaches to the curve.

2. Sections where number of lanes or width of carriageway changes abruptly.

3. Sections where there are many accident records of run-off-carriageway type at nighttime or where found as necessary by engineer to ensure safe traffic flow.

(2) Raised Pavement Marker (Chatter Bar)

1. Curve sections of which curve radius is 150m or less.

2. Sections where centerline crossing by vehicles is to be prohibited.

3. Boundary of chevron marking which is drawn on the pavement near to rigid hazards, e.g., raised traffic island, pier in the carriageway, etc.

5.5 Warrants of Sidewalk and Bicycle Path

(1) Sidewalk

1. Vehicle traffic* per day is 3,000 or more and pedestrian traffic is 250 or more. (For the roads in urban areas, it is desirable, regardless of the above traffic volume, to construct sidewalk on any roads, when found necessary to do so and no land acquisition problems exist.)

(2) Bicycle-Pedestrian Path**

1. Vehicle traffic* is 2,000 or more and bicycle traffic per day is 1,000 or more.
2. Vehicle traffic* is 2,000 or more and bicycle traffic per day is 500 or more, when considerably high vehicle speed suggests the need for bicycle traffic segregation.

(3) Sidewalk Plus Bicycle Path

1. Pedestrians and bicycles should be separated when the total volume of both exceeds 3,000 per day.

5.6 Warrants of Pedestrian Crossing Facility

(1) Crosswalk

1. Section where a number of school children cross,
2. Walking part within an intersection,
3. Section where vehicular traffic makes it difficult for a number of pedestrians to cross roadway.

(2) Pedestrian Refuge Island

1. Sections where pedestrians can not cross carriageway in one movement of crossing and are apt to wait for a traffic gap in the middle part of roadway of which carriageway has 4 lanes or more.

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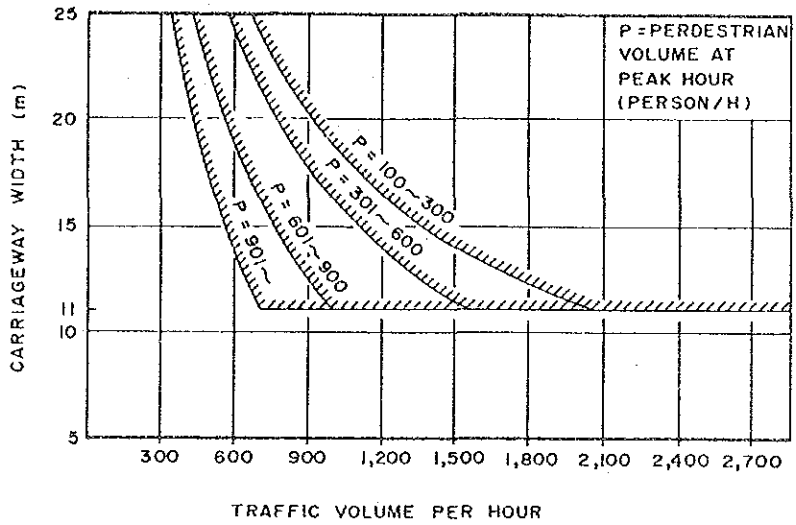
* Vehicle traffic traveling on outer lanes of both directions.

** Bicycle path permissive of pedestrian traffic.

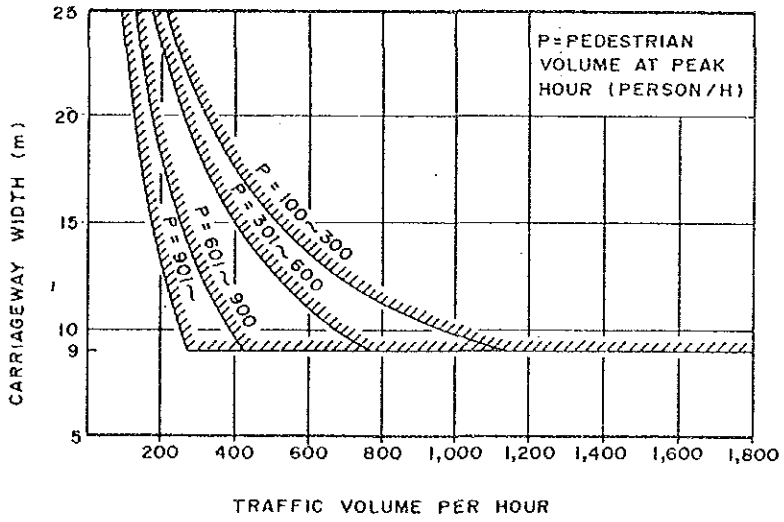
(3) Pedestrian Overpass

1. The number of pedestrians per hour exceeds 100 persons at a peak hour, and the conditions of vehicular volume and width of carriageway meet the range indicated by the oblique line in the figure a) below, while the figure b) shall be applied when school children comprise the large component of pedestrian.

a) Warrant of Pedestrian Overpass



b) Warrant of Pedestrian Overpass for School Children



2. The width of carriageway exceeds 25 meters, and there are no proper space like median or refuge island where pedestrians can wait for traffic gap.

3. Pedestrian's volume is so high that vehicular traffic is affected to a large extent.

4. No pedestrians are allowed to cross to ensure high running speed of vehicles on roads such as freeway.

5. When pedestrian's volume is high at such as locations, within 200 meters from railway crossing, immediate vicinity of grade-separated road, or sub-standard sight distance, where pedestrian safety cannot be accomplished by at-grade crossing.

5.7 Review of Technical Guidelines on Sign and Marking

A review was made on the "Manual on Traffic Control Devices" of DOH, which comprises two parts, Traffic Signs and Markings.

Concerning the traffic signs, repetitive usage of the regulatory signs and the proper erection of "Intersection Ahead" signs, "Curve (Turn)" signs and "Route Markers" are discussed. Furthermore, some formula for calculation of sign positioning is proposed.

As to the pavement markings, extensive usage of longitudinal markings is discussed.

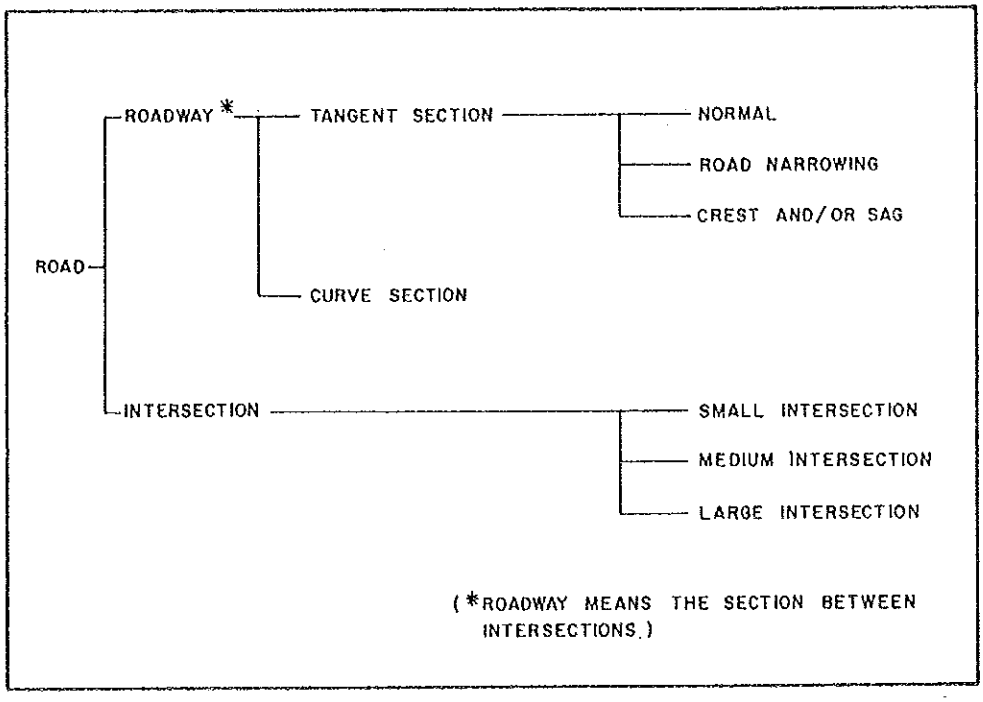
6. Traffic Safety Planning

(1) Guideline for Traffic Safety Planning

Traffic accidents are mostly phenomena accrued from multicauses and can be prevented with comprehensive remedy works specific to each hazardous site. However, from various studies on accidents, it is a well known fact that there are, to a large extent, common relations between accident patterns and accident causes. The relations become more obvious when discussed by road type.

The detailed analyses on the relation and the past experiences in traffic safety improvements enable highway engineers to work out a "guideline for traffic safety planning" which contains basic concept and information needed for preparation of an actual and effective safety plan at a given road site.

In the guideline for traffic safety planning in this study, the relations between accident causes and necessary measures to be taken at each of the following road types are discussed in detail. The discussions are made separately for the typical accident patterns specific to each of the road types.



