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THE KINGDOM OF THAILAND

BANGKOK METROPOLITAN ADMINISTRATION

STUDY ON ROAD IMPROVEMENT, REHABILITATION AND TRAFFIC SAFETY IN BANGKOK

FINAL REPORT

VOLUME IV TRAFFIC SAFETY

MARCH 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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LIST OF ABBREVIATIONS

BMA	Bangkok Metropolitan Administration
CPD	City Planning Division, BMA
CMD	Construction and Maintenance Division, BMA
DD	Design Division, BMA
PPD	Policy and Planning Division, BMA
PPSd	Public Works Planning Sub-division, BMA
DPW	Department of Public Works, BMA
DDS	Department of Drainage and Sewerage, BMA
TED	Traffic Engineering Division, BMA
MOI	Ministry of Interior
OARD	Office of Accelerated Rural Development, MOI
OCMRT	Office of the Committee for the Management Road Traffic, MOI
OPP	Office of Policy and Planning, MOI
PWD	Public Works Department, MOI
TCPD	Town and Country Planning Department, MOI
TPD	Traffic Police Division, MOI
LDPD	License Division of Police Department, MOI
MOC	Ministry of Communications
DOH	Department of Highways, MOC
DLT	Department of Land Transport, MOC
ETA	Expressway and Rapid Transit Authority of Thailand
NESDB	National Economic and Social Development Board
SRT	State Railway of Thailand
MEA	Metropolitan Electricity Authority
AIT	Asia Institute of Technology
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
BS	British Standards
CAB	Cable Box
CBD	Central Business District
HCM	Highway Capacity Manual
MCI	Maintenance Control Index
MSL	Mean Sea Level
MTS	Mass Transit System
NECO	National Executive Council Order
PCU	Passenger Car Unit
PSI	Present Serviceablility Index
RAL	Richtlinien für die Anlage von Landstraßen
SSES	Second Stage Expressway System
STTR	Short Term Urban Transport Review

TRAFFIC SAFETY

1. INTRODUCTION

Road traffic accidents in Bangkok have been very rapidly increasing in the past few years in parallel with the increase in the number of vehicles and the heavy traffic flows in most of the major roads in the Metropolitan area.

Traffic accident gives very severe impact to the life of the general public as well as to national economy by means of casualties to the people and property damages. This problem is complex and its solution requires ceaseless efforts, and shall be resolved by various safety measures including education of the traffic safety minds, training to keep the traffic rules and regulations and enforcement by the police, etc. However, this study focus its efforts to the safety measures from the standpoint of engineering approaches on road improvement and safety devices.

The main objectives of the part of traffic safety in the study are as follows;

- To grasp the situation of traffic accidents in Bangkok
- To develop rating method to identify hazardous road sections
- To prepare traffic safety plans for selected hazardous road locations
- To evaluate the economic viability of proposed traffic safety plans.

In order to carry out the traffic safety study, the following study works are required.

a) Collection of traffic accident data
b) Data compilation of traffic accident, including preparation of Basic Accident Data File
c) Preparation of Accident Master File
d) Analyses of traffic accidents
e) Preparation of Road Section File
f) Development of rating method to identify hazardous road sections
g) Selection of hazardous road sections
h) Supplemental survey on selected road locations for safety planning
i) Preparation of traffic safety plans.
j) Economic evaluation on prepared traffic safety plans

2. APPROACH TO COMPREHENSIVE TRAFFIC SAFETY PLAN

2.1 Basic Concept of Traffic Safety

The basic concept and objective of the road traffic safety improvement are to reduce the frequency and severity of traffic accident. The safety improvement will be most effectively realised and accomplished when the undernoted three measures would act on in completed harmony.

- Creation of adequate physical environmental conditions to the road traffic from engineering viewpoint, like installation and improvement of safety devices.
- Prevailance of traffic safety consciousness and observance of the traffic rules and regulations among the general public, through training of drivers and education of children, and through campaign to the general public on the importance of traffic safety.
- Intensive and extensive enforcement of traffic laws and ordinances by the traffic police as well as relevant agencies. It may also be desirable to revise a part of present traffic laws in order to improve safety environment. (e.g. prohibition of drunken driving, etc.)

For the effective implementation and realisation of the traffic safety plan, it is indispensable not only for the BMA but also for all the government agencies concerned to have and keep close and good coordination among themselves for promotion of safety improvement programmes.

2.2 Traffic Safety Policy and Organization of BMA

(1) Current traffic safety policy of the BMA

In the 2nd Five Year Development Plan of the BMA (1982 - 1986), the following targets were set forth to realize steady reduction of traffic accidents in compliance with the traffic accident reduction targets set in the corresponding 5th National Economic and Social Development Plan.

- To reduce the rate of traffic accident by three (3) percent per annum.
- To reduce the mortality rate by one (1) percent per annum.

The National Plan for Prevention and Control of Road Traffic Accident formulated in April, 1982 by the National Safety Council points several existing problems to be solved, namely; the problem on road user, vehicle itself, road and transportation system, and traffic environment. The policy guidelines for resolution of the traffic accident set up by the BMA are;

- Strict enforcement of traffic laws will be undertaken.
- Research on traffic accidents will be promoted, together with creating a sense of responsibility among government officials and road users.
- Traffic accident will be prevented through proper engineering design of roads.
- Additional local courts will be set up in various districts of the Bangkok Metropolitan Area and laws will be revised to facilitate the prompt disposition of traffic violation cause.

In compliance with the above policy guidelines, Department of Public Works (DPW) and Traffic Engineering Division (TED) under the Office of the Permanent Secretary of the BMA formulated the road development plan within the framework of the 2nd BMA Five Year Development Plan, and have been undertaking an important role in the implementation of the road traffic safety improvement in spite of their hard financial restraint and lack of concrete traffic safety plan.

(2) Traffic safety administration of BMA

At present, activities of the following Divisions of BMA are concerned with the traffic safety. In addition, planning, installation and maintenance of street lightings on BMA roads are under responsibility of the Metropolitan Electlicity Authority (MEA).

Table 2.2.1 Traffic Safety Administration of BMA

Division	Major Activity
Department of Public Works	
1. Design Division	Design of road facilities including pedestrian overpass.
2. Construction and Maintenance Division	Construction and maintenance of Road facilities, including pedestrian overpass.
Office of Permanent Secretary	
3. Traffic Engineering Division	* Production, installation of traffic signs. * Painting and maintenance of pavement markings. * Planning, installation and maintenance of traffic signals. * Planning of pedestrian overpass
Department of Social Welfare	
4. Public Park Division	Planting all road side trees and maintained thom only along Ratchada Pisek Road and Sri Ayutthaya Road
5. District Offices	Maintenance of road side trees other than the responsibility of Public Park Division

2.3 Traffic Safety Plan from Engineering Approach

The foregoings lead to the needs for comprehensive traffic safety measures to reduce road accident effectively to accomplish the set targets.

In this study, however, traffic safety plans are discussed mainly from engineering approaches with an assumption that enforcements of traffic laws and trainings and educations needed for traffic safety are to be coordinated by the respective agencies concerned.

(1) Planning procedure for traffic safety plan

It is possible to prepare the preliminary safety plan systematically utilizing the data from the Police Department of the Ministry of Interior. In this approach, hazardous locations can be screened by the rating methods and the preliminary safety plan for each hazardous location can be prepared, by application of technical guidelines for safety devices and standardized traffic safety measures suitable to classified accident patterns.

(2) Evaluation process for traffic safety plans

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. The accident reduction rates can be worked out mainly based on various literatures on the subject as well as the comparison of accident indices before and after the implementation of safety plans.

For evaluation of effectiveness on the safety plan, it is possible, to a certain extent, to convert the benefit accrued from the investment (saved life, prevented injury and property damage) to monetary terms, but it would be advisable to make final decision on the safety plan from the other factors such as national interest and humanitarianism.

For preparation of safety plans, it is also important to verify the quantity of the existing safety devices and to work out the budget needed for new installation, replacement, repair and maintenance of the safety devices.

(3) Maintenance of safety devices

The safety devices are effective when properly placed, operated and

maintained. For preparation of the safety plan, besides the initial costs for the installation of safety devices or road improvements, the operation and maintenance shall also be incorporated in the plan.

3. TRAFFIC ACCIDENT DATA AND ANALYSES

3.1 Traffic Accident Data Collection

(1) Investigation and recording of accident

As for the investigation and recording of traffic accidents on roads in Bangkok, the Police Department of the Ministry of Interior, through its police stations, is responsible. The police organization which is directly responsible for traffic accidents in Bangkok is illustrated in Figure 3.1.1.

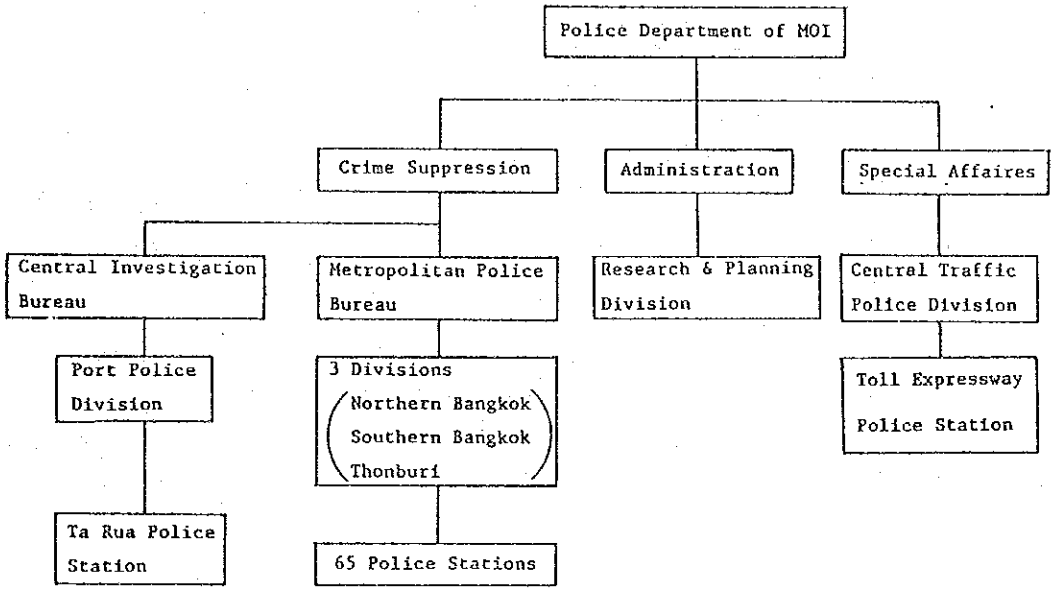

Figure 3.1.1 Organization Chart of Police in Charge of Traffic Accidents in Bangkok

The Metropolitan Police Bureau under the Police Department is in charge of the Bangkok Metropolitan area. Under the Bureau, there are 3 divisions, i.e. Northern Bangkok, Southern Bangkok and Thonburi.

Under these three divisions, there are 65 police stations which are, among others, in charge of investigation and recording of traffic accidents on roads in their respective regions. The accident data in a format specified by the Research and Planning Division are forwarded to the police stations through the organizational hierarchy as shown in Figure 3.1.1. However, the police stations do not necessarily, reportedly, report all the specified data of accidents occurred in their precincts to the Police

Department.

As for traffic accidents in the Klong Toey port area, Ta Rua Police Station under the Port Police Division is responsible.

The Central Traffic Police Division is mainly responsible for law enforcement and traffic management planning in Bangkok, although it receives reports on traffic accidents verbally from police stations. In addition, Toll Expressway Police Station, which is responsible for accident investigation on the Expressway is under the Central Traffic Police Division.

Although there is no uniform recording format, most of the police stations' records contain the following information on traffic accident;

- Year, month, date, day and time
- Name of district
- Location of accident
- Number of fatality and injury
- Type of accident
- Type of vehicle involved
- Cause of accident

Collision diagrams which are very helpful for accident analyses and preparation of traffic safety plan, are not available from the original records of the police stations, except the brief explanation of accident situation by words.

(2) Data collection

In order to grasp the accident situation on the study roads as well as in the BMA area, the team collected traffic accident data from 68 police stations, including Ta Rua Police Station under the Port Police Division, Toll Expressway Police Station under the Central Traffic Police Division and Bang Kruay Police Station in Nonthaburi Province. Although the data on the study roads were collected only for the year 1983-1985, they are regarded as satisfactory for the study purpose.

The information items collected for study roads were tabulated in the accident record format shown in Appendix 3.1.1. As seen from the format, the extent of information is limited to minimum requirements for the study. There are, however, some cases where all of these limited information were not available from the police stations' records. They were supplemented through hearings from traffic police officers to the extent possible.

In addition to the data collection of traffic accidents on the study roads, data collection of accidents which occurred on either minor roads other than the study roads in the study area or roads outside the study area, were also carried out simultaneously. The information obtained in these traffic accidents were limited to the extent so that only general analyses for the whole traffic accidents in BMA area could be made. Appendix 3.1.2 shows accident record format for data collection for this purpose.

Then, all accident data collected were compiled, coded and input into a microcomputer for analyses in connection with the development of rating methods to identify hazardous road sections and preparation of safety plans.

(3) Results of traffic accident data collection

The size of the traffic accident data collected from police stations is summarized in Table 3.1.1.

Table 3.1.1 Size of Collected Traffic Accident Data

Area	Road Length	Year		
		1983	1984	1985
BMA Area	1,883 Km			
No. of Accident		12,564	13,093	6,578
No. of Fatality		627	639	361
No. of Injury		4,888	5,061	2,306
Study Road	350 Km			
No. of Accident		4,321	4,271	1,948
No. of Fatality		152	158	93
No. of Injury		1,702	1,827	768

Note : Traffic Accident Data in 1985 are from January through June.

Source : Study Team

(4) Opinions from traffic police officers

In solving traffic accident problems, information on accidents from those who are familiar to localities and experienced in traffic problems is of a great use. Therefore, in parallel with the above mentioned data collection, the team made an interview with traffic police officers in 43

police stations and obtained their opinions about hazardous road sections in their jurisdictions.
As a result, 139 mid-block sections and 69 intersections were pointed out as hazardous road sections through interviews. These results were, then, utilized for the empirical approach.

In addition, opinions about causes of accidents and proposals for safety measures for these road sections from traffic police officers have been referred during the safety planning stage.

3.2 Compilation of Traffic Accident Data

(1) Basic accident data file

Every accident data collected from police stations was coded and entered into a microcomputer to prepare original data files (the Basic Accident Data File).