In the case of curve sections on roadway, for example, the following table accompanied with detailed illustrations is presented in the guideline. For other road types, the guidelines for safety planning were worked out in a similar manner.

Causes of Accident	Safety Measures	Safety Devices
Excessive speeding	Limitation of running speed Information of road condition Treatment of superelevation	Regulatory sign Pavement marking Warning sign Lighting
Restricted sight distance	Provision of optical guidance	Lane marking Delineator Reflective raised pavement mark
Slippery surface	Treatment of surface	Skid resistant pavement
—	Prevention of serious accident	Guardfence

(2) Traffic Safety Plan for Study Road

A case study to prepare practical safety plans for 17 sites on the study roads (total length is 316km) which were selected by DOH, was carried out applying a set of traffic safety measures in the "guideline for the traffic safety planning". The case study sites were selected in consideration of 1) high frequence of accidents, 2) sub-standard alignment and disorderly flow and 3) concerns expressed by relevant parties. Besides the above, the care to the effect that at least one safety measure for all typical accidents could be proposed was also paid. The case study sites are summarized in the following table.

The safety plans for the selected sites were worked out based on thorough analyses on traffic accidents and road conditions such as right-of-way, topography and land use. The drawings of the proposed remedy works were prepared on 1/1,000 scale road plans.

(High Frequency of Accidents)

	Route No.	Kilo Post	Length (km)
1)	Route 1	(KP 19.0 - 22.0)	3.0
2)	Route 1	(KP 29.5 - 32.5)	3.0
3)	Route 1	(KP 47.5 - 51.0)	3.5
4)	Route 2	(KP 253.8 - 254.3)	0.5
5)	Route 302	(KP 1.0 - 4.0)	3.0
6)	Route 306	(KP 1.2 - 2.0)	0.8
7)	Route 306	(KP 13.0 - 14.0)	1.0
8)	Route 336	(KP 2.0 - 5.0)	3.0
9)	Route 3113	(KP 1.8 - 2.8)	1.0
			(Sub total = 18.8)

(Substandard Alignment)

	Route No.	Kilo Post	Length (km)
1)	Route 2	(KP 254.5 - 255.0)	0.5
2)	Route 32	(KP 52.5 - 67.5)	17.0
3)	Route 205	(KP 1.3 - 1.7)	0.4
4)	Route 304	(KP 64.5 - 67.0)	2.5
5)	Route 306	(KP 2.7 - 3.1)	0.4
			(Sub total = 20.8)

(Concerns Expressed by Relevant Parties)

	Route No.	Kilo Post	Length (km)
1)	Route 11	(KP 97.3 - 97.8)	0.5
2)	Route 323	(KP 79.5 - 80.0)	0.5
3)	Route 1141	(KP 1.0 - 1.8)	0.8
			(Sub total = 1.8)

These 3 sites were selected based on the results of interviews with relevant parties, with whom the Team communicated through DOH counterparts

The safety plans for the selected sites were worked out based on thorough analyses on traffic accidents and road conditions such as right-of-way, topography and land use. The drawings of the proposed remedy works were prepared on 1/1,000 scale road plans.

7. Experimental Works

(1) Effectiveness Assessment of Experimental Works

To obtain firsthand information on the effectiveness of the traffic safety plans proposed for seventeen (17) sites on the study roads, experimental works were executed at the selected five (5) sites. The effectiveness of the proposed safety plans was assessed through before-and-after surveys on traffic accidents, traffic behaviours and users' opinions. The major objectives of the experimental works at the five sites are as follows.

1) "Improvement f Lane Line Marking" (Route 1)

On straight roads, drivers tend to run at high speeds and trespass on adjacent lane, and this sometimes leads to a serious traffic accidents. A clearer marking of lane lines encourages drivers to confine their vehicles within the driving lane resulting in reduction of rear-end and head-on collision accidents. In this case, 20cm wide lane lines were introduced in place of the standard 10cm wide line on DOH roads. For one-kilometer section (KP 48.0 - 49.0) of left carriageway on Route 1, 20cm wide "lane line" and "edge line" were painted, whereas the longitudinal interval of broken line was kept same as the DOH standard (4m solid line, and 8m interval).

2) "Improvement of a Sub-standard Curve by Visual Guidance" (Route 306)

Appropriate reflectors and signs lead the drivers' eyes effectively to the sharp curves, and make the driving smooth and safe. In the experimental work executed around kilo-post 3.0 on Route 306, "delineators" were attached directly onto guardrails, and "chatter-bars" were inserted into center lines.

3) "Safeguard of Pedestrian" (Route 306)

"Refuge island" 20cm high and 2-meter wide, was constructed at the center part of the crosswalk. The curbs were also placed between carriageways and shoulders to separate pedestrians from the vehicular traffic and to induce pedestrians to the refuge island. The site of this experiment is at the section of KP 13 + 500 to 14 + 000 on Route 306.

4) "Improvement of Turning Traffic by Signalization" (Route 336)

The road network in Bangkok is composed of a set of arterial roads associated with a number of side streets called "Soi", and many of them are cul-de-sac. The traffic disturbance which results from the vehicles from these side streets to the arterial road or vice versa, is the major cause of frequent collision accidents. Such accidents are caused by sudden turnings and improper weaving of vehicles. The prohibition of turning movements by closing open parts of median strips where a number of accidents had taken place, and the introduction of a traffic signal, were planned to ameliorate the above problems. The improvements were made for the three-kilometer section (KP 2 + 000 to 5 + 000) on Route 336.

5) "Intersection Improvement by Channelization" (Route 1141)

On DOH roads in rural area, there are many T intersections where the "branch approach" carries more traffic than the straight part of the intersection. In this case the vehicles flowing out from the branch part and into the straight section, i.e. the right turning vehicles which are usually running at high speed, conflict with the traffic on straight part of the intersections.

An improvement by channelization was planned in order to give priority to right-turning vehicles through remodeling alignment. The site for this experiment is located at the section (KP 1 + 000 to 1 + 800) on Route 1141.

The summary of the traffic safety plans at the selected five experimental work sites and their effectiveness in terms of accident reduction rate, conflict reduction rates and users' opinions are as follows.

Safety Measure	Contents	Accident Reduction Rate (%)	Reduction Rate of Conflicts (%)	Support Rate of User Opinion (%)
Improvement of Lane Line Marking	Widening Width of Line	40	62	88
Improvement of a Sub-standard Curve by Visual Guidance	- Delineator - Chatter-Bar - Pavement Marking	50	59	100
Safeguard of Pedestrian	Sidewalk - Curb Pedestrian Crossing - Refuge Island - Marking - Warning Sign	67	(48)*	(95)*
Improvement of Turning Traffic by Signalization	Signalization - Signals for Vehicle Traffic - Signals for Pedestrians Channelization - Right-Turn and U-Turn Lanes at Signalized Intersection - Closure of Median Openings - Pedestrian Crossing - Marking	48	80	57
Intersection Improvement by Channelization	- Channelized Island - Marking	55	51	72

* As to only pedestrians

(2) Accident Reduction Rate

To evaluate traffic safety plans and to select priority measures from various alternatives, it is necessary to estimate accident reduction expected from planned safety measures. In this study, expected accident reduction rates by safety devices are presented as a general information applicable to macroscopical analyses on safety plans or safety measures. The accident reduction rates were worked out mainly based on various literatures on the subject as well as the results of the experimental works, provided that strict law enforcement and road users' education are practiced. It should, however, be noted that they do not necessarily guarantee the effectiveness of safety devices.

Accident Reduction Rates

	Safety Devices	Reduction Rate of Number of Accident
Roadway	Traffic Signal for Pedestrian	50
	Refuge Island	65
	Crosswalk	30
	Overpass	55
	Sidewalk	45
	Improvement of Surface	85
	Shoulder Treatment	50
	Guardfence	40
	Lighting	30
	Visual Guidance	50
	Median Island	20
	Marking (Edge Line)	30
	Traffic Sign	15
Intersection	Traffic Signal	50
	Lighting	30
	Channelization	50

8. Information for Master Plan

(1) Concept of Master Plan

In this study, the traffic safety plan for DOH roads is approached from engineering improvement with an assumption that enforcement of traffic laws and training and education of the drivers and the public are to be coordinated by the respective agencies concerned.

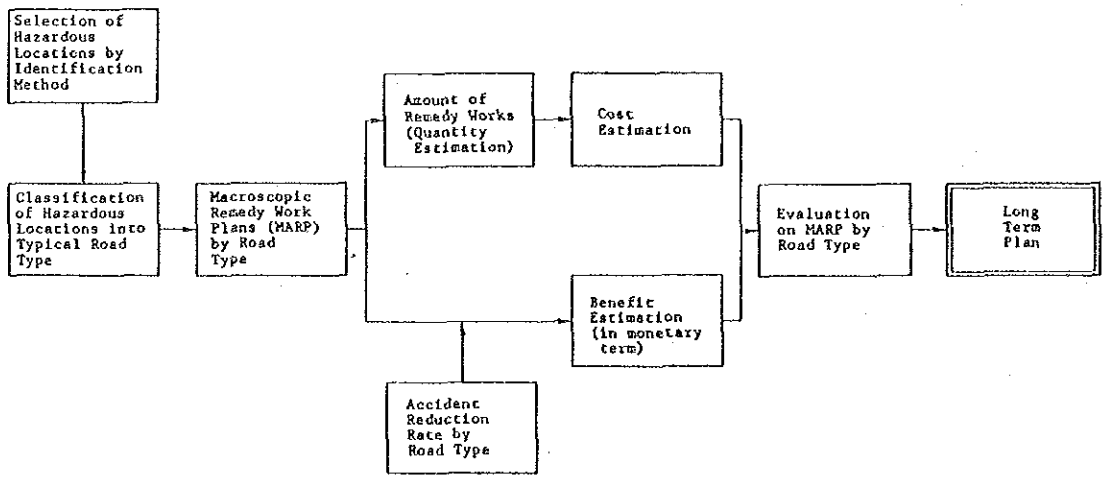
The master plan in this study means a set of plans in long term and medium term, and is presented herein aiming at furnishing necessary information which may contribute to preparation of a long term plan for traffic safety through case study and to formation of a medium term plan on DOH roads from engineering approaches.

The main purpose of the long term plan is to set forth a goal of traffic accident reduction together with quantity of remedy works and approximate investment amount needed to achieve the goal. For this purpose, very precise and detailed plans may not be necessarily required. Therefore, the scope of remedy work plan and the financial needs are to be determined macroscopically.

A medium term plan is to be worked out so as to identify the hazardous locations screened from those in the long term plan, where there are more urgent needs for implementation of the traffic safety measures. In the medium term plan, a realistic investment plan with annual allocation shall be also set forth, since it has a nature of action plan.

(2) Method for Development of Long Term Plan

A process to macroscopically formulate a long term plan is shown in the following figure, and the steps for formulation are described as follows:



1) to select hazardous locations where high frequency of traffic accidents occur by the identification methods,

2) to classify the selected hazardous locations by road patterns (intersection/roadway, traffic volume, number of lane),

3) to plan out standardized remedial measures (a macroscopic remedy work plan) for each classified road pattern,

4) to quantify the amount of remedy works and to estimate implementation cost, based on the macroscopic remedy work plan,

5) to determine accident reduction rate by standardized remedial measure.

6) to evaluate the effectiveness of the long term plan by application of the method identifying the net benefits and benefit/cost ratio, and of other means of evaluation methods.

(3) Case Study for Long Term Plan

The case study in this study has been carried out with limited data and information, and with a number of assumptions and judgements made by the Team. Therefore, the objectives of the case study should be interpreted as a demonstration of the macroscopical method for formulation of a long term plan, and not be meant necessarily to propose a conclusive plan. The summary of long term plan is as follows:

1) Number of Hazardous Locations

The total number of classified hazardous locations is 877 with the breakdown of 639 locations for roadway and 238 for intersection having 8,852 estimated number of casualties. The hazardous locations are classified by road patterns in 6 types for roadway and 4 types for intersection as shown in the following tables.

2) Standardized Safety Measure

To cope with the accidents at the classified hazardous locations, 10 sorts of standardized safety measures are worked out, each measure comprising a mix of safety devices conceived most effective and suited as the countermeasure for prevention of traffic accident at each classified hazardous location. The detailed standardized measures are listed in the following table.

Road Type Classification : Roadway

Road Type			No. of Sections	No. of Casualties
Lane Composition	Configuration of Road	Type of Plans		
Divided 4 - lanes	Tangent	RT - 1	98	1,405
	Curve *	RC - 2	17	366
Undivided 4 - lanes	Tangent	RT - 3	63	861
	Curve *	RC - 4	11	225
2 - lanes	Tangent	RT - 5	382	3,680
	Curve *	RC - 6	68	983
Total			639	7,520

*; Section which have curve segment within each hazardous section

Road Type Classification : Intersection

Road Type			No. of Intersection to be Remedied	No. of Casualties
No. of Lane of Approach Road	Traffic Volume on DOH Road	Type of Plans		
4 x 4		I - 1	25	153
4 x 2		I - 2	24	130
2 x 2	High	I - 3	42	235
	Low	I - 4	147	814
Total			238	1,332

3) Amount of Investment

The total amount of investment needed in the long term plan in this case study has been estimated at approximately 1,300 million Baht at 1985 price, consisting of about 960 million Baht for installation/construction and about 340 million Baht for operation and maintenance. This estimation was made on the condition that the long term plan would be implemented over the period of 10 years starting from 1985.

4) Implementation Plan

As indicated above, the 10-year term plan in this case study has been prepared macroscopically which has come out to require a fairly large amount of investment.

Safety Device \ Road Type		Unit	Roadway							Intersection				
			RT-1	RC-2	RT-3	RC-4	RT-5	RC-6	Total	I-1	I-2	I-3	I-4	Total
Marking		m^2	137,200	23,800	88,200	15,400	292,230	61,200	618,030	12,000	13,680	22,260	36,750	84,690
Traffic Sign	Guide	set	196		126				322	100	96	168	588	952
	Warning Regulator	set	588	102	378	66	2,292	408	3,834	800	768	1,176	4,116	6,860
Delineator with post		p	14,330	2,110	4,610	680	27,960	4,210	53,900					
Raised Pavement Marker		p			6,048	1,537		15,844	23,429					
Median	Roadway	m			25,200	4,400			29,600					
	Intersection	L								100	48[1)]	2)		
Guardfence		m	14,700	17,000	4,725	5,500	28,650	34,000	104,575	3,000	2,880	5,040		10,920
Crosswalk		m	2,940		1,890		2,865		7,695	2,375	1,680	2,730	7,350	14,135
Lighting	Roadway	l.m	14,700	17,000	9,450	11,000		17,000	69,150					
	Intersection	set								25	24	42		91
Traffic Signal	Large Scale	set								25	24			49
	Medium Scale	set										42		42
Right-turn Lane		L								25	24	42		91
Sidewalk		m	58,800	10,200	25,200	4,400	76,400	13,600	188,600	9,000	5,760	5,040		19,800
Pedestrian Overpass		set	59		38				97					

Note; 1),2) The quantity of painted island is transfered to the quantity of marking.

Therefore, this sort of plan needs to be reorganized into a plan of action with a relatively shorter implementation period, e.g. 5-year plan with annual implementation schedule and budget allocation.

5) Reduction Rate

The reduction rate of casualty by each standardized remedial measure for each road type is estimated by the Team, which ranges from 30% to 55% with an overall average of 43% for the long term plan in this case study.

6) Effectiveness Evaluation

The effectiveness evaluation of the long term plan in this case study is practised by identification of net benefits and benefit/cost ratio. The investment schedule of this plan being spread over 10 years would create a situation that the effects or the benefits of this investment should yield to the full extent in the years after completion of the plan. Therefore, the period of evaluation is determined in the total of 20 years, with necessary replacement and maintenance costs accounted for the additional 10 years. For comparison purpose, the evaluations with 10 year period and the lst year rate of return are also attempted.

The components of evaluation applied in this study are

1) 8,852 casualties which are broken down into fatality and injury for each standardized safety measure,

2) reduction rate of each safety measure which comes in average of 43 percent,

3) about 1,300 million Baht of investment cost spread over the period of 10 years within the plan period and additional 1,250 million Baht for the next 10 years required for replacement and maintenance, and

4) the unit value of fatality, injury and property damage which are accounted for 0.3, 0.03 and 0.0216 million Baht respectively.

The result of evaluation with constant price of 1985 proves that the long term plan for the highway traffic safety can be justified with the net benefits for about 4,100 million Baht and the B/C ratio of 2.59 for the 20 year evaluation period, and about 860 million Baht and 1.66 for the 10

year period. In other words, by implementation of this long term plan it is estimated that about 14,000 persons are to be saved from fatality and 42,000 persons are to be prevented from injury during 20 year period, and 4,500 fatality saved and 13,600 injury prevented for the 10 year period. The summary of the effectiveness evaluation is shown in the following table.

Summary of Economic Evaluation

(Unit : Baht in Million)

Type of Evaluation	Investment Amount Install.	Maint.	Total	Gross Benefits	Net Benefits	B/C
1. 20 Year Period (1985-2004)	961.30	1,610.04	2,571.34	6,657.57	4,086.23	2.59
2. 10 Year Period (1985-1994)	961.30	342.13	1,303.43	2,164.27	860.84	1.66
3. 1st Year Rate of Return	961.30	0.0	961.30	451.73	-509.57	0.47

Regarding the financial resources needed for this long term plan, it is estimated that the investment cost amounting to 1,300 million Baht would be about 0.8% of the total DOH budget for the 10 years.