Two types of Basic Accident Data Files were prepared. One file contains detailed information of accidents which occurred on the study roads and this file is utilized for preparation of Accident Master Files and Road Section Files, as well as for the accident analyses on study roads. In this file, accident locations are fully coordinated with control links or primary nodes employed by the road inventory.

The other type of file contains only basic information of accidents not only on the study roads but also on minor roads in the study area and roads outside the study area. This type of file is utilized for the statistical analysis of traffic accidents in the whole BMA area.

(2) Accident master files

In order to carry out detailed traffic accident analyses on the study roads, the Team prepared Accident Master Files for 1983, 1984 and 1985 adding traffic volume data and some road information to the Basic Accident Data Files. The information items in this file is shown in Table 3.2.1.

At this stage, since the road inventory data did not include every necessary information, except for the Pilot Area, the Team carried out site observations in order to complete the information files of mid-block section and intersection.

In this Accident Master File, the selected information from the accident data, traffic volume data and road information are sorted by traffic accident. Therefore, the information in this file can be retrieved on the basis of each accident.

(3) Road section file

It is practical to analyse traffic accidents on mid-block sections not by spots but by road sections, the Road Section File for mid-block sections was prepared based on the Accident Master File. On the other hand, the Road Section File for intersections was prepared separately from the Road

Section File for mid-block sections since it is necessary to analyse traffic accidents at intersections by spots.

In these Road Section Files, the total number of accidents and casualties at each mid-block section and intersection in 1984 and 1985 up to June were converted into the yearly figures, in order to obtain the average feature of accidents at each mid-block section and intersection.

Table 3.2.1 Accident Master File

Information	Remarks
1. Police Station Name	
2. District Name	
3. Date	
4. Month	
5. Year	Budhist Era
6. Day	
7. Time	
8. No. of Fatalities	
9. No. of Serious Injuries	
10. No. of Light Injuries	
11. Control Link No.	For accident on mid-block section
12. Primary Node No.	For accident at intersection
13. Type of Accident	5 types
14. Type and No. of Vehicle Involved	
15. Weather Condition	
16. Cause of Accident	19 categories
17. Location	8 categories
18. Collision Pattern	26 categories
19. Traffic Volume (ADT)	Including Motorcycle
20. Street Code	
21. No. of Lanes	
22. Type of Roads	Two-way road, One-way road, Divided road, Others
23. Exxistence of Sidewalk	
24. Intersection Name	
25. No. of Legs	3 legs, 4 legs, 5 legs, 6 legs
26. Shape of Intersection	At grade, Roundabout, Fly-over, Interchange
27. Type of Control	Signal, Flashing Signal, Traffic Sign, None

The procedure to prepare Road Section Files is illustrated in Figure 3.2.1, while the information items in these Road Section Files for mid-block sections and intersections are shown in Tables 3.2.2 and 3.2.3, respectively.

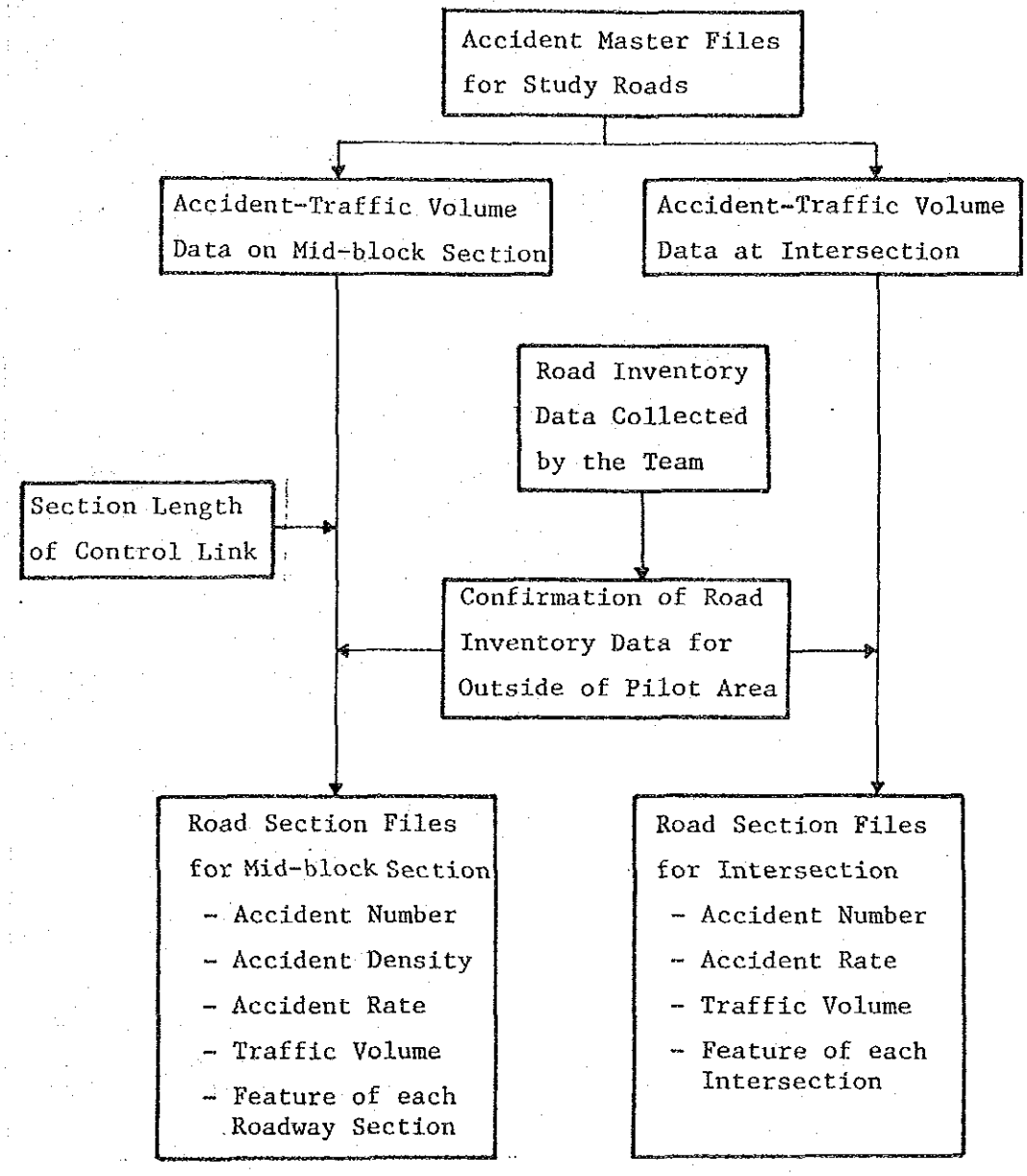

Figure 3.2.1 Procedure to Prepare Road Section Files

Table 3.2.2 Road Section File for Mid-block Section

Information Item	Remarks
1. Control Link No.	
2. Street Code	
3. Section Length (m)	
4. No. of Lane	
5. Type of Road	Divided Road, Undivided Road, One-way Road
6. Sidewalk	Exist, None
7. Width of Carriageway (m)	
8. Traffic Volume (ADT)	Including Motorcycle
9. No. of Accidents	
10. No. of Casualties	
11. Accident Rate by Accidents	
12. Accident Rate by Casualties	
13. Accident Density by Accidents	
14. Accident Density by Casualties	

Table 3.2.3 Road Section File for Intersection

Information Item	Remarks
1. Primary Node No.	
2. Intersection Name	
3. No. of Legs	3 legs, 4 legs, 5 legs, 6 legs
4. Shape of Intersection	At Grade, Roundabout, Fly-over, Interchange
5. Type of Control	Signal, Flashing Signal, Traffic Sign, None
6. Total No. of Lane	
7. Total Width of Carriageway	
8. Traffic Volume (ADT)	Inflow Traffic Volume Including Motorcycle.
9. No. of Accidents	
10. No. of Casualties	
11. Accident Rate by Accidents	
12. Accident Rate by Casualties	

3.3 Traffic Accident Analyses

(1) Traffic accidents in Thailand and Bangkok

Based on the statistical data obtained from the Research and Planning Division and the Central Traffic Police Division of the Police Department, the number of traffic accidents, fatalities and injuries for past 10 years in Thailand and in the whole area of Bangkok are summarized in Table 3.3.1.

Table 3.3.1 Statistics of Traffic Accident in Thailandand Bangkok

Description		1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
Number of Accident	Thailand	13,831	16,583	18,669	23,120	17,742	16,361	16,047	17,864	18,445	18,420
	Bangkok	7,965	10,482	11,680	12,045	11,190	11,802	9,794	13,674	14,092	14,295
	Bangkok per Thailand	0.58	0.63	0.63	0.52	0.63	0.72	0.61	0.77	0.76	0.77
Fatality	Thailand	3,764	2,545	3,952	8,365	4,493	2,760	3,091	3,005	2,908	2,700
	Bangkok	403	474	534	571	624	631	689	708	736	657
	Bangkok per Thailand	0.11	0.19	0.14	0.07	0.14	0.23	0.22	0.24	0.25	0.24
Injury	Thailand	10,183	9,306	10,568	21,639	13,392	9,297	9,340	9,026	5,949	8,289
	Bangkok	3,628	4,751	4,844	5,032	4,585	4,810	3,693	4,551	4,672	4,330
	Bangkok per Thailand	0.36	0.51	0.45	0.23	0.34	0.51	0.40	0.50	0.79	0.52

Source : Research and Planning Division, Police Department
Central Traffic Police Division, Police Department

The number of accident, fatality and injury in Bangkok, in 1985 are about 77%, 24% and 52% of the total numbers in the whole Thailand, respectively. From the fact that the number of vehicle registered in Bangkok accounts for about 35% of the total of Thailand, the frequency of traffic accident occurrence is greatly high in Bangkok, while the share of fatality is relatively less.

It is noteworth that the number of fatalities have been on up-trend continuously for the past 9 years with an average growth rate of about 9%. The sharp increase (40%) in the number of traffic accident between 1982 and 1983 is also worthy of careful attention.

These statistical data indicate that adequate safety measures should be taken without delay to arrest this worsening traffic accident condition by all the concerned agencies as well as road users.

(2) Characteristics of traffic accidents in Bangkok

In order to grasp the general features of traffic accidents in the Bangkok, traffic accident analyses were carried out, by using the Basic Accident Data File. These analyses were made by using either 1984 data or combined data of 1984 and 1985 (up to June). Most of related figures and tables are presented in Appendix 3.3.1.

1) Number of accidents and casualties

It can be noticed that about 18% of accidents occur in Bang Khen District, followed by Phra Kha Nong District (13%) and Phaya Thai District (9%), while, about 15% of casualties are recorded in Bang Khen District, followed by Phra Kha Nong District (13%) and Dusit District (9%).

2) Comparison of accident indices with capitals of ASEAN countries and Tokyo

Table 3.3.2 shows a comparison of several accident indices, such as fatalities rate per population and registered vehicles with capital cities in ASEAN countries as well as Tokyo. It is noteworthy that the rate of fatality per 1,000 casualties in Bangkok is the highest as 112. This indicates the traffic accidents in Bangkok are generally severer than those in other cities.

Table 3.3.2 InternationalComparisonof Road Traffic Accident

City	Accident	Fatality	Casualties	Fatality Rate per 1,000 casualties	Fatality Rate per 100,000 population	Fatality Rate per 10,000 vehicles ****
Bangkok*	13,093	639	5,700	112	11.40	9.2
Kuala Lumpur**	13,819	176	2,434	73	18.76	31.85
Jakarta**	6,553	455	5,155	91	7.00	13.96
Metro Manila**	47,567	501	13,333	38	8.49	12.43
Singapore**	N.A.	259	N.A.	-	10.73	10.28
Tokyo***	35,296	390	41,974	9	3.30	1.04

Note : * 1984 figures
** 1980 figures
*** 1985 figures
**** Excluding motorcycle

Source : * Study Team
** Survey on Road Safety Conditions in Major Southeast Asian Cities, Phase I, February 1983, Southeast Asian Agency for Regional Transport and Communication Development.
*** National Police Agency, Japan

3) Yearly fluctuation of accident

Particular difference of number of accidents by month can not be noticed, however number of accidents in June and July are slightly higher than other months.

4) Hourly fluctuation of accident

In Bangkok, about 55% of accidents occur in the daytime (6.00 - 18.00). However, it can be noticed that many accidents are recorded between 10.00 to 23.00 and the peak hour is 17.00 - 18.00. On the other hand, number of accidents in the morning commuting hours (from 7.00 to 9.00) are not many, even though the traffic volume is heavy

(3) Characteristics of traffic accidents on the Study Roads

In order to grasp the general features of traffic accidents on the study roads, the detailed analyses of traffic accidents were carried out. These analyses were made by using Accident Master Files of either 1984 data or combined data of 1984 and 1985 (up to June).

The analyses were carried out for the following items.

- Situation of traffic accident occurrence
- Comparison of traffic accident by road section

1) Situation of traffic accident occurrence

The following sections describe the situation of traffic accident occurance on the study road, while related figures are mostly presented in Appendix 3.3.2.

a) Number of accidents and casualties

The relationship between the number of accidents and casualties in Bangkok and on the study roads are illustrated in Figure 3.3.1. It can be observed that about 32% of accidents in Bangkok occur on the study roads (19% of road length in Bangkok), while fatalities, serious injuries and light injuries are counted as 25%, 35% and 35%, respectively.