7) Target of Long Term Plan

The long term plan is assumed to be implemented in 10 years between 1985 and 1994. When the plan would be fully undertaken and executed, the expected number of casualties saved by the safety improvement would be about 3,800 per annum which can be estimated at approximately 26% against the number of casualties on all DOH roads, provided that the present number of casualties on DOH roads will remain unchanged in the future.

(4) Method for Establishment of Medium Term Plan

The establishment of a medium term plan for the traffic safety improvement is to be made in accordance with and within the framework of the long term plan, taking into account the priority on the hazardous locations and related remedial measure, related safety improvement policy, available financial resources and the annual implementation schedule and budgetary allocations.

The first step for the medium term plan is the adoptation of the specific policy or strategy for the safety improvement, and the second is the determination of priority on the hazardous locations to be remedied during the medium term period. The priority rating of the locations is to be made objectively by application of effectiveness evaluation in terms of net benefits or B/C ratios, which shall also be crosschecked with the accident number method. The third step is that those hazardous locations selected shall be justified by the authorities concerned for the safety improvement.

The final step for establishment of the medium term plan is the reviews on the financial aspects taking into account the annual implementation schedule and budgetary allocation. In other words, it is recommended that the utmost attention be paid for establishment of the medium term plan so that it has the complete harmony in engineering, economic and financial aspects.

Chapter 1

INTRODUCTION

Chapter 1 INTRODUCTION

1.1 Background

The road traffic accidents in Thailand have considerably increased in recent years. The number of fatalities marked about 8,300 in the year of 1979 and the ratio in terms of fatality per vehicle is approximately 40 times greater as compared with Japan. The traffic accident thus constitutes a serious social problem, and the Government of Thailand, with the Department of Highways (DOH) being as one of direct responsible executing agencies, has given the highest priority to the solution of the problem.

The road traffic accidents are phenomena accrued from multifactor events, i.e. mainly, the behavior of road users, the mechanical conditions of vehicles and road conditions. Therefore, to reduce road traffic accidents, a comprehensive counter-measure, including drivers' education, strict enforcement of traffic laws, appropriate vehicle maintenance, and improvement of road and its safety devices, is requisite.

The improvement of road and provision of adequate safety devices, in particular, play an important role in reduction of road traffic accidents. DOH, which is responsible for the national and provincial highways in Thailand, has been exerting itself to the utmost to cope with the traffic accidents and wishes to employ the experience and technology on road safety engineering in Japan who has succeeded in remarkable reduction of road traffic fatalities.

The Government of Thailand, therefore, requested the Government of Japan for technical assistance to conduct a study on traffic safety plan for roads (hereinafter referred to as the Study).

The Japan International Cooperation Agency (JICA), the official agency responsible for implementation of technical cooperation programs of the Government of Japan, has set up a study team (hereinafter referred to as the Team) for consulting services to the Study.

1.2 Objectives and Scope of Work of the Study

The objectives of the Study are;

- to assist DOH in formulation and preparation of the traffic safety plan from the engineering point of view for reducing road traffic accidents in Thailand; and
- to perform technology transfer to Thai counterpart personnel in the course of the Study.

In order to achieve the objectives, the main activities in the Study are;

- to collect information and data relevant to the Study;
- to develop identification methods of hazardous road locations;
- to carry out a case-study, including road safety planning and experimental works on selected roads;
- to prepare necessary information for preparation of traffic safety master plan by DOH.

In the study, besides the above study items, reviews on the present data collecting systems and data analyses also are to be carried out.

The roads which are to be covered under the Study, are those for which DOH is directly responsible for improvement and maintenance. The case-study roads, for which road traffic safety plan is to be prepared and some experimental works are to be undertaken, are those shown in Appendix 1.1. They are mainly roads in and around Bangkok, Chiang Mai and Nakhon Ratchasima.

1.3 Study Flow

The Study consists of five major items as aforementioned, i.e., data collection, development of identification methods of hazardous road locations, execution of case-study, preparation of technical guidelines for safety planning and production of necessary information for preparation of traffic safety master plans. The study flow for the items is schematically shown in Figure 1.1.

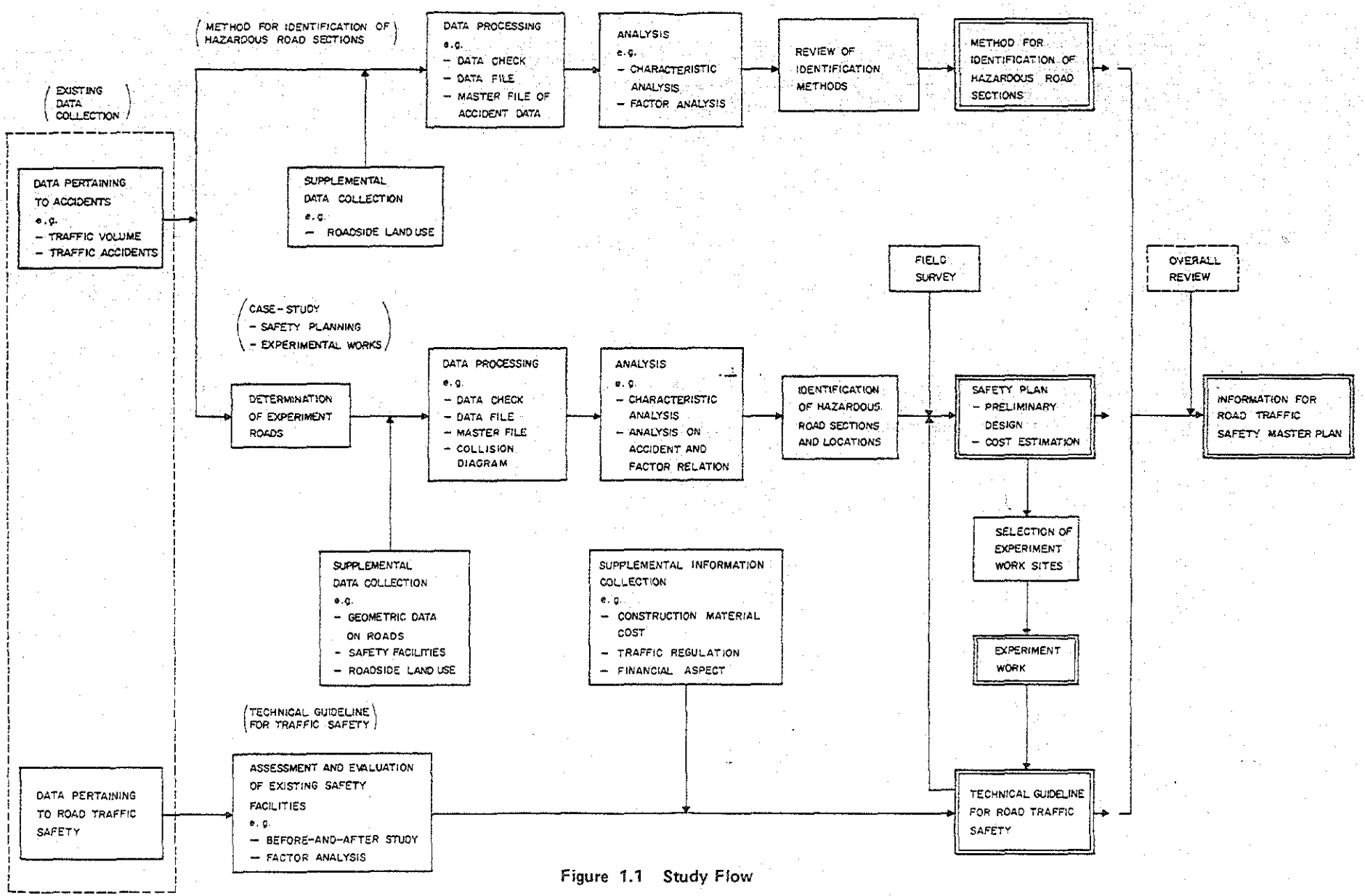


Figure 1.1 Study Flow

1.4 Study Schedule

The Study was commenced in May 1984 and is completed in January 1985. The detailed work schedule is shown in Figure 1.2.

Following reports were presented to DOH at the times as indicated below.

- Inception Report (20 copies) : May 1983.
- Progress Report (I) (20 copies) : August 1983.
- Progress Report (II) (20 copies) : December 1983.
- Progress Report (III) (20 copies) : March 1984.
- Interim Report (30 copies) : August 1984.
- Draft Final Report (30 copies) : November 1984.
- Final Report (50 copies) : January 1985.

1.5 Organization

The agencies directly concerned with the Study are DOH, JICA and the Team. The schematic organization chart during implementation of the Study is shown in Figure 1.3. The Study has been carried out by the Team under the supervision of the Supervisory Committee consisting of Japanese Government officials, organized by JICA. The Study Team will perform its consulting service in collaboration with DOH through its counterpart personnel.