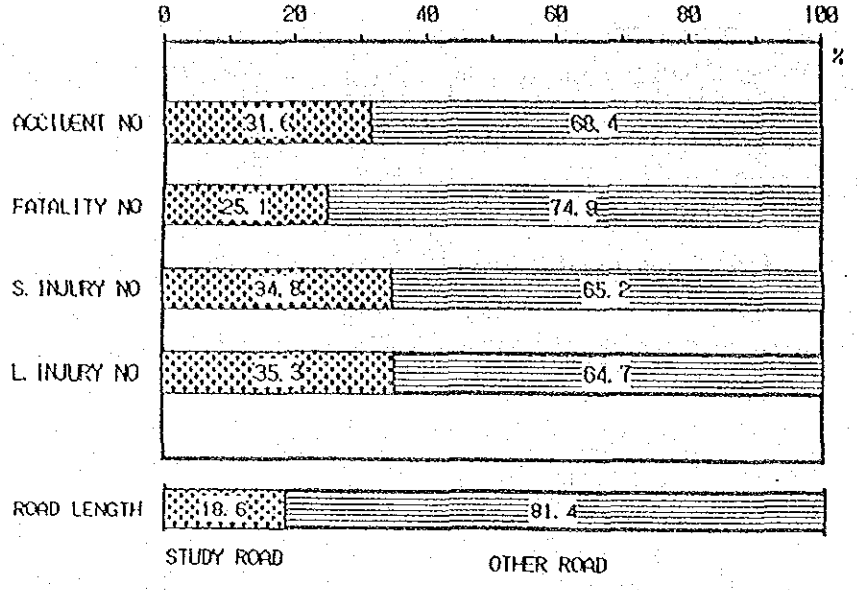

Figure 3.3.1 Accidents on the Study Roads and Other Roads

b) Type of accident

On the study road, vehicle-vehicle type of accident (including motorcycle) is the largest (76%) in number of accident, followed by vehicle-pedestrian type (20%) and accident plunging into fixed object.

c) Type of vehicle involved in accidents

For the type of vehicles involved in accidents, it can be observed that passenger cars shows the highest composition rate (71%), followed by motorcycles (16 %) and Taxis (including Samlor - 7%).

d) Accident location

On the study roads, about 71% of accidents occur on straight section, while 25% of accidents are recorded at intersections. At this time, it should be noted that only the primary nodes are considered as the intersections, while accidents occur on fly-overs at intersections are considered as accidents on bridges.

e) Cause of accident

For the major causes of accidents occur on the study roads, it can be

observed that improper driving speed (41%) is the highest cause of accidents, followed by improper overtaking (27%) and improper turning (24%).

f) Collision pattern

For the collision pattern of accidents on the study roads, 25% of accidents are rear-end collision (veh.vs.veh.), followed by right turn collision (veh.vs.veh. - 20%), side contact (veh. vs.veh. - 17%) and crossing other part (veh.vs.pede. - 11%).

2) Comparison of accident by road section

On the study roads, 62% of accidents and 67% of casualties are recorded on mid-block sections. The following section describes the accident situation on mid-block sections and intersections, while related figures are presented in Appendix 3.3.3.

a) Mid-block sections

For mid-block sections, 57% of accidents occur at undivided roads (66% of total road length). On the other hand, 82% of accidents are recorded at two-way roads (81% of total road length), while 18% of accidents occur on one-way roads.

The comparison of number of accidents and road length by number of lanes indicates that 36% of accidents occur on 6 lane roads (27% of total road length), followed by 27% on 4 lane roads (37%) and 21% on 8 lane roads (12%).

On the study roads, 13% of accidents occur on mid-block sections carrying 50,000 to 60,000 traffic volume (12% of total road length), while the frequency of accident are higher on mid-block sections carrying traffic volume ranging from 20,000 to 60,000 than others.

b) Intersection

Regarding to intersections, 84% of accidents are recorded in at-grade intersections (85% of all intersections), followed by 8% at intersections with fly-over (3%), while 81% of accidents occur at signalized intersections (46% of total intersection).

On the other hand, 57% of accidents occur at intersections with 4 legs (40% of total intersection), followed by 39% at intersections with 3 legs

(57%).

In addition, the comparison of number of accidents and intersections by the inflow traffic volume rank indicates that 23% of accidents occur at intersections with 80,000 - 100,000 inflow traffic volume, although these intersections are only 10% of total intersections, while the frequency of accidents are much higher at intersections with 40,000 - 100,000 inflow traffic volume than others.

(4) Accident location histogram

In order to pinpoint road sections where a number of accidents occurred, the Team developed the computer program to illustrate the accident location histogram. Figure 3.3.2 shows an example of an accident location histogram. In this histogram, the number of accidents, fatalities and injuries are shown in 100m pitch by bar-graph, with indication of location of intersections.

Accident location histograms for major roads in the study area are presented in Appendix 3.3.4.

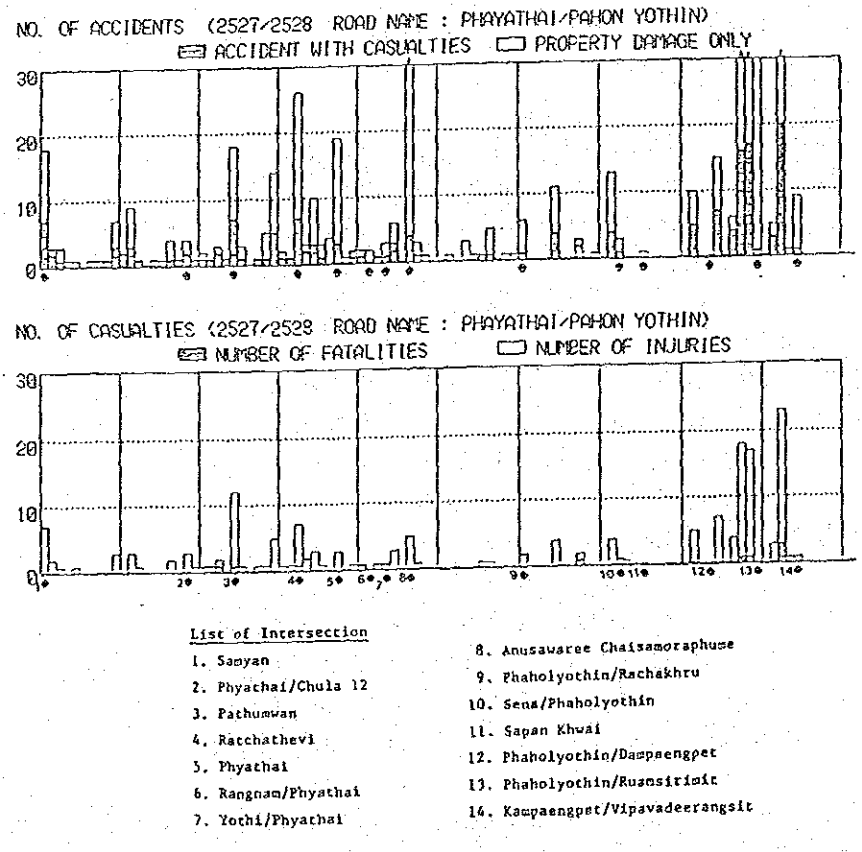

Figure 3.3.2 Accident Location Histogram

4. IDENTIFICATION OF HAZARDOUS ROAD SECTIONS

4.1 Rating Method to Identify Hazardous Road Sections

In this section, the rating methods used to identify hazardous road sections, which will be utilized to screen out high risk road sections on the study roads, are examined and proposed for employment in the Study.

Traffic accident problems should be solved, on a priority basis, within a limitation of manpower and budget, and it is extremely helpful to establish a systematic approach to identify high risk road sections from the range of road networks in Bangkok.

A "hazardous road section" can be defined as the site where a high risk of traffic accident exists and some remedial measures are required. As the definition of "hazardous", however, is always relative and not absolute, the final identification criteria should be established by considering various aspects.

(1) Review of rating methods

At present, 7 rating methods are available to identify hazardous road sections.

- Accident number method
- Number-volume method
- Accident density method
- Accident rate method
- Number-rate method
- Rate-volume method
- Statistical method

1) Accident number method

This method is the simplest of all and the easiest approach to adopt. The sections with a higher number of accidents (i.e. a certain absolute number of accidents or casualties) are identified as hazardous regardless of the traffic volume in the section.

2) Number - Volume method

When dealing with a set of road sections which have greatly differing traffic volumes, accident number method explained above creates confusion. This means that two sections with the same number of accidents should not

be regarded to have the same degree of hazard potential, especially when one on them carries much more traffic than the other.

The use of two indices, accident number and traffic volume, is one of the answer to this problem. When both the accident number and traffic volume exceeds the critical value, the section can be reasonably assumed to be hazardous.

3) Accident density method

When there is a considerable difference in the road section length, the identification method using the number of accidents alone can lead to a misleading conclusion. In this case, "accident density" represents a better criteria for the detection of high accident frequency road sections.

Accident density is defined as the number of accidents (or casualties) per unit length of road section, and sections which exceed a certain critical density are identified as hazardous regardless of the traffic volume, which is the same as the accident number method.

This method is considered to be as simple because it requires only the number of accidents and the length of road section. But this tends to choose sections with heavy traffic volumes because traffic accident frequency is generally proportional to traffic volume.

4) Accident rate method

With a same argument introduced in the number - volume method, the difference in traffic volumes as well as section length also creates confusion. This means that two sections (different section length) with the same number of accidents (or accident densities) should not be regarded to have the same degree of hazard potential, especially when one of them carries much more traffic than the other. This leads to the concept of "accident rate". In general, accident rate (Ra) is calculated by the following equation.

$$Ra = \frac{(\text{Number of accidents or casualties}) \times 10^8}{\left(\begin{matrix}\text{Average daily} \\ \text{traffic volume}\end{matrix}\right) \times (\text{Section length in Km}) \times 365}$$

When accident rate Ra exceeds a certain acceptable value, the section is identified as hazardous. This method is likely to choose those sections

with low traffic volume where an accident leads to a higher accident rate as compared with the sections carrying heavy traffic volume.

5) Number-rate method

When dealing with a set of road sections which have greatly differing traffic volumes, the accident rate method explained above tends to lose its reliability. For example, a road section can have a relatively low number of accidents, but when the traffic volume on this section is also low, the resulting accident rate could then be very high. If this section is selected as a hazardous road section and is given a high priority, the policy on road traffic safety loses its efficiency.

The use of two indices, accident rate and accident number, is an obvious answer to this problem. If certain critical values for both indices are set, the misleading analyses explained above may be eliminated.

That is, when both the number of accidents and rate exceeds the critical value, the section can be reasonably assumed to be hazardous. However, this method is likely to neglect those sections where the traffic volume is very heavy, due to rather low accident rate in spite of high frequency of accident occurrence, or those sections where traffic volumes are low regardless of the possibly high accident rate.

6) Rate-Volume method

The sensitivity of accident rates in low traffic volume sections are noted in the previous paragraph. The number-rate method is proposed as one of approaches to solve this problem. The limit of applicability of this number-rate method is also discussed in the preceding paragraph. An analysis of the relationship between accident rate and traffic volume, then, leads to the rate-volume method.

The past records reveal that the relationship between accident frequency and traffic volume is nonlinear but traces a curve with a diminishing rate of increase. This results in a commonly known tendency that accident rates show relatively higher values in low traffic volume sections, and lower values in high traffic volume sections.

Then for practical purposes, the critical values are stepped instead of a continuous curve.

7) Statistical method

There are several kinds of rating methods to identify hazardous sections by statistical method. One of the popular method is the so-called Rate-Quality Control Method which is often employed in the United States.

The other is the method which uses the deviation between the actual accident index (such as accident density, accident rate, number of accident and casualties), and the estimated index which can be determined generally by using a multiple regression model.

The deviation value (Zi) is calculated by,

$$Zi = \frac{Yi - yi}{\sqrt{yi}}$$

where, Yi : Actual accident index in section i
yi : Estimated accident index in section i

When Zi exceeds a certain critical value (with a confidence level at 95%, the critical value becomes 1.96), the section i is identified as hazardous from probability theory.

It should be noted that the critical value for identification is computed for each section and compared to the actual value. It means that each section has its own criterion which is calculated by the above formula.

(2) Selection of rating method

As the available rating methods to identify hazardous road sections as previously mentioned have their particular characteristics, due considerations must be given in when selecting the method. The most important issues to be discussed are;

- The rating method should be able to identify hazardous road sections from the study roads with various level of traffic volumes.
- The method should be practical for easy application.

Based on the previous reviews and experiences in Japan, the Rate-Volume Method is found reasonable and is proposed as the rating method to identify hazardous mid-block sections. On the other hand, the Number-Volume Method is proposed as the rating method to identify hazardous intersections, since intersection should be assessed on a basis of spot.

In addition, identified results will be verified by the other rating methods as well as by the opinions from police officers prior to the final

conclusion

(3) Approaches to determination of identification criteria

It is required that the reasonable criteria are to be set to identify the hazardous road sections based on the Rate-Volume Method for mid-block sections and the Number-Volume Method for intersections. Two approachs to determine the criteria, i.e., statistical approach and empirical approach, are discussed in this section. In this section, the term "approach" instead of "method" for the means of determination of criteria in an identification method is used.

However, it is necessary to take into account economic and social considerations because hazardous road sections imply the recognized necessity of immediate remedy works requiring a large amount of investments.

1) Statistical approach

This approach utilizes the results of Statistical Method, and the procedure is as follows:

- To determine road sections which are judged to be hazardous by using deviation value (Zi) as mentioned in the former section.
- To plot the results on a rate-volume diagram for mid-block sections and a number-volume diagram for intersections (see Figure 4.1.1). The circled points show the "hazardous sections" identified by the statistical method.

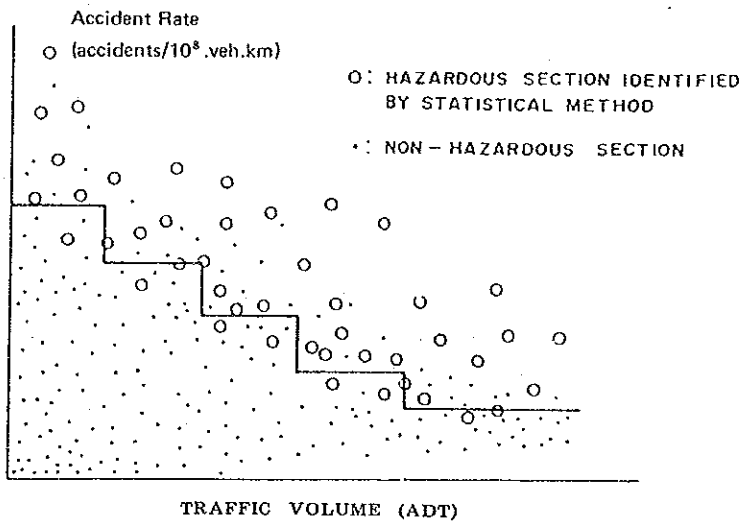

Figure 4.1.1 Identification Criteria in Rate-Volume Method

- To determine the criteria 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.

2) Empirical approach

This approach is based on the experiences and judgments by the experts such as engineers of BMA who are in charge of road administration and maintenance, and traffic policemen who are in charge of traffic management and accident investigation. They usually have the knowledge about the particular sections which are recognized to be hazardous from empirical and engineering points of views. The applicable criteria can be obtained utilizing their information on classification of hazardous and non-hazardous sections in the following steps.

- To identify hazardous sections by engineers and/or traffic policemen.
- To plot the hazardous sections and non-hazardous sections with different marks on the same diagram as shown in Figure 4.1.1.
- To determine the criteria for each traffic volume interval in the same manner as the statistical approach.

4.2 Identification of Hazardous Road Sections

(1) Application of rating method to the study roads

The occurrence of traffic accidents generally correlate closely to characteristics of traffic flows, physical features of road and its environments. The traffic accidents also occur sporadically and incidentally in the road networks. To identify hazardous road sections in a systematic (or statistical) manner, it is reasonable to assess a road in terms of traffic safety by road sections, which are set out dividing a road into sections in which the traffic flow is uniform and the physical features of the sections are generally homogeneous.

In the study, therefore, the control links and the primary nodes determined by the Road Inventory Study are considered as reasonable unit road sections for the identification of hazardous road sections.

1) Process of establishing criteria

Figure 4.2.1 shows the process of establishing identification criteria. This diagram describes the flow of analytical process, the data handling and processing to lead to the setting of identification criteria.

2) Opinions from traffic police officers

For the application of empirical approach for setting the identification criteria, the Team made interviews with traffic police officers in 43 police stations, as explained before. These results were, then, utilized for the empirical approach.

3) Identification criteria for mid-block section

a) Determination of model

In order to carry out the statistical approach, it is necessary to predict accident indicators, such as number of accidents, accident densities or accident rates. For this purpose, the regression analyses and the multiple regression analyses were carried out entering road conditions and traffic characteristics as the explanatory variables.

As the results of these analyses, a regression model as shown below got the highest correlation coefficient (R), and this correlation coefficient was statistically satisfactory. Therefore, this model is proposed for

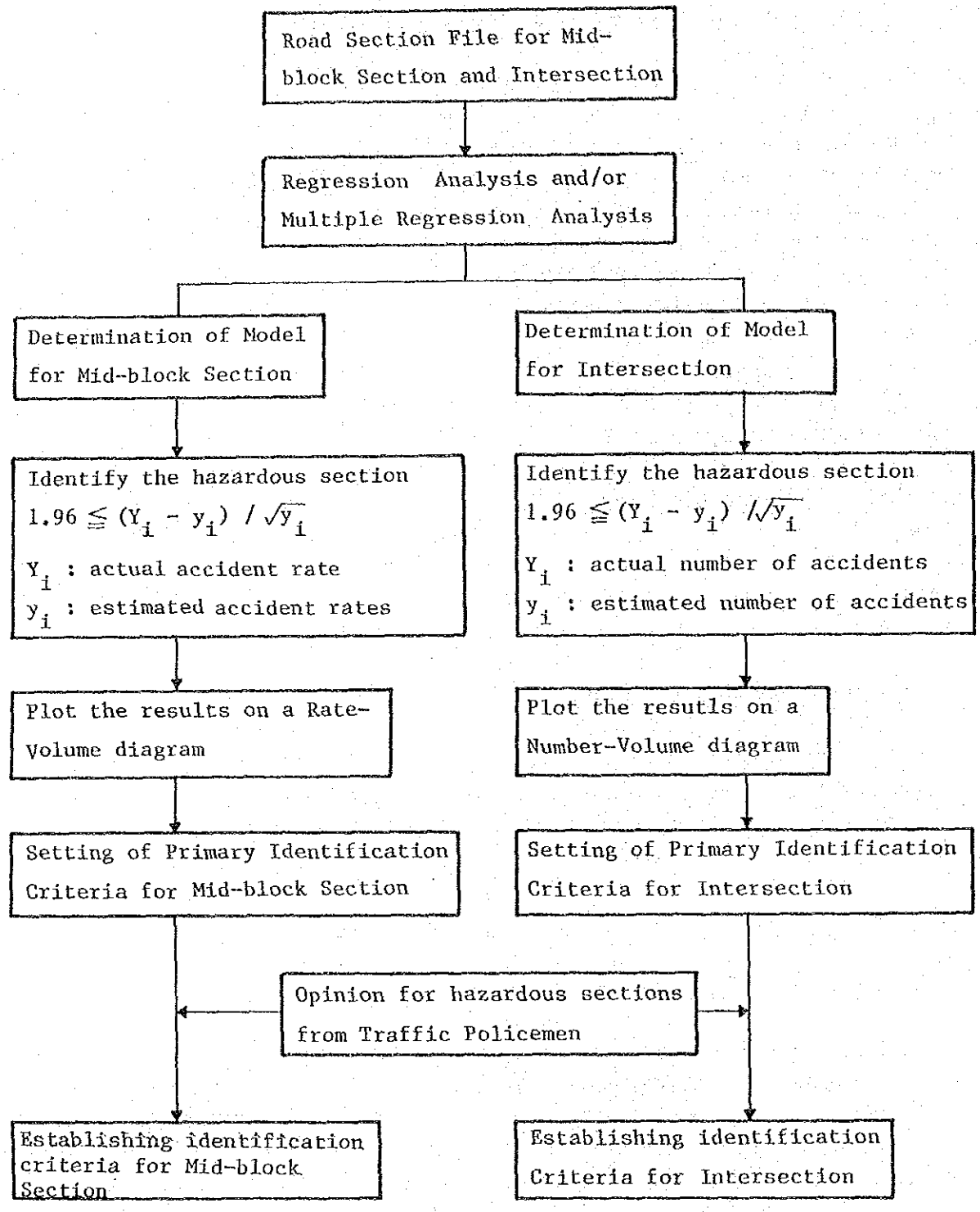

Figure 4.2.1 Process of Establishing Criteria

the prediction of accident indicators of mid-block section.

$Y = 53.85 + 572503/X$ $(R = 0.67)$

where,

Y : Accident rate (accidents/10^{-8}·veh·km)

X : Average daily traffic volume (veh./day)

b) Setting of primary identification criteria

The model proposed in the former section was, then, used for deriving predicted accident rate in every mid-block section i (yi in equation) and the sections with the Zi exceeding 1.96 (confidence level is at 95%) were identified as hazardous. The result is shown in Figure 4.2.2.

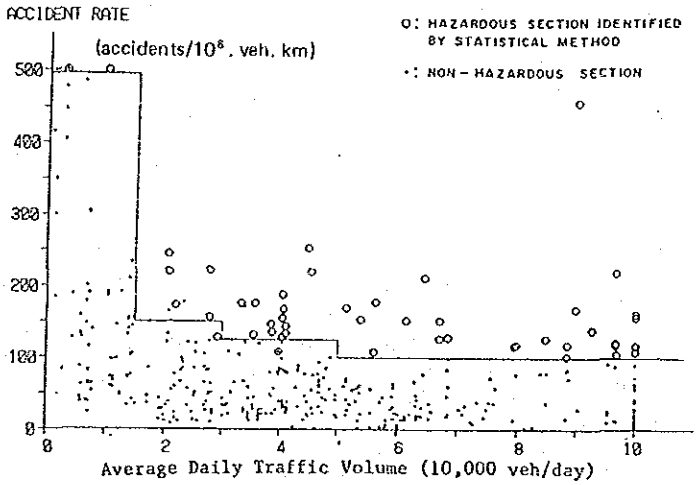

Figure 4.2.2 Hazardous Mid-block Sections Identified by the Statistical Approach

As it can be observed from the figure, fairly clear delineation exists between selected and non-selected sections. In order to use this result properly and conveniently, the criteria for several categories of traffic volume need to be established.

In considering the delineation between selected and non-selected sections in Figure 4.2.2, and the traffic volume ranking, the primary criteria was set and shown in a same figure as "staircase-like" lines.

c) Empirical approach

The primary identification criteria set in the former section are entirely the results of the statistical works. This method to identify

hazardous sections was proved effective through various experiences and practices in many places. But it is desirable to certify the propriety of the criteria worked out in this method utilizing available relevant information.

This was carried out by the empirical approach by using opinions for hazardous sections from traffic policemen.

Figure 4.2.3 shows the hazardous sections identified by traffic policemen, and the criteria were set taking into account the results of the empirical approach as well as the statistical approach.

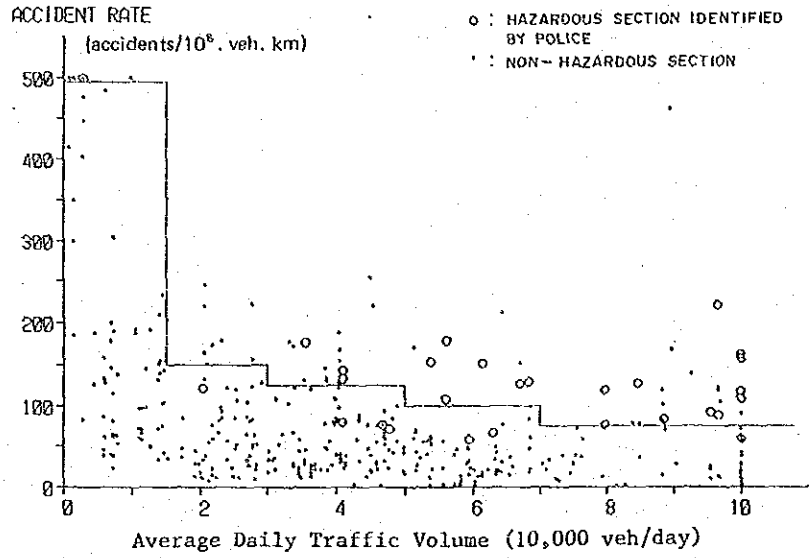

Figure 4.2.3 Hazardous Mid-block Sections Identified by the Empirical Approach

d) Establishing identification criteria for Mid-block Section

Based on results of the statistical approach and the empirical approach, the identification criteria for mid-block section are proposed and summarized in Table 4.2.1 and Figure 4.2.4.

Table 4.2.1 Proposed Identification Criteria for Mid-block Section

Average Daily Traffic Volume (veh/day)	Identification Criteria (Accident Rate)
- 15,000	500
15,001 - 30,000	150
30,001 - 50,000	125
50,001 - 70,000	100
70,001 - 100,000	75
100,001 -	75

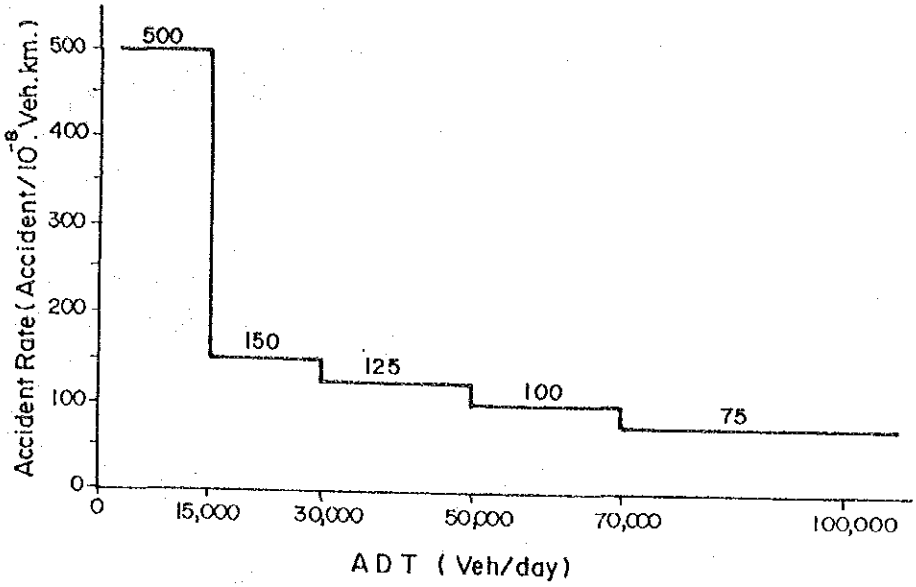

Figure 4.2.4 Proposed Identification Criteria for Mid-block Section

3) Identification criteria for Intersection

a) Determination of model

In order to predict accident indicators, the regression analyses and the multiple regression analyses were carried out entering conditions of intersectios and traffic characteristics as the explanatory variables.

As a result, a multiple regression model as shown below got the highest correlation coefficient (R) and this correlation coefficient was statistically satisfactory. Therefore, this model is proposed for the prediction of accident indicators for intersection.

$$Y=0.0002X_1 + 0.47X_2 - 3.56 \quad (R = 0.53)$$

where; Y : Number of accidents

X_1 : Average daily inflow traffic volume (veh./day)

X_2 : Number of Lanes

b) Setting of primary identification criteria

The model proposed in the former section was, then used for deriving predicted accident number at intersection i (yi in equation) and the sections with the Zi exceeding 1.96 (confidence level is at 95%) were

identified as hazardous. The result is shown in Figure 4.2.5.

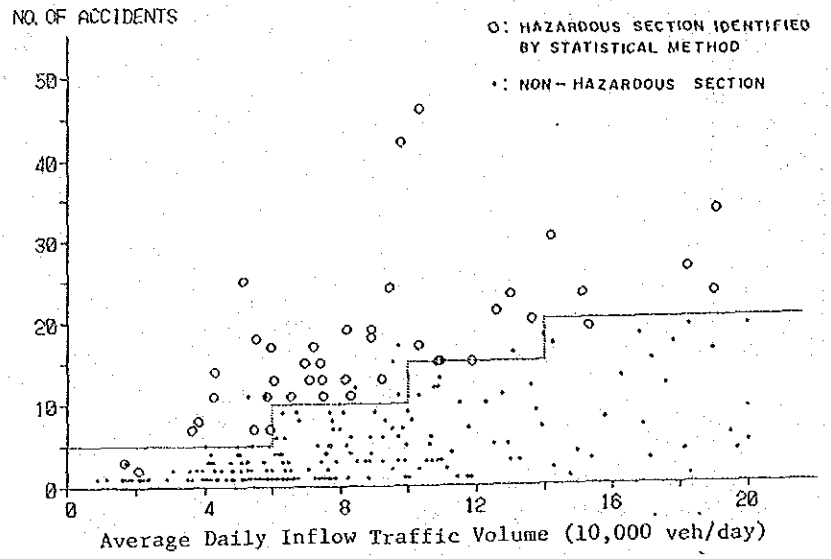

Figure 4.2.5 Hazardous Intersections Identified by the Statistical Approach

In considering the delineation between selected and non-selected sections in Figure 4.2.6, and the traffic volume ranking, the primary criteria was set and shown in a same figure as "staircase-like" lines.

c) Empirical approach

Figure 4.2.6 shows the hazardous intersections identified by empirical approach, and the criteria were set taking into account the results of the empirical approach as well as the statistical approach.