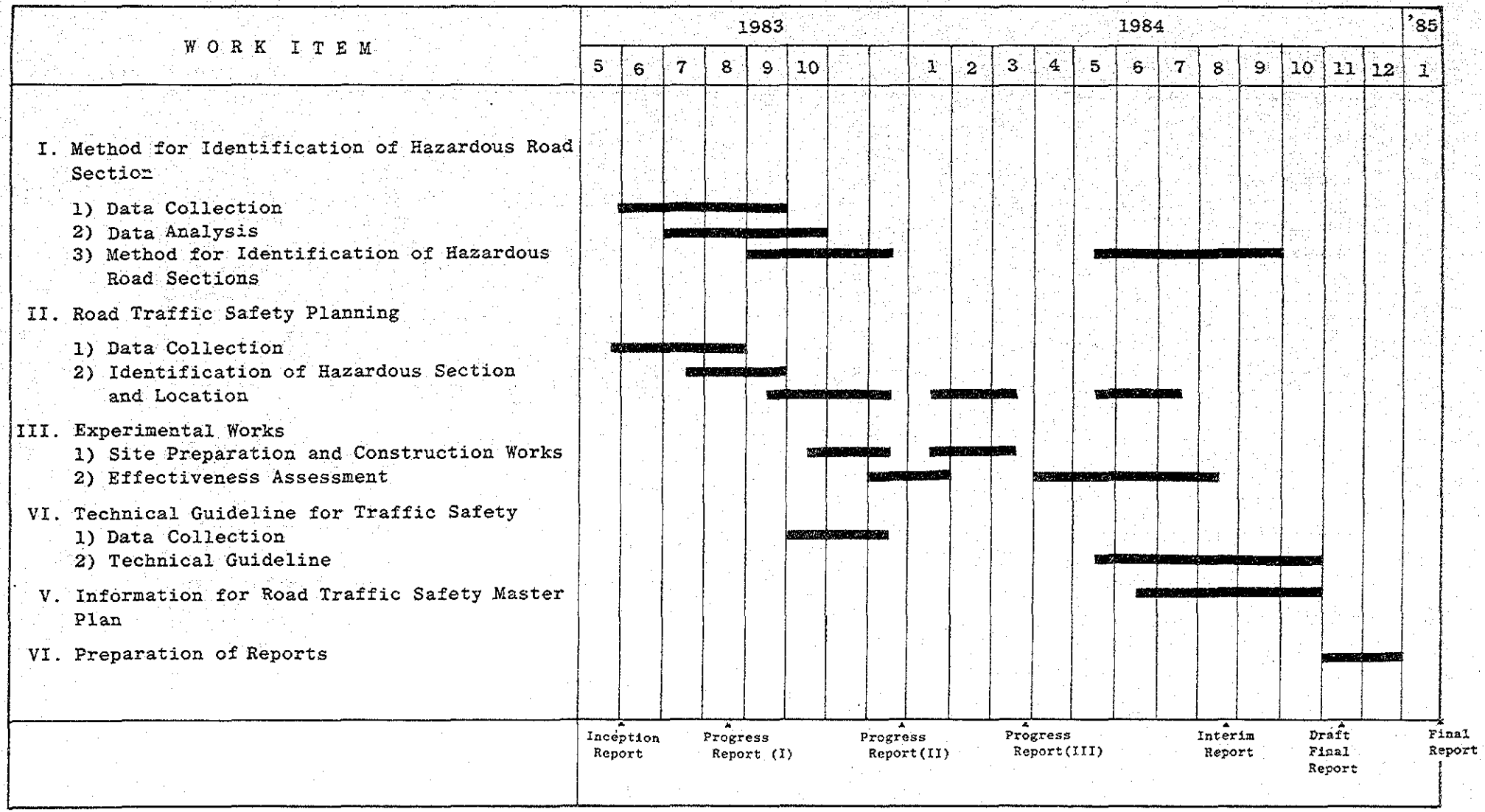


Figure 1.2 Work Schedule

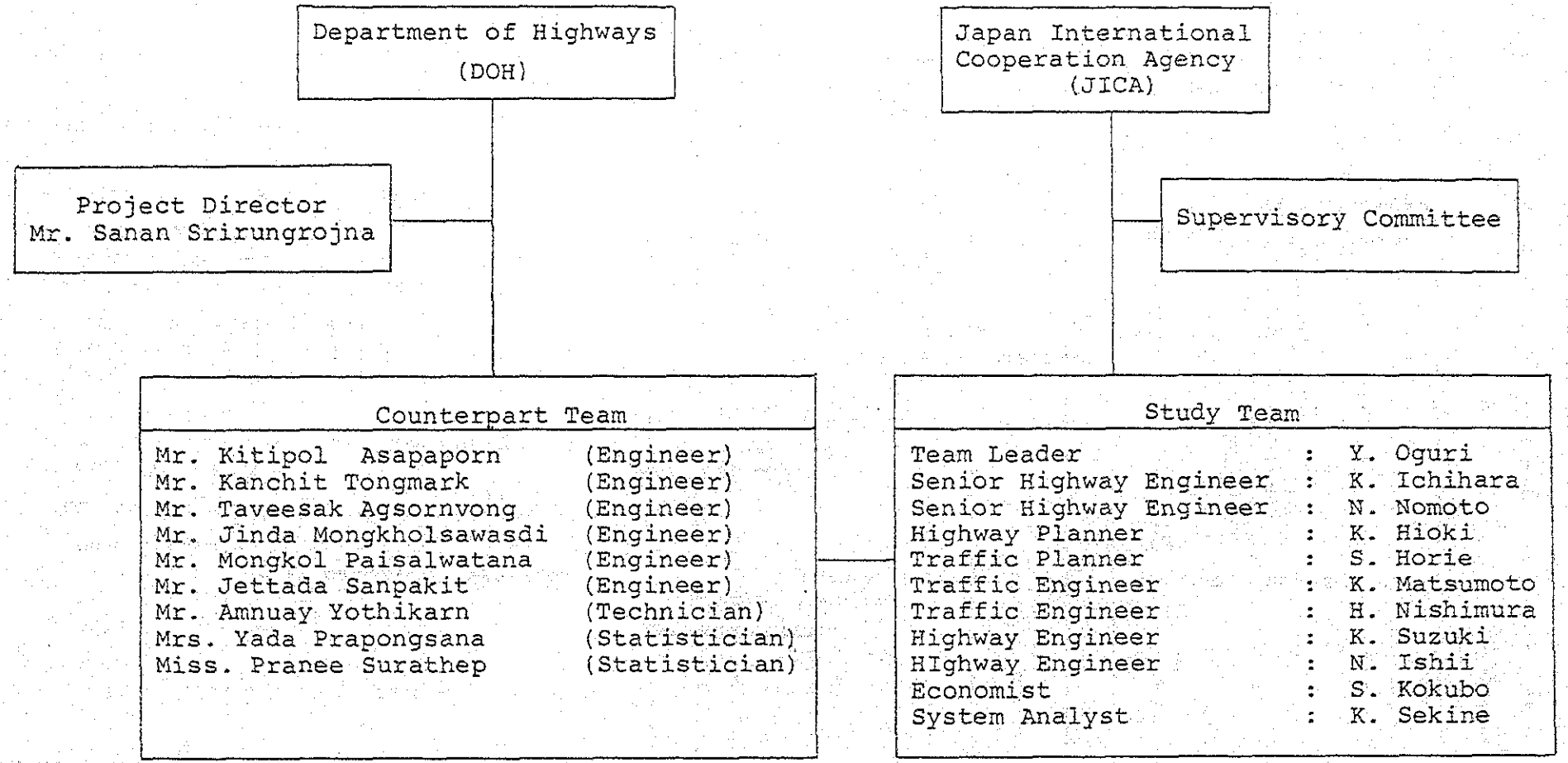


Figure 1.3 Organization for the Study

Chapter 2

ROAD AND ACCIDENT

Chapter 2 ROAD AND ACCIDENT

2.1 Road Transportation

During the past 20 years, from the beginning of the First National Economic and Social Development Plan (1962 - 1966) up to the present, the transportation system of the country has been remarkably developed and expanded in order to facilitate social and economic developments. As the efforts for such expansion have been primarily directed to the development of the road transportation system, the country's road network has gained an advantage over other transportation modes.

As for domestic transport of goods, about 80 percent (13,000 million ton-kilometers) are transported by road and the remaining 20 percent are by railway (see Table 2.1). Inland water transportation, which used to be the country's main transport means in the past, now plays much less important role. A road transport also has performed as important role in passenger transport. The passenger transport by road in 1977 was 37,000 in terms of million passenger-kilometers or 85 percent of the total. Therefore, it can be said that the road transportation is the most important means in domestic transport.

International comparison of transportation share between road and railway is shown in Table 2.1. According to this table, although there are some fluctuations among the countries, the shares of road in ASEAN countries are higher than those of the developed countries. This indicates that, in the developing countries, the road networks have been playing a dominantly important role in transportation.

Table 2.1 International Comparison of Transportation Shares between Road and Railway

Country	Year	Freight Transport (Million Ton-Kilometres)					Passenger Transport (Million Passenger-Kilometres)				
					Composition (%)					Composition (%)	
		Railway	Road	Total	Railway	Road	Railway	Road	Total	Railway	Road
Thailand[1]	1977	2,930	12,710	15,640	18.7	81.3	5,788	36,800	42,588	13.6	86.4
Malaysia[1]	1977	1,212	8,680	9,892	12.3	87.7	1,273	36,300	37,573	3.4	96.6
Indonesia[1]	1977	854	13,580	14,434	5.9	94.1	3,809	72,900	76,709	5.0	95.0
Philippines[1]	1977	49	12,090	12,139	0.4	99.6	655	59,500	60,155	1.1	98.9
Germany[2]	1978	56,500	96,700	153,200	36.9	63.1	37,600	51,370	88,970	42.3	57.7
France[2]	1978	67,300	89,100	156,400	43.0	57.0	53,500	-	-	-	-
U.K.[2]	1978	20,000	99,100	119,100	16.8	83.2	30,700	46,300	77,000	39.9	60.1
Japan[3]	1978	41,204	156,065	197,269	20.9	79.1	311,129	403,052	714,181	43.6	56.4

Source : 1) "Roads In Asian Economic and Social Development Role of the Asian Development Bank" M. Ganesan, Documentation VII th International Road Federation World Meeting.

2) "Trends in Transport Investment and Expenditure in 1979" European Conference of Ministers of Transport.

3) "Annual Report of Transport Economics, 1979" Ministry of Transport, Japan.

2.2 Road Network

2.2.1 Road Network

Roads in Thailand are classified legally into 7 categories under the Announcement of the Revolutionary Party No. 295 (Highway Law) issued on 1st December, 1972. They are Special Highway, National Highway, Provincial Highway, Rural Road, Municipal Road, Sanitary Road and Concession Road. The road length in Thailand totals approximately 157,000km. This consists of some 15,600 km of national highways including special highways, about 28,400 km of provincial highways and about 113,000 km of rural and municipal roads. (see Table 2.2 and Appendix 2.1)

Table 2.2 Road Length in Thailand

Road Category	Length (Km)
National Highways (Including Special Highways)	15,600
Provincial Highways	28,400
Rural Roads (Including Sanitary Roads and Concession Roads)	106,000
Municipal Roads	6,500
Total	156,500

DOH is responsible for construction and maintenance of national highways and provincial highways and their changes in road length are shown in Appendix 2.2. The national and provincial highway network has expanded rapidly from 28,000 km in 1968 to about 44,000 km in 1982.

2.2.2 Highway Development Plans of DOH

To develop the road networks, DOH had prepared four highway development plans i.e., 7-Year Plan (1965 - 1971), Third 5-Year Plan* (1972 - 1976), Fourth 5-Year Plan (1977 -1981) and Fifth 5-Year Plan (1982 - 1986) (see Table 2.3 and Table 2.4), within the frameworks of the National Economic and Social Development Plans, and had carried out the implementation of the plans.

In the First Plan (1965 - 1971), major efforts were made to expand national and provincial highways so as to provide efficient road networks between Bangkok and provincial areas. Under the Third and Fourth 5-Year Plans, the highway policies adopted by DOH, aimed at constructing about 19,000km** of major highways with an emphasis on the rural areas in order to alleviate the imbalance of economic developments between urban and rural areas.

Since the road networks of major highways have almost been developed throughout the country under the preceding highway development plans, in the Fifth Plan (1982 -1986), the construction of secondary roads and rehabilitation of the existing roads in rural areas have been given higher priority in order to promote balanced income distribution and to accelerate agricultural activities in rural areas. This plan aims at construction and rehabilitation of about 10,000km of roads (see Table 2.4).

As the road networks have been expanded and traffic volume has increased sharply throughout the nation, road traffic accidents on DOH roads as well as other roads have also rapidly increased.

The government, in the Fifth National Economic and Social Development Plan, set forth the following targets in order to cope with this rapid increase of accidents:

- to reduce the rate of road accidents by three percent per year, and
- to reduce the fatality rate by one percent per year.

DOH follows this national policy and has been making strenuous efforts to prevent and reduce traffic accidents on its roads in collaboration with other concerned governmental agencies.

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* Because of introduction of 5 year term in the highway development plans, the First Plan (7-year Plan) are now assumed a combination of First and Second 5-Year Plans.

** About 13,000 km of highway were completed.

Table 2.3 Past Highway Development Plans

Past Highway Development Plans		National Highway		Provincial Highway		Total	
		Length (Km)	Baht Million	Length (Km)	Baht Million	Length (Km)	Baht Million
7-Year Plan (1965 - 71)	Plan	6,711	8,439	5,953	3,526	12,664	11,965
	Completion	5,849	N.A.	4,500	N.A.	10,349	N.A.
	Percentage	87.2	N.A.	75.6	N.A.	81.7	N.A.
Third 5-Year Plan (1972 - 76)	Plan	3,827	5,607	5,226	4,402	9,053	10,009
	Completion	2,839	4,990	3,627	3,967	6,466	8,957
	Percentage	74.2	89.0	69.4	90.1	71.4	89.5
Fourth 5-Year Plan (1977 - 81)	Plan	2,516	7,519	7,886	9,029	10,402	16,548
	Completion	2,081	6,900	4,219	5,537	6,300	12,437
	Percentage	82.9	91.8	53.4	61.3	60.6	75.2

Source : Department of Highways

Table 2.4 The Fifth 5-Year Plan (1982--1986)

Project Priority	National Highway			Provincial Highway			Total		
	Number of Roads	Length (Km)	Baht Million	Number of Roads	Length (Km)	Baht Million	Number of Roads	Length (Km)	Baht Million
1. Paved Road Rehabilitation Project	69	2,293	3,558	41	838	778	110	3,131	4,336
2. Laterite Road Construction	-	-	-	10	192	174	10	192	174
3. Paved Road Construction	2	57	68	263	6,493	7,995	265	6,550	8,063
4. 4 - Lane Road Construction	28	178	2,335	3	10	76	31	188	2,411
5. New Road Construction	23	286	1,901	5	64	285	28	350	2,186
Total	122	2,814	7,862	322	7,597	9,308	444	10,411	17,170

Source : Department of Highways

2.3 Road Traffic

2.3.1 Registered Motor Vehicles

In parallel with the rapid expansion of road network for the past 20 years, the number of registered motor vehicles also has rapidly increased in Thailand. The number of registered motor vehicles in Thailand and Bangkok are shown in Appendix 2.3, while the increasing trend of registered motor vehicles is illustrated in Figure 2.1.

In Thailand, the total number of registered motor vehicles is 2.6 million in 1982. One of the features of motor vehicle registration is seen in a high composition rate of motorcycles (53.1% in 1982), followed by trucks (21.5%), passenger cars (5.4%), buses (8.2%) and others (1.8%).

The average annual growth rate of registered motor vehicles between 1972 and 1982, was 12.0%.

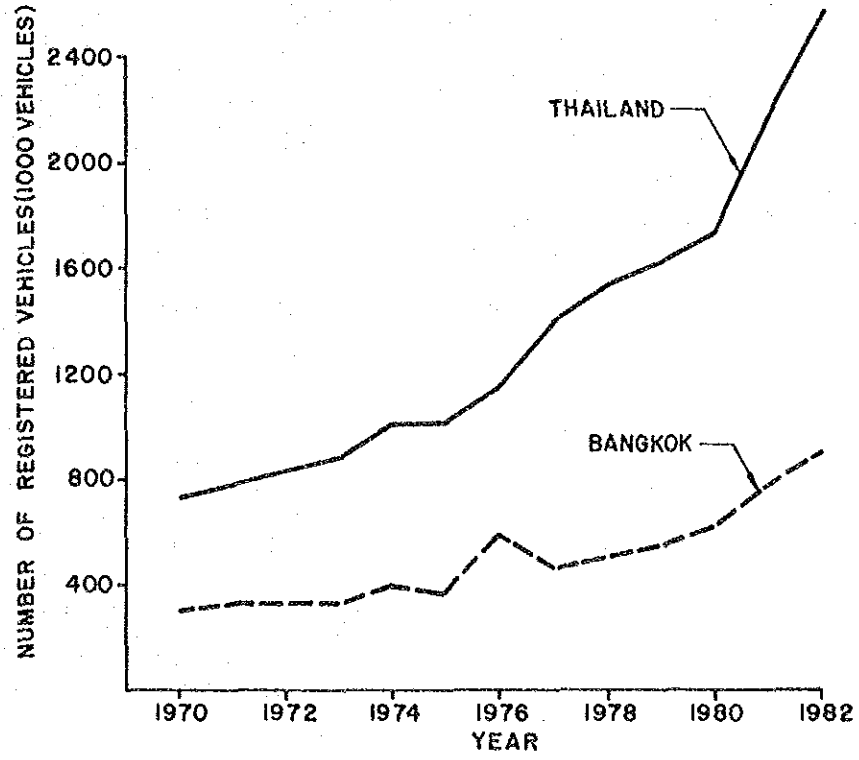

Figure 2.1 Trend of Registered Motor Vehicles

2.3.2 Traffic Volume

The traffic volumes on DOH roads (National and Provincial Highways) vary with the regions and routes. The traffic flow map for DOH roads is presented in Appendix 2.4, while Appendix 2.5 presents the traffic volumes on the national highways.