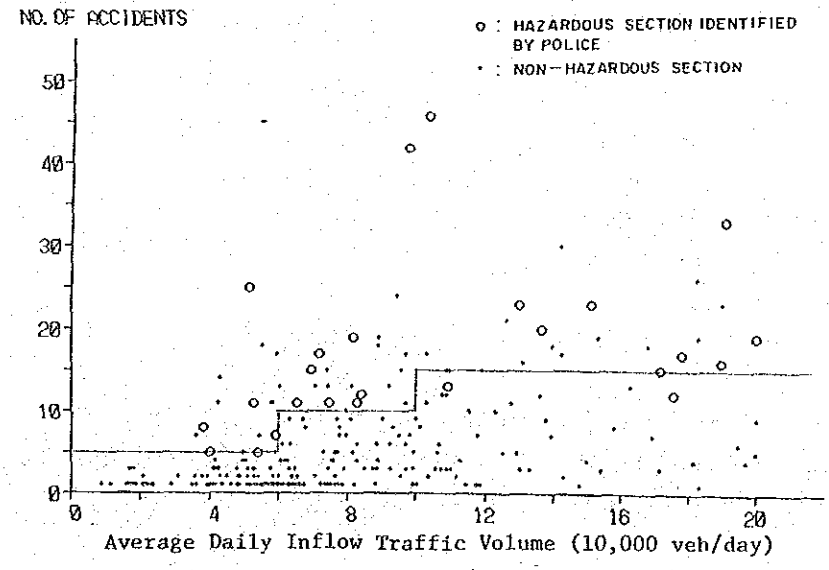

Figure 4.2.6 Hazardous Intersections Identified by the Empirical Approach

d) Establishing identification criteria for Intersection

Based on results of the statistical approach and the empirical approach, the identification criteria for intersection are proposed and summarized in Table 4.2.2 and Figure 4.2.7.

Table 4.2.2 Proposed Identification Criteria for Intersection

Average Daily Inflow Traffic Volume (Veh./day)	Identification Criteria (No. of Accidents)
- 30,000	5
30,001 - 60,000	5
60,001 - 100,000	10
100,001 - 140,000	15
140,001 - 200,000	15
200,001 -	15

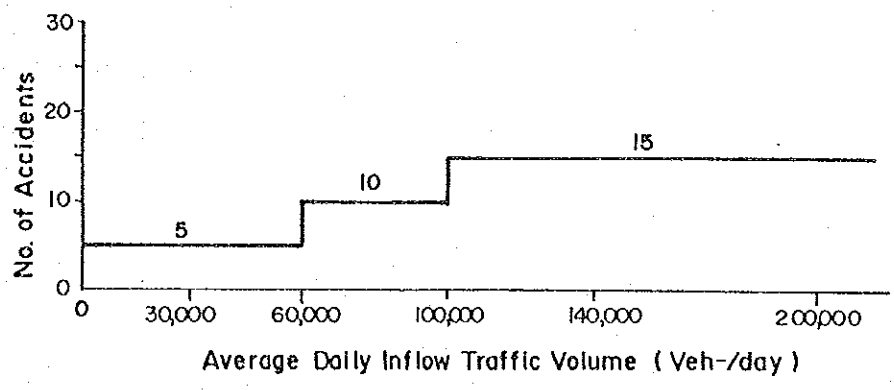

Figure 4.2.7 Proposed Identification Criteria for Intersection

(3) Results of identification

The number of hazardous mid-block sections and intersections identified by the proposed criteria are summarized in Table 4.2.3. From this table, it can be noticed that the number of accidents at hazardous mid-block sections identified are 48% of total number of accidents on mid-block sections. On

the other hand, number of accidents at hazardous intersections identified occupies 55% of accidents at whole intersections.

Within these 112 hazardous road sections identified by the proposed criteria, 102 road sections were picked up by the statistical approach, while 43 road sections were picked up by the empirical approach (opinions of traffic policemen). And also, 33 road sections were picked up by both the statistical approach and the empirical approach.

In addition, hazardous mid-block sections and intersections identified are shown in Figure 4.2.8, while the list of these road sections are attached in Appendix 4.2.1.

At this stage, the primary rankings were set for these hazardous mid-block sections and intersections by considering the identification process (rating methods and/or empirical approach) and the order of accident indicators. And then, priority for implementation could be determined taking into account not only these primary rankings but also the available financial resources and social considerations.

Table 4.2.3 Number of Hazardous Road Sections

	No. of Sections	No. of Accidents at whole section	No. of Hazardous Sections	No. of Accidents at Harzardous Sections
Mid-block Section	659	2,645	61 (9.3%)	1,256 (47.5%)
Intersection	393	1,632	51 (13.0%)	890 (54.5%)

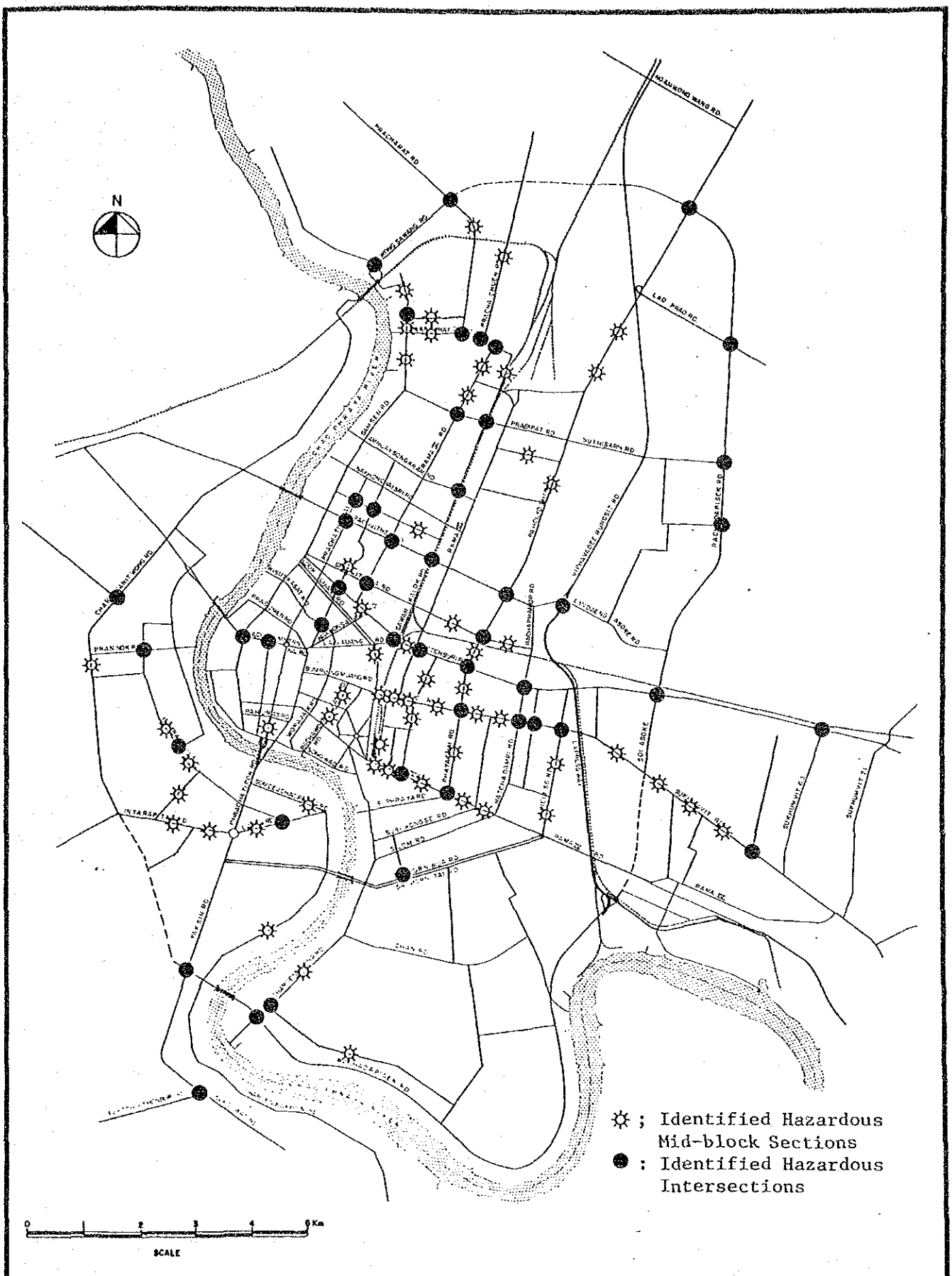

Figure 4.2.8 Identified Hazardous Road Sections

5. TRAFFIC SAFETY PLANNING

5.1 Outline of Traffic Safety Planning

The traffic safety planning for engineering remedy works is to determine effective and realistic safety measures for hazardous road locations and to prepare safety plans. A traffic safety plan for a certain location is generally mapped out in the following sequence of step:

- To select a location which needs for remedy works.
- To collect and analyze data and information pertaining to traffic accident.
- To clarify major accident causes and accident patterns.
- To prepare a safety plan.

(1) Planning process

1) Selection of location

It is general that the requests for safety improvement surpass the fund available for remedy works. To optimize of limited fund, the selection of hazardous locations should be carried out in a way that high risk road locations are accorded with high priority.

To select hazardous spots within hazardous road locations, application of accident location histograms, accident patterns and site investigations would be of a great helpful means.

2) Collection and analysis of data

To plan out remedy works, accident data, especially accident patterns and the collision diagrams, are prerequisite. In order to obtain these information, it is necessary to visit police stations concerned and refer the original accident reports. The procedure of this data collection is explained later.

As for road conditions, available information are very limited and thus field investigation should be undertaken to get information as to the condition of pavement, alignment, existing safety devices, land use in the vicinity of road, etc.

Traffic conditions such as traffic volumes, intersection traffic volume and pedestrian activities are also important element to grasp the causes of accident.

The obtained data and information should be thoroughly analyzed so as to pinpoint a particularly hazardous spot in a selected road location, to grasp features of accidents and major causes of accident, and possibly to find deficiencies in road conditions if any.

3) Clarification of major accident causes and accident pattern

The traffic accidents are phenomena resulting from complex causes. But there are some accidents of which causes are not attributable to road conditions. When hazardous locations for safety planning are selected, series of observation and analyses on the data of accidents at the locations should be made to clarify the accidents' causes and to see whether engineering remedy works are workable.

The analyses can be conducted using accident records, collision diagrams, location maps and information of road conditions, and will clarify the major causes of accidents at the locations.

To know the road condition and its surrounding in detail, observation at the site should be conducted. At this case, a Video Tape Recorder would be of a great helpful mean.

4) Preparation of safety plans

The safety measures should be finalized selecting the most suitable one or combination of some alternatives among the possible alternatives, taking into account the accident patterns, the existing safety devices at the location, traffic regulations, traffic characteristics and road conditions as well as available funds. The technical guideline on the safety devices presented in Volume VI of this report also should be referred to. Traffic safety measures according to the principle of safety improvement and effects of safety measures by type of collision patterns are presented in Table 5.1.1 and Table 5.1.2, respectively.

Safety plans for the finalized safety measures shall be prepared in a way that the safety devices installed at the location will fully realize the intended function in the safety measures.

Table 5.1.1 Traffic Safety Improvement Measures

Principle of Safety Improvement	Traffic Safety Improvement Measures	
	Installation of Road Appurtenances	Improvement of Road
To separate the conflicting traffics by time and/or by space	Traffic Signal Stop Control (Sign, Marking) Guardfence Longitudinal Pavement Marking Raised Pavement Markers Crosswalk	Construction of By-pass and Expressway Sidewalk Bicycle Path Bicycle-Pedestrian Path Pedestrian Overpass Median Frontage Road Refuge Island
To simplify the traffic stream	Channelization of Intersection Pavement Markings Guide Signs Access Control One-Way System Parking Restriction	Bus Bay Grade Separation Traffic Island
To create proper driving circumstances	Highway Lighting Post Delineator Curve Mirror Warning Signs Guide Signs Glare Screen Traffic Information System	Elongation of Sight Distance Improvement of Shoulder Road Geometry Improvement (Alignment, Cross-Section) Anti-Skid Treatment Pavement Leveling
To mitigate the accident severity	Guardfence Speed Control Overtaking Control Breakaway Treatment of Roadside Appurtenance	Pavement Grooving Side Slope Flattening

Note : Measures listed in the table are not all-inclusive.

Classification was made according to the principal facet of each measure.

Table 5.1.2 Effects of Safety Measures

Safety Measures		Vehicle vs Pedestrian						Vehicle itself					Vehicle vs vehicle					
		Along Carriage-way	Crossing Inter-section	Crossing on Crosswalk	Crossing other part	Emerging	Playing Working	Off carriage-way	With parked vehicle	With guard-rail	With electric poll	Other collision	Head on Collision	Rear end Collision	Crossing Collision	Right turn Collision	Left turn Collision	Contact
Simplification of Traffic Flow	Channelization															○	○	
	Turning Lane													○		○	○	
	Division Line	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Restriction of turning vehicles													○		○	○	
	Restriction of overtaking												○		○			○
	One-way System	○			○								○					○
	Restriction of speed	○			○	○	○	○	○	○	○	○	○					○
	Restriction of Parking	○				○								○				○
Separation of Traffic Flow	Traffic Signal		○	○											○	○	○	
	Stop Control		○	○											○	○	○	
	Sidewalk	○				○								○				
	Crosswalk		○		○									○				
	Pedestrian Overpass			○	○									○				
	Median Island												○					
	Guard-fence Guardrail	○	○		○	○		○						○				
	Bus Bay			○					○					○				○
	Frontage Road								○					○	○			
Improvement in road Structure and Geometry	Roundabout														○	○	○	
	Refuge island for pedestrian														○	○	○	
	Improving Skid resistance							○		○	○			○				
	Leading equipment	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
	Lighting equipment	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

5.2 Selection of Road Locations for Safety Planning

(1) Selection of road locations

Based on the results of identification of hazardous road sections, the candidate road locations for safety planning are determined by engineering judgment, as shown in Appendix 5.2.1. For the determination of candidate road locations, not only individual road sections but also the combination of several road sections are considered. Appendix 5.2.2 summarizes characteristics of accidents as well as the existing improvement plan relating to traffic safety for these candidate road locations.

Then, characteristics of accidents and the existing improvement plan for these candidate road locations are examined in detail, and finally, ten (10) road locations are selected for safety planning based on the result of the discussion with BMA and the engineering judgment. Selected road locations for safety planning are shown in Figure 5.2.1.

(2) Collision diagram

For the preparation of traffic safety plans, reference to the collision diagrams are requisite. In fact, accident data collected by the Team in 1985 was not in detail and it was difficult to identify the exact collision patterns. Therefore, the Team visited police stations concerned with selected road locations and refer the original accident reports (reports prepared by policemen in charge of traffic accident investigation). Then, the details of accident was transferred to a format attached in Appendix 5.2.3.