The average traffic volumes on the national highways between major cities are in the range of 1,000 to 3,000, while the average traffic volumes around the major cities range from 3,000 to 5,000 vehicles per day. In particular, the traffic volume around Bangkok is remarkably high with a wide variation ranging from 20,000 to 80,000 vehicles per day.

The past trend in increase of traffic volume is shown in Appendix 2.5, in which vehicles traffic counts at typical points in 4 regions for the years 1978 to 1982 are compared. The traffic volumes in the northeastern and southern regions have increased by about 8 and 14 percent annually from 1978 to 1982, respectively. In the central region including Bangkok, however, the increase rate of the traffic volume during the same period was relatively low (3% annually) compared with the other areas.

As for vehicular composition of traffic in all regions, heavy vehicle ratio of approximate 30 to 50 percent is higher than any other vehicles. In the central region, passenger car also has relatively large share of about 30% contrary to the small shares in other regions.

It is anticipated that high priority on the construction and rehabilitation of the rural roads in the Fifth Plan will bring about an increase of traffic volume in rural area in the near future.

2.4 Road Traffic Accident

2.4.1 Road Traffic Accidents in Thailand

(1) Changes in Traffic Accidents

The rapidly expanded road network throughout the country has contributed to the promotion of economic activities and development both in rural and urban areas. However adverse effects of traffic accidents have become very serious in spite of the various measures taken on the traffic control and safety.

During the period of 1973 to 1982, cases of accidents reported in Thailand increased at the average annual rate of 5 percent from 9,945 to 16,047 cases.

It is observed that there are more road accidents in urban areas, especially in Bangkok than in rural areas. In 1982 there were 9,794 cases of road accidents in Bangkok which account for 61% of the total in Thailand (see Appendix 2.6).

(2) Road Traffic Accidents in Various Foreign Countries

Table 2.5 shows a comparison in the number of deaths caused by road traffic accidents among various countries. The rates of traffic deaths per 10,000 of vehicle in the ASEAN countries range approximately 20 to 50, while the developed countries and Japan have a low level of 2 to 6. It is noteworthy that the rate of fatality per 1,000 of casualty in Thailand is the highest at 251. This indicates the traffic accidents in Thailand are generally severer than those in other countries.

Table 2.5 International Comparison of Road Traffic Accidents in 1981

Country	Accident	Death	Casualty	Death Rate per 1,000 casualty	Death Rate per 100,000 population	Death Rate per 10,000 Vehicle*
Thailand[1]	17,742	4,493	17,885	251	10.0	49.2
Malaysia[2]	59,084	2,001	22,404	89	18.0	21.1
Indonesia[2]	50,743	11,456	48,963	234	7.8	94.7
Philippines[2]	N.A.	1,493	N.A.	N.A.	3.1	17.1
West Germany[3]	379,235	13,041	500,463	26	21.1	5.3
France[3]	241,049	12,384	333,593	37	23.0	5.7
U.K.[3]	257,282	6,239	329,635	19	11.2	3.6
U.S.A.[4]	2,298,000	51,091	3,410,000	15	22.5	3.3
Japan[5]	476,677	8,760	607,479	14	7.5	2.3

Source : 1) Research and Planning Division, Police Department, Thailand
2) Survey on Road Safety Conditions in Major Southeast Asian Cities, Phase I, February 1983. Southeast Asian Agency for Regional Transport and Communications Development.
3) The Economic Commission for Europe.
4) The Federal Highway Administration and National Safety Council, U.S.A.
5) National Police Agency, Japan.

Note ; * Excluding Motorcycles

2.4.2 Traffic Accidents on DOH Roads

The accident records on DOH roads for the past six (6) years are presented in table 2.6 together with those of Thailand. The ratios of the accidents on DOH roads to the total of the nation remain almost unchanged during the 6 years. The number of annual accident on DOH roads is the order of 3,000 cases and casualties are about 7,000 to 8,000 persons. It should be noted that the figures for DOH roads in Table 2.6 are investigated by the Highway Police Division (HPD)*, which is responsible for investigation of accident on about 15,700Km of DOH roads (hereinafter referred to as HPD area). In addition, some accidents investigated by DOH** for its road length of about 28,300 Km, for which the local police stations (LPs)*** is responsible (hereinafter referred as to LPs area), are included.

On DOH roads in HPD area, the share of the total number of accidents to the whole roads in the country is about 20%, whereas these DOH roads (15,700 km) share about 10% of the total road length (about 157,000 km) in the country. This indicates the frequency of accident occurrence on DOH roads is twice as high as the nation's average.

The severity of the accidents on DOH roads is remarkably greater than that of the accidents in Thailand. The number of casualties per accident are 0.66 and 2.3 for Thailand and DOH roads, respectively.

Table 2.6 Traffic Accidents on DOH Roads

Year	Number of Accidents			Death			Casualties			Length of Road (KM)		
	Thailand	DOH	DOH per Thailand	Thailand	DOH	DOH per Thailand	Thailand	DOH	DOH per Thailand	Thailand	DOH	DOH per Thailand
1977	16,583	3,924	0.237	2,545	1,927	0.757	11,851	8,356	0.705	N.A.	38,244	
1978	18,669	3,616	0.194	3,952	2,067	0.523	14,520	8,271	0.570	N.A.	41,841	
1979	23,120	2,808	0.121	8,365	1,573	0.188	30,004	7,069	0.236	N.A.	42,805	
1980	17,742	1,727	0.097	4,493	1,169	0.260	17,885	5,092	0.285	N.A.	43,840	
1981	16,361	3,211	0.196	2,760	1,652	0.599	12,057	6,401	0.531	156,497	43,961	0.281
1982	16,047	3,264	0.203	3,091	1,952	0.632	12,431	8,154	0.656	N.A.	43,956	

Source : 1) Figures for all Thailand are based on data from the Research and Planning Division, Police Department.
2) DOH data is from the Traffic Engineering Office, Department of Highways.

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* Highway Police Division, Police Department, Ministry of Interior.

** DOH also investigates some of traffic accidents on its roads (For detail, see Chapter 3).

*** Local police stations, Police Department, Ministry of Interior

2.5 Approaches to Safety Improvement

2.5.1 Road Traffic Safety Administration

It is a general understanding that an effective reduction of the traffic accidents can only be achieved by a coordinated and integrated measures on the highway and traffic engineerings, motor vehicle mechanical engineering, driving skills, traffic law enforcements and traffic safety educations. The traffic safety measures and related activities being adopted in Thailand by the various authorities and agencies are described below.

In Thailand, several agencies are carrying out a variety of activities with respect to traffic safety under the relevant laws. Their major activities and related laws of each agency are described in Appendix 2.7. The following present briefly the major activities directly concerned with traffic safety and the roles of the related agencies.

(1) Road Administration by DOH

DOH is fully responsible for planning, construction and maintenance of every national and provincial highways. DOH has also responsibility for traffic safety of his highways in the engineering area. The road safety administration, such as planning, implementation and maintenance of traffic safety devices and related data collections are carried out by Planning Division, Traffic Engineering Office, Maintenance Division, Design and Location Division, Material and Research Division, Public Relation Section of Office of Secretary and Highway Field Division and its district offices. The functions of each division and office in DOH relating to the road safety are summarized in Appendix 2.8.

(2) Motor Vehicle Registration

According to the "Automobile Act (1979)", the Licences Division of Police Department (LDPD) of MOI has full responsibility for registration of motor cycles, taxis, passenger cars and light buses with capacity of 6 passengers or less, and light trucks with maximum laden weight of 1.6 tons or less.

Owners of motor vehicles classified as above are required to register their motor vehicles at LDPD and to renew the registration annually. Requirements for registration are the submission of an application from and motor vehicle inspection certificate, and the payment of vehicle tax and registration fee.

On the other hand, according to the "Transport Act (1979)", the Department of Land Transport (DLT) of MOC has full responsibility for light buses with capacity of more than 7 passengers, heavy buses, and trucks with maximum laden weight more than 1.6 tons. The registration procedure and requirements by DLT are same as those by LDPD. However, the type of licence-plates to motor vehicles registered by DLT is different from that of LDPD.

(3) Motor Vehicles Inspection

Both LDPD and DLT conduct motor vehicle inspection for those vehicles assigned to their responsibility. LDPD has one motor vehicle inspection center in each Changwat, while modernized equipment for inspection is installed only in Bangkok. However, it seems that inspections are conducted insufficiently due to manpower and facility constraints. Owner of motor vehicle intending to register under LDPD is required to get his motor vehicle inspected by LDPD prior to the motor vehicle registration procedure. For the renewal of registration, owner or commercial vehicle is required to get his motor vehicle inspected annually, while every in three years for owner of private vehicles.

DLT also owns one motor vehicle inspection center in each Changwat, while a modernized inspection center is located only in Bangkok. Since the number of motor vehicles to be inspected by DLT is much less than that of LDPD, it seems that sufficient inspections are conducted by DLT at present. In addition, DLT has recently authorize some private motor vehicles repair shops to conduct vehicle inspection for DLT.

(4) Driving License

In the same manner as the motor vehicle registration, both LDPD and DLT issue driving licenses according to their respective responsibilities.

Driving licenses issued by DLT for larger vehicles are not valid for smaller vehicles, which come under the responsibility of LDPD.

The condition and requirement for driving license issued by each agency is summarized in Table 2.7. Besides, DLT also issues licenses for conductors, inspectors and service personnel who are attached to vehicles.

The total number of driving license issued by both LDPD and DLT are summarized in Appendix 2.9.

There are 43 private driving schools in Thailand and the Ministry of Education (MOE) supervises these schools. DLT owns one driving school in Bangkok. The teaching attitude of most driving schools is mainly to help their students pass examinations conducted by LDPD or DLT, with few lessons on road safety.

Table 2.7 Condition and Requirements for Driving License Issued by LDPD and DLT

	LDPD	DLT
Minimum Age of applicants	For private use vehicle : 18 years old For public vehicle : 25 years old	For private use vehicle : 20 years old For public vehicle : 25 years old
Requirements of new applicants	To pass written examination and driving test	To pass written examination driving test To take course for 8 hours. (including road safety education)
Special requirements for renewal	None	To take course for 1 hour
Classification of driving license	9 types	3 types
Validity of driving license	For private use vehicles : 1 year or lifetime Temporary and for public use vehicle : 1 year	1 year

Note : DLT deals with large vehicles such as trucks with more than 1.6 ton laden weight and bus with capacity of more than 7 passengers.

(5) Insurance

It is not compulsory for the motor vehicle owners to be covered by insurance for third party liabilities in Thailand. Therefore, the number of motor vehicle covered by insurance is extremely low (about 8% in 1979). Under the present insurance system, average insurance coverages are ฿250,000/person for fatality and ฿500,000 for property/vehicle damage in 1982.

At present, the Government of Thailand is preparing the draft of a new regulation related to the compulsory insurance system for traffic accidents. In parallel with this movement, DLT introduced a "Surety Bond System" in 1979. Under this system, licensed operators of commercial vehicles are required to deposit bond to the central registrar for compensation to others in traffic accidents.

(6) Traffic Law Enforcement

There are 3 major laws, i.e. "Land Traffic Act (1979)", "Transport Act (1979)" and "Automobile Act (1979)", in order to ensure the safe driving as well as the smooth traffic flow. It seems that the contents of these laws are adequate for their objectives, and the strict enforcements of these laws are one of the most important factors for safety improvement.

Traffic laws are enforced by policemen of HPD, Traffic Police Division (TPD) of Police Department (only in Bangkok) and each LPs, and inspectors of DLT.

The policemen in uniform are empowered to stop and arrest any driver, passenger or pedestrian, who commits offences under the "Land Traffic Act (1979)", "Transport Act (1979)", and/or related regulations. On the other hand, inspectors of DLT are empowered to stop and to check the driving licence and motor vehicle itself under the "Transport Act (1979)".

The basic policy of HPD as to law enforcement is to prevent traffic accidents, and major enforcements are directed to speeding, improper overtaking and reckless driving. On the other hand, TPD and LPs enforce the laws mainly to maintain smooth traffic flows, especially to crack down on parking offences. While the law enforcement against offences such as reckless driving, speeding, obstruction of pedestrians, etc., which caused traffic accidents, is also exercised by DLT, its main activities are crackdowns on license offenders, default of motor vehicle inspection and over-loading.

Most of traffic offences are compoundable with penalties ranging ฿100 - ฿50,000. There are heavy penalties for serious offences, such as suspension or revocation of driving licenses and imprisonment.

(7) Road Safety Education

In Thailand, several agencies, such as the Police Department, HPD, DLT, the National Safety Council (NSC), and MOE are conducting road traffic safety education for pupils, drivers, and the public. Unfortunately, there was not much coordination among agencies regarding road safety education in the past.

In order to cope with this problem, NSC, established in 1982, is trying to coordinate activities related to the road traffic safety educations. At present, NSC are giving the road traffic safety course for truck drivers who have committed offences and the road traffic safety campaign through television and radio.

And also, a "Traffic Game Center" was constructed in Bangkok for public to practice actual road traffic safety procedures under the provision of NSC, TPD and MOE. In parallel with those activities, above mentioned agencies are also carrying out their own traffic safety education programmes by their own budgets.

2.5.2 Approach to Safety Improvement

As mentioned in the previous sections, several agencies have been carrying out various activities related to the traffic safety improvement. DOH, as one of these agencies, has been exerting itself to prevent and reduce traffic accidents in its road network, mainly from engineering practices.

Presented in the following chapters in this study, which aims at providing useful information for DOH to facilitate traffic safety improvement, are essential items to work out a systematic safety improvement plans and prepare effective counter-measures for DOH roads. The main subjects in the chapters are:

1) basic data and their collection (Chapter 3),
2) method to identify hazardous road locations (Chapter 4),
3) technical guideline on traffic safety devices (Chapter 5),
4) detailed information for traffic safety planning (Chapter 6 and Chapter 7), and
5) information for preparing master plan (Chapter 8).

Chapter 3
DATA COLLECTION

Chapter 3 DATA COLLECTION AND COMPILATION

3.1 Introduction

The main objectives of the Study are to develop methods for identification of hazardous locations on DOH roads, to prepare safety plans for the sections of the selected roads (the Study Roads) as a case study and to present information for preparation of traffic safety master plans. To achieve the above objectives of the Study, accident data, traffic volume data and road data are essential.

This chapter discusses;

- present practices of investigation, recording and reporting of traffic accidents on DOH roads;
- present practices of the traffic counting system for DOH roads;
- supplemental data collection by the Team for the accidents on the Study Roads; and
- compilation of data pertaining to traffic safety.

Based upon the experiences gained through the Study, some recommendations on the present DOH's practices for recording and reporting, traffic counting and data compilation are also proposed in this chapter.

3.2 Traffic Accident Data

3.2.1 Investigation

With regard to the investigation of traffic accidents on DOH roads, there are three concerned agencies;

- Highway Police Division (HPD), Police Department of Ministry of Interior;
- Local Police Stations (LPs), Police Department of Ministry of Interior; and
- Department of Highways (DOH), Ministry of Communications.

Although HPD is a part of Police Department, most of its expenditure is financed by DOH's budget.

HPD is responsible for accidents on the major DOH roads outside the municipal areas (about 15,700 Km - HPD area). The field investigation into the accidents in the HPD area is to be made by 35 inspector's offices of HPD scattering throughout the whole highway network of DOH.

LPs, on the other hand, have responsibility for the major DOH roads in the municipal areas and all minor DOH roads with a total road length of about 28,300 Km (LPs area). The field investigation is carried out by each LPs.

In spite of the aforementioned official demarcation for accident investigation between HPD and LPs, out of 35 inspector's offices of HPD, only 6 inspector offices (with a coverage of about 2,200Km road) are empowered to investigate and record accidents due to shortage of manpower and budget. For the remaining road sections, respective LPs conduct investigation and recording for HPD's inspector offices. A copy of accident record for each accident is then forwarded to the respective inspector office of HPD.

In parallel with accident investigation and recording by the concerned police, DOH, through its sub-district offices (454 offices in the country) also investigates and records traffic accidents on DOH roads. As the main objective of the investigation by DOH is to record damages of road properties, the investigation does not necessarily cover all accidents occurred on the roads.

3.2.2 Recording and Reporting

Since the main purposes of the accident investigation by three agencies, i.e., HPD, LPs and DOH are different, they have their own accident recording forms. The DOH's recording form is shown in Appendix 3.1. The records filled in by sub-district offices are sent to the Traffic Engineering Office and the Maintenance Division of DOH headquarters.

The traffic accident records by the inspector offices of HPD are prepared in HPD's own form as well as DOH's form. Then these records are forwarded to their headquarters. At the headquarters of HPD, the records in DOH's form are sent to DOH regularly.

Each LPs records traffic accidents in their own form which contains detailed information, in particular, as to those which are necessary for prosecution. At the same time, LPs also prepare records briefing each accident and send them to Police Department headquarters. There is no established system for DOH to receive the accident data from LPs.