Since these data collections were limited for certain road sections, it was possible to obtain data for the road location within one or two days. Therefore, it is recommended for BMA to collect these accident data only for hazardous road locations, prior to the preparation of actual safety plans. An example of collision diagram prepared by the Team is presented in Figure 5.2.2, while collision diagrams for selected ten (10) road locations for the safety planning are attached in Appendix 5.2.4.

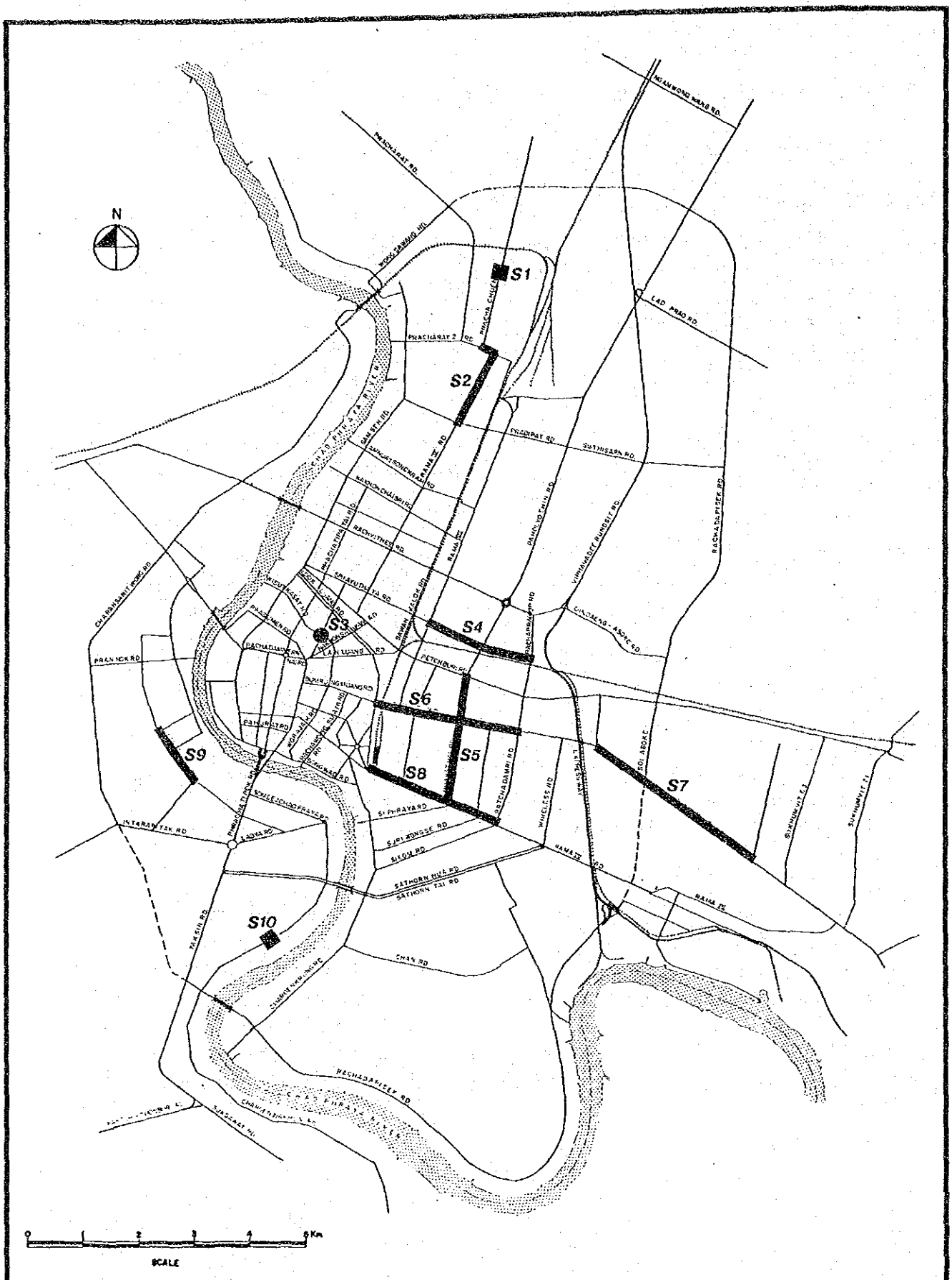

Figure 5.2.1 Road Locations for Safety Planning

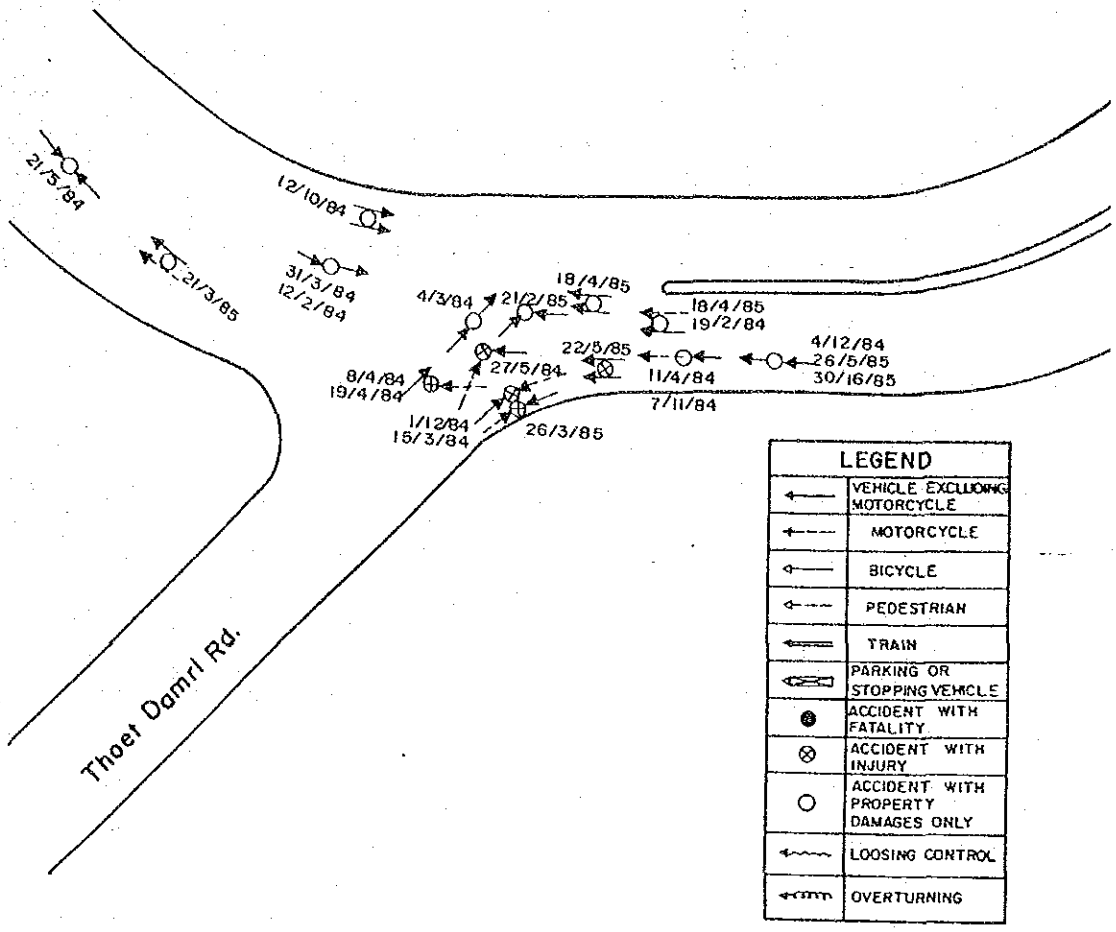

Figure 5.2.2 Example of Collision Diagram (Saphan Soong Intersection)

(3) Characteristics of accidents on selected road locations

Through the series of site investigations and accident analyses based on the following data, characteristics of accidents on selected road locations are clarified.

- Accident location histograms
- Result of accident analyses
- Collision diagrams
- Result of site investigations

As to characteristics of accidents, results for all selected road locations

are summarized in Appendix 5.2.5, while characteristics of accidents on mid-block section and at intersection for each road location are presented in Appendix 5.2.6.

In fact, safety plans are prepared either for the whole stretch or for the certain stretch of selected road locations (hereinafter referred as "road segment" in this chapter), depending on the frequency of accidents, workability of remedy works and type of safety measures, based on the analyses for the characteristics of accident on each road location. Accident characteristics for each selected road location are described below.

1) Pracha Chuen Road (S1)

Major causes of accidents on this road location are improper speed, overtaking and improper turning, while pedestrian accident and right turn collision occupy high percentage as the collision pattern.

Along this section, accidents frequently occur at the small size intersections with Sois (such as entrance to Soi Phoem Sap and Soi Prachanivet) and the road section in the congested commercial area in front of the Pracha Chuen Market.

In the Study, therefore, the Team decided to prepare the safety plan for the intersection at Pracha Chuen Road with Soi Phoem Sap. On the other hand, the same safety measures for the similar road segment on Techa Wanit Road, in front of the Bang Sue market, can be applicable for the location in front of the Pracha Chuen Market.

2) Techa Wanit Road (S2)

Major causes of accident on this road location are improper turning, overtaking and improper speed. Along this road location, more than a half of accidents occur at intersections. While on mid-block sections, accident frequently occur at congested commercial area in front of the Bang Sue Market, and accidents involving pedestrians shows high percentage.

Therefore, the safety plans are prepared for the intersection with Thoet Damri Road (so called Saphan Soong Intersection) and the road segment in front of the Bang Sue Market.

3) Ratchadamnoen Nok Road (S3)
(Yeak Jor Por Ror Intersection)

This road location is a large size 4-leg intersection at Ratchadamnoen Nok Road with Wisut Kasat Road and Chakkapatpong Road. Major causes of accident at this intersection are improper speed and improper turning.

Therefore, the improvement of the intersection is considered as the safety plan at this road location.

4) Si Ayutthaya Road (S4)

Major causes of accident on this road location are overtaking and improper turning, while more than a half of accidents were recorded at night time. Along this road location, accidents frequently occur on mid-block sections.

On the mid-block section between Phaya Thai Road and Ratchaprarop Road, accidents frequently occur at openings of outer separators. On the other hand, on the mid-block section between Rama VI Road and Phaya Thai Road, pedestrian accident shows high percentage, however, reduction of a number of accidents are expected by a pedestrian overpass newly constructed by BMA.

As a result, the Team selects mid-block section between Phaya Thai Road and Ratchaprarop Road as the road segment for the safety planning.

5) Phaya Thai Road (S5)

Major causes of accident along this road location are improper speed and overtaking. Actually, traffic accident along this road locations are concentrated to the following 3 locations.
- Intersection with Petburi Road (Ratchathevi Intersection)
- Intersection with Rama I Road (Pathumwan Intersection)
- Approach sections of the Hua Chang Bridge.

At the Pathumwan Intersection, overhang type traffic signals were installed in April, 1986 and this might be effective for reduction of accidents at this intersection. And also, at the third section, improvement of pavement markings have been planned by BMA, while widening of the Hua Chang Bridge is also under consideration.

Therefore, the Team selects the Ratchathevi Intersection as the road segment for the safety planning.

6) Rama I Road (S6)

Improper speed is outstanding as the cause of accidents, followed by overtaking. Accidents frequently occur on mid-block sections and their major accident patterns are rear end collision and head on collision.

Accident density in the section between Krung Kasem Road and Rama VI Road (two-way system) is highest among the whole road location. Therefore, the Team selects this section as the road segment for the safety planning.

7) Sukhumvit Road (S7)

The features of accident along this road location are as follows:

- Improper speed is outstanding as the cause of accidents.
- Accidents involving pedestrians occupy higher percentage in the whole road location.
- Accidents occur more frequently along mid-block sections than at intersections except Thonglor Intersection.
- On the mid-block section, accidents of vehicles vs. vehicle type frequently occur at openings of the median.
- More than a half of accidents occur in the night time.

Since several kinds of safety plans are necessary for this road location, including improvement of mid-block section regarding openings of the median, the whole stretch of this road location are considered as the road segment for the safety planning.

8) Rama IV Road (S8)

Accidents caused by improper speed shows highest percentage, while rear end collision is outstanding as the collision pattern. More than a half of accidents occur in the night time at intersections.

It can be noted that accidents involving pedestrians occupied high percentage, especially on the mid-block sections (more than one third of accidents occurred on mid-block sections). In addition, rear end collisions and side contacts are supposed to be caused to large extent by disturbance by pedestrians making at random crossings on the carriageway.

Therefore, the whole stretch of this road location are considered as the road segment for the safety planning.

9) Itsaraphap Road (S9)

Accidents with casualties shows high percentage on this road location. Overtaking is the main cause of accident, while accidents involving pedestrians and motorcycles occupy high percentage.

Accidents frequently occur at the intersection with Wangderm Road and mid-block sections on both side of this intersection.

Therefore, the Team selects this section as the road segment for the safety planning.

10) Charoen Nakhon Road (S10)

Accidents with casualties shows high percentage on this road location and improper speed is the main cause of accident. Many accidents on this road location are concentrated at mid-block section near the Wat Sawettachat.

As a result, the Team selects this section as the road segment for the safety planning.

Location of 11 road segments selected for the safety planning are shown in Figure 5.2.3, while classification of selected road segments by road type is summarized in Figure 5.2.4.

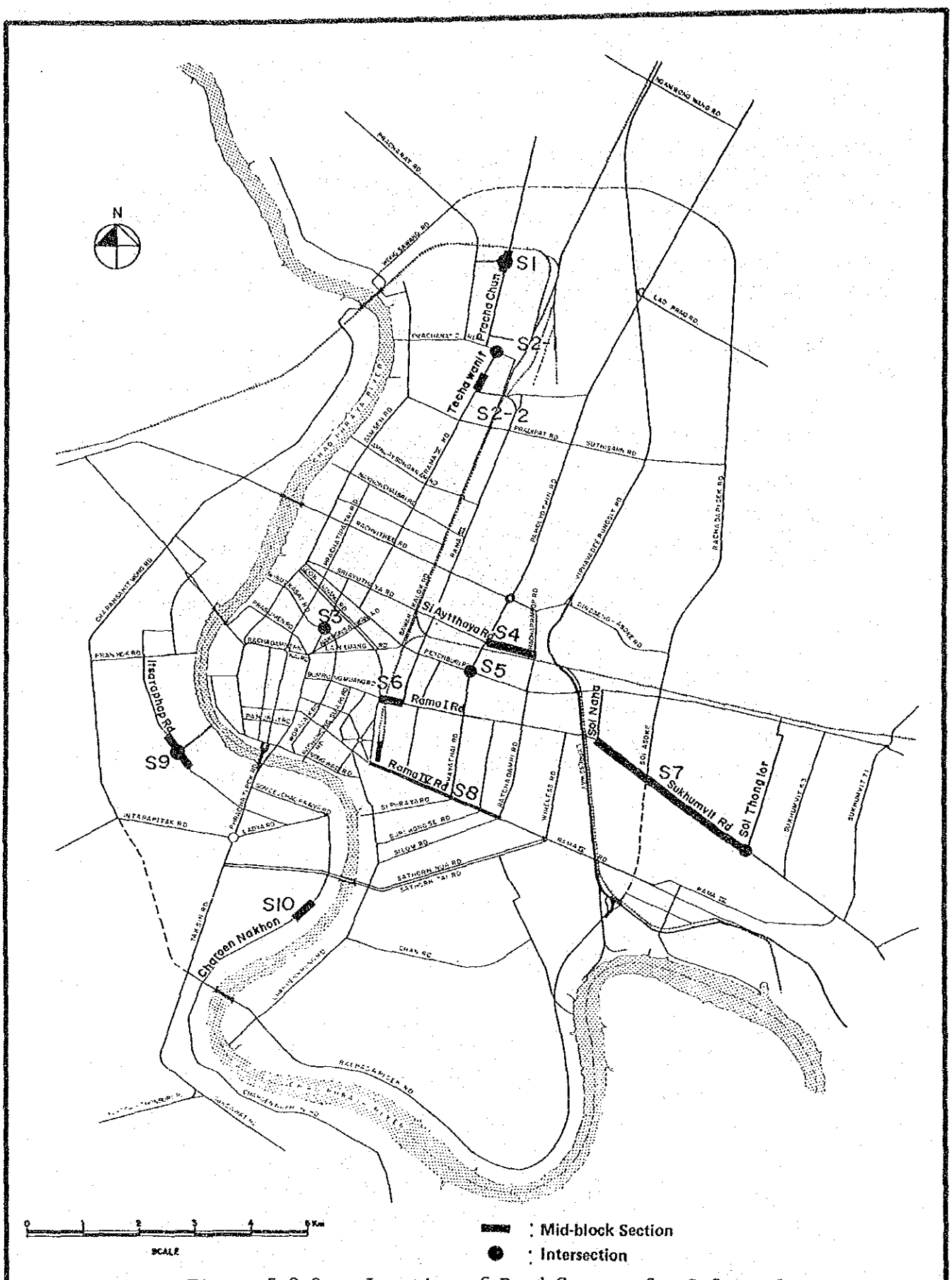

Figure 5.2.3 Location of Road Segment for Safety Planning

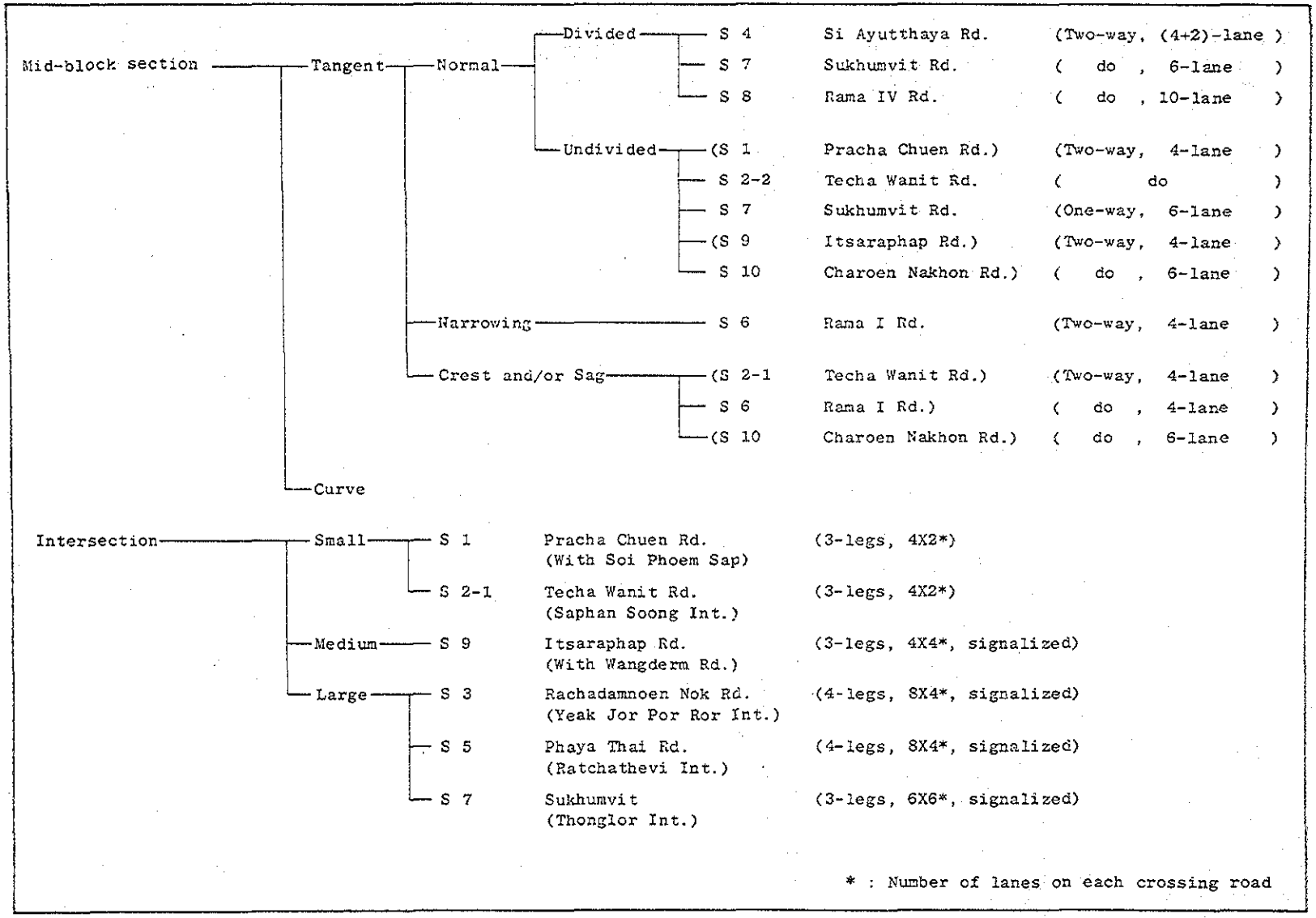

Figure 5.2.4 Classification of Selected Road Segment by Road Type

5.3 Supplementary Data Collection

For the preparation of safety plans , it is required to collect supplementary data of road conditions including existing traffic safety devices, and traffic conditions.

(1) Topographic survey

Detailed maps for a part of selected road locations are prepared based on the results of the topographic surveys. Topographic surveys consist of the plane-table survey, the cross-section survey and the profile survey. Among them, plane-table surveys and cross-section surveys at representative cross-sections were carried out for each safety planning site, while profile surveys were conducted at poor vertical alignment sections on Techa Wanit Road, Rama I Road and Charoen Nakhon Road.

In addition, existing major traffic safety devices such as traffic signals, pavement markings, pedestrian overpasses, street lightings and etc. were also checked and indicated on maps.

(2) Traffic survey

Traffic data were collected by supplementary traffic surveys conducted for this study. Types and locations of traffic surveys are shown in Table 5.3.1. Vehicle types classified in the survey are motorcycle, small sized vehicle and large sized vehicle.

Traffic volumes and number of pedestrians were measured during peak hours in the morning (7 a.m. - 9 a.m.) for 2 hours. At Ratchathevi Intersection on Phaya Thai Road, however, traffic volumes were also counted during evening peak hours (4 p.m. - 7 p.m.) because of introduction of two-way system on Phaya Thai Road in the evening.

In addition, measurement of running speed were also carried out at road locations where "improper speed" were pointed out as a major cause of accidents. In order to measure the running speed of undisturbed traffic flows, mid-block sections other than near to bus stops and intersections were selected as survey sites. Results of running speed survey are presented in Appendix 5.3.1.

Table 5.3.1 Type and Location of Traffic Survey

Type of Traffic Survey	Road Name (Road Segment No.)
Intersection traffic volume count	* Pracha Chuen Road (S1) * Techa Wanit Road (S2-1) * Rachadamnoen Nok Road (S3) * Phaya Thai Road (S5) * Rama I Road (S6) * Sukhumvit Road (S7) * Itsaraphap Road (S9)
Turning movement at openings of the median or outer separators	* Sukhumvit Road (S7) * Si Ayutthaya Road (S4)
Traffic volume at road section	* Si Ayutthaya Road (S4) * Sukhumvit Road (S7) * Charoen Nakhon Road (S10)
Number of pedestrians crossing at crosswalk	* Sukhumvit Road (S7) * Rama IV Road (S8) * Charoen Nakhon Road (S10)
Running Speed	* Pracha Chuen Road (S1) * Si Ayutthaya Road (S4) * Phaya Thai Road (S5) * Rama I Road (S6) * Sukhumvit Road (S7) * Rama IV Road (S8) * Charoen Nakhon Road (S10)

5.4 Preparation of Safety Plans

In this section, details of safety plans prepared by the Team for selected road segments are described.

The drawings are prepared using the 1/1,000 scale maps and attached in Volume VII of "DRAWINGS".

The explanation of safety plans for each road segment consists of: (a) general description of road segment; (b) accident patterns; (c) major problems identified; and (d) proposed safety measures.

In addition, major problems and proposed safety measures for each road segment are summarized in Table 5.4.1, while existing road conditions, accident patterns and traffic data related to each road segment are presented in Appendices 5.4.1 to 5.4.3.

(1) Pracha Chuen Road (S1)

a) General description

Along Pracha Chuen Road, accidents frequently occur at small size intersections.

Safety planning for a small size intersection with Soi Phoem Sap which is connected to Krungthep-Nonthaburi Road, is descried in this study as the representative plan for many of the other small intersections. Figure 5.4.1 indicates the location of this segment.

Table 5.4.1 Summary of Proposed Safety Plans

No.	Road Name	Location	Major Problems	Safety Plans
S1	Pracha Chuen Road	Intersection with Soi Phoem Sap	- Traffic volume beyond the capacity of stop control intersection. - Excessive speed vehicles	- Installation of overhang type traffic signals. - Provision of a right turn lane
S2-1	Techa Wanit Road	Saphan Soong Intersection	- Traffic volume beyond the capacity of stop control intersection. - Inadequate sight distance.	- Installation of overhang type traffic signals with an advance notice traffic signal - Improvement of channelization
S2-2	Techa Wanit Road	In front of Bang Sue Market	- Many pedestrians crossing carriageway - Disturbance on main traffic flow by parked vehicles, buses and jaywalkes	- Installation of pedestrian signals - Extension of existing sidewalk guardfence. - Improvement of markings
S3	Ratchadamnoen Nok Road	Yeak Jor Por Ror Intersection	- Poor visibility of traffic signals - Complicated traffic flow due to traffic on frontage roads	- Replacement of signals by overhang types - Rearrangement of signal phase. - Improvement of pavement markings.
S4	Si Ayutthaya Road	Mid-block section between Phaya Thai Rd. and Ratchaprarop Rd.	- Disorderly traffic flow at openings of outer separators - High speed vehicles - Difficulties of crossing by pedestrians	- Restriction of turning movements at 2 openings of outer separators - Installation of overhang type traffic signals at 1 location.
S5	Phaya Thai Road	Ratchathevi Intersection	- Poor horizontal alignment - Complicated turning movements - Many crossing pedestrians	- Control the right turn movement from Petburi Rd. - Improvement of channelization and horizontal alignment.
S6	Rama I Road	Mid-block section between Rama VI Rd. and Krung Kasem Rd.	- Shortage of sight distance - Invasion on the opposing lane - Difficulty of left turn at the intersection with Krung Kasem Road.	- Installation of the median by pavement markings and chatter-bars. - Improvement of markings - Improvement of intersection with Krung Kasem Road.
S7	Sukhumvit Road	Between Soi Nana Nua and Soi Thonglor	- Many pedestrians crossing carriageway - Disordery traffic flow due to many turning vehicles at openings of the median - Disordery traffic flow at Thonglor Intersection	- Construction of 3 pedestrian overpasses. - Installation of traffic signals at 6 intersections - Closing openings of the median at 5 locations. - Improvement of Thonglor Intersection.
S8	Rama IV Road	Between Mahaphruttharam Rd. and Silom Rd.	- Difficulty of crossing by pedestrians - At random crossing by pedestrians - Poor visibility of traffic signals at intersections.	- Construction of 7 pedestrian overpasses. - Installation of median guardfence. - Replacement of signals by overhang types at 5 intersections.
S9	Itsaraphap Road	Intersection with Wang Doem Road	- Poor visibility of traffic signals - At random crossings by pedestrians - Confusion of traffic flow	- Replacement of signals by overhang types - Installation of chatter-bars, - Provision of right turn lane
S10	Charoen Nakhon Road	In front of Wat Sawettachat	- Many pedestrians crossing carriageway - Insufficient sight distance	- Construction of a pedestrian overpass - Installation of the median - Installation of median guardfence.

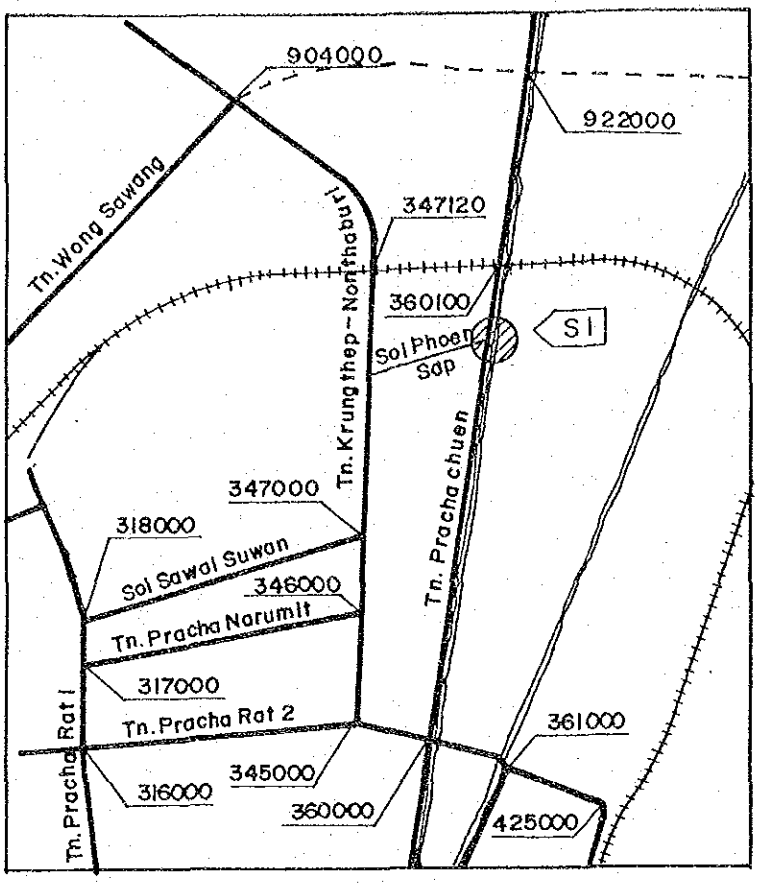

Figure 5.4.1 Road Segment for Safety Planning on Pracha Chuen Road

b) Accidents patterns

The results summarized here are obtained from the detailed analysis on accident data. Collision diagram for this section is contained in Appendix 5.2.4 and accident pattern statistics at this intersection prepared for the analysis is shown in Table 5.4.2.

At this intersection, most of accidents are in the category of "vehicle vs. vehicle", and among them, right turn collision is prominent and rear end collision and side contact rank second and third.

Table 5.4.2 Accident Pattern Statistics for Road Segment on Pracha Chuen Road (S1)

Accident Patterns	Numbers	Composition
10. Vehicle vs. Pedestrian	1	(8.3)
11. Hit pedestrian walking along carriageway		
12. Hit pedestrian crossing carriageway at intersection		
13. Hit pedestrian crossing carriageway at crosswalk		
14. Hit pedestrian crossing carriageway other than crosswalk	1	(8.3)
15. Hit pedestrian emerging on carriageway		
16. Hit pedestrian playing on carriageway		
17. Others		
20. Vehicle vs. Bicycle	0	(0)
30. Vehicle only	0	(0)
31. Off carriageway		
32. Collision with parked vehicle		
33. Collision with guard rail		
34. Collision with electric pole		
35. Collision with other objects		
36. Others		
40. Vehicle vs. Vehicle	11	(91.7)
41. Head on collision	0	
42. Rear end collision	3	(25)
43. Side collision during crossing	0	(0)
44. Side collision during right turn	5	(41.7)
45. Side collision during left turn	1	(8.3)
46. Side contact	2	(16.7)
47. Others	0	(0)
50. Unknown	0	(ρ)
TOTAL	12	100%

(accidents in January 1984 - June 1985)

c) Major problems

The possible causes of the above accident patterns are studied by a series of site investigations at the planning site, and results are summarized below.

- Traffic volume at this intersection beyond the capacity of stop control intersection because of heavy traffic volume of through traffic on Pracha Chuen Road and right turn traffic to/from Soi Phoem Sap. Difficulty of right turn induces the improper turning. Traffic volume at this intersection is shown in Figure 5.4.2.
- Sudden brakings and changing lanes caused by turning vehicles.
- Excessive speed vehicles due to a good straight alignment. Result of running speed survey on the Pracha Chuen Road is summarized in Table 5.4.3.
- Insufficient street lightings at intersection.
- Uneasy turnings at the corner due to small radius.

d) Safety measures

The following safety measures are proposed to cope with above mentioned problems.

- Installation of overhang type traffic signals.
  Overhang type traffic signal is desirable to ensure the effectiveness of signal functions and to prevent the increase of rear end collisions.
- Provision of a right turn lane.
- Installation of specific lightings at intersection.
- Widening of carriageway at the corner in order to secure the necessary turning radius.

In addition, improvement of vertical alignment at the approach section of Soi Phoem Sap is desirable.

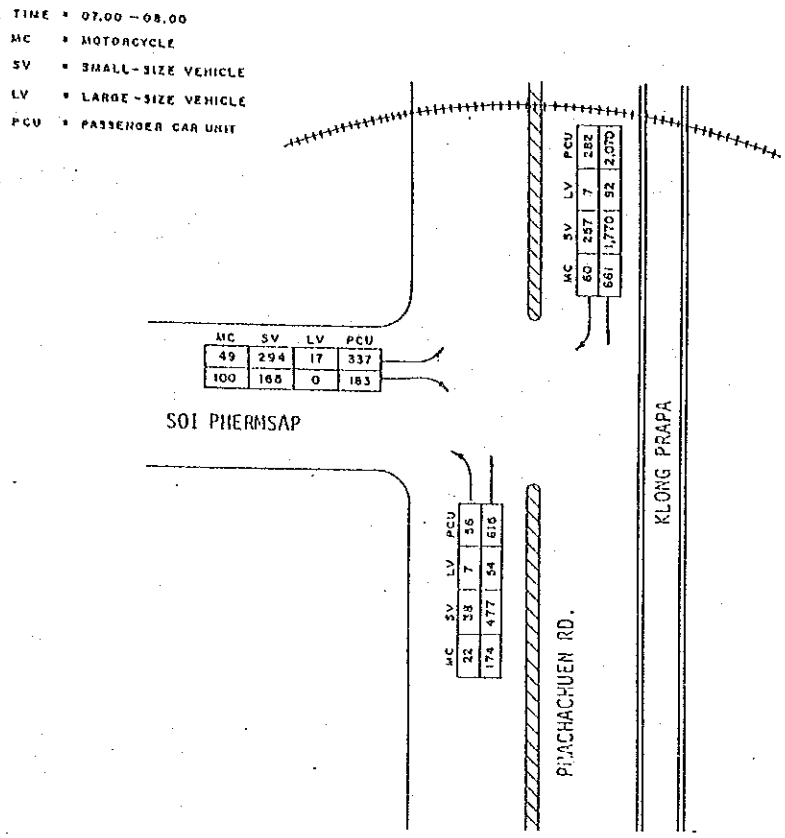

Figure 5.4.2 Traffic Volume at Intersection on Pracha Chuen Road with Soi Phoem Sap

Table 5.4.3 Running Speed of Vehicles on Pracha Chuen Road

RUNNING SPEED

RUNNING SPEED (KM/H)	ORDINARY VEHICLES NUMBER	ORDINARY VEHICLES RATIO(%)	HEAVY VEHICLES NUMBER	HEAVY VEHICLES RATIO(%)	T O T A L NUMBER	T O T A L RATIO(%)
20 - 25	0	0.0	0	0.0	0	0.0
25 - 30	0	0.0	0	0.0	0	0.0
30 - 35	0	0.0	0	0.0	0	0.0
35 - 40	2	2.0	1	12.5	3	2.8
40 - 45	18	18.2	0	0.0	18	16.8
45 - 50	25	25.3	3	37.5	28	26.2
50 - 55	24	24.2	2	25.0	26	24.3
55 - 60	20	20.2	1	12.5	21	19.6
60 - 65	6	6.1	1	12.5	7	6.5
65 - 70	2	2.0	0	0.0	2	1.9
70 - 75	2	2.0	0	0.0	2	1.9
75 - 80	0	0.0	0	0.0	0	0.0
80 - 85	0	0.0	0	0.0	0	0.0
85 - 90	0	0.0	0	0.0	0	0.0
90 - 95	0	0.0	0	0.0	0	0.0
95 -100	0	0.0	0	0.0	0	0.0
100 -	0	0.0	0	0.0	0	0.0
T O T A L	99	100.0	8	100.0	107	100.0
AVERAGE SPEED	51.4KM/H		50.6KM/H		51.4KM/H	
MAXIMUM SPEED	70.0KM/H		63.0KM/H		70.0KM/H	
STANDARD DEVIATION	7.2KM/H		7.5KM/H		7.2KM/H	
15 PERCENTILE	43.0KM/H		38.8KM/H		43.1KM/H	
75 PERCENTILE	55.3KM/H		53.0KM/H		55.3KM/H	
85 PERCENTILE	57.2KM/H		55.4KM/H		57.0KM/H	

(2) Techa Wanit Road

Along Techa Wanit Road, safety plans for the two road segments S2-1 and S2-2 are prepared. Figure 5.4.3 indicates their locations.

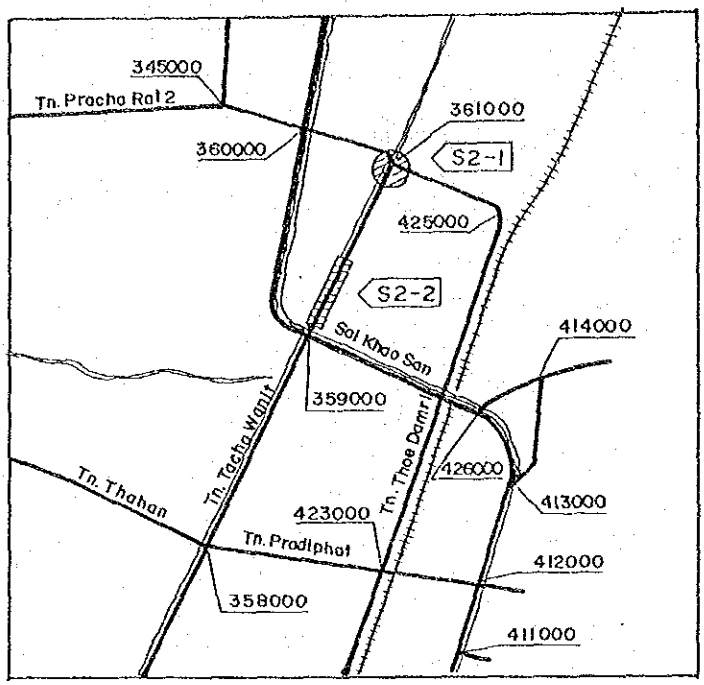

Figure 5.4.3 Road Segments for Safety Planning on Techa Wanit Road

1) Saphan Soong Intersection (S2-1)
(Techa Wanit Road/Thoet Damri Road)

a) General description

This is a Y-shape intersection on the bridge crossing over Khlong Prem Pracha.

Number of conflict points at this intersection are less than an ordinary 3-legs intersection due to the provision of exclusive right turn and left turn lane under the bridge leading to the Bang Sue Market and the Bang Sue Railway Station, and exclusive pedestrian path and overpass. However, accidents frequently occur at this intersection. Major stream lines of traffic and conflict points are shown in Figure 5.4.4.

b) Accident patterns

Major accident patterns at this intersection are right turn collision, rear end collision and side contact.

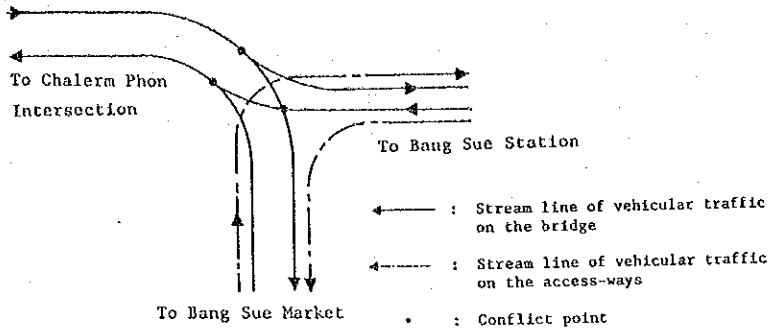

Figure 5.4.4 Major Stream Lines and Conflict Points at Saphan Soong Intersection

c) Major problems

The following problems can be pointed out at this intersection:

- Heavy traffic volume beyond the capacity of a stop control intersection.
- Heavy and continuous vehicular traffic on Techa Wanit Road cause conflicts with right turn traffic from Thoet Damri Road.
- Sudden brakings and changing lanes by vehicles of through traffic caused by right turn vehicles.
- Inadequate sight distance caused by small horizontal radius curve and small vertical curve.
- Vehicles striding over the center line.
- Insufficient pavement markings.

d) Safety measures

Since improvement of intersection itself such as vertical and/or horizontal alignment is difficult, reduction of accident number will be achieved by the following safety measures.

- Installation of overhang type traffic signals together with an advance notice traffic signal for the approach section from the Chalerm Phon Intersection.
- Installation of chatter-bars on Techa Wanit Road for the approach from Bang Sue market and Thoet Damri Road.
- Improvement of pavement markings.

2) Mid-block section in front of Bang Sue Market (S2-2)

a) General description

This segment is the narrow 4-lane mid-block section in front of the Bang Sue Market and opposite side of the market is Khlong Prem Pracha. One crosswalk exists in front of the Bang Sue Market.

One big market (Bang Sue Market) and many shops are concentrated along this road segment, while two schools are located near this segment.

b) Accident patterns

Many pedestrians are involved in the accidents, especially when they are crossing the carriageway.

Typical accident patterns of vehicle-vs-vehicle accidents are side contact and rear end collision.

c) Major problems

Major problems at this road segment are summarized as follows:
- Many pedestrians including school children cross carriageway.
- Difficulty of road crossing by pedestrians due to heavy traffic volume.
- Insufficient walking spaces for pedestrians on the sidewalks due to the obstruction by street vendors. This causes the jaywalkings on the carriageway.
- Disturbance on main traffic flow by parked vehicles, bus movement and jaywalkers. This induce drivers to change lanes suddenly or to stride over the centerline.
- Shortage of sight distance at small size intersections due to street vendors.

d) Safety measures

In order to reduce accidents, following safety measures are proposed for this road segment.
- Installation of pedestrian signals.
  Pedestrian signals are more suitable than a pedestrian overpass for this segment because of narrow carriageway width (12m). Narrower width carriageway tends to lead to declining of usage of a pedestrian overpass.

- Extension of existing sidewalk guardfence.
- Improvement of raised pavement markers.
- Elucidation of bus stops by pavement markings and restriction of parkings in their vicinity sections.

In parallel with above mentioned countermeasures, it is desirable to remove street vendors from sidewalks.

(3) Ratchadamnoen Nok Road (S3)
(Yeak Jor Por Ror Intersection)

a) General description

Figure 5.4.5 illustrates the location of this intersection. This is a signalized large size 4-leg intersection at Ratchadamnoen Nok Road with Wisut Kasat Road and Chakkapatpong Road.

Ratchadamnoen Nok Road consists of 6-lane main roadway, and wide outer separator (10 m) and 2-lane frontage road for each side. On the other hand, Wisut Kasat Road and Chakkapatpong Road are undivided 6-lane roads.

At this intersection, old pedestal type signals are installed and exclusive right turn phase is provided for traffic on Ratchadamnoen Nok Road.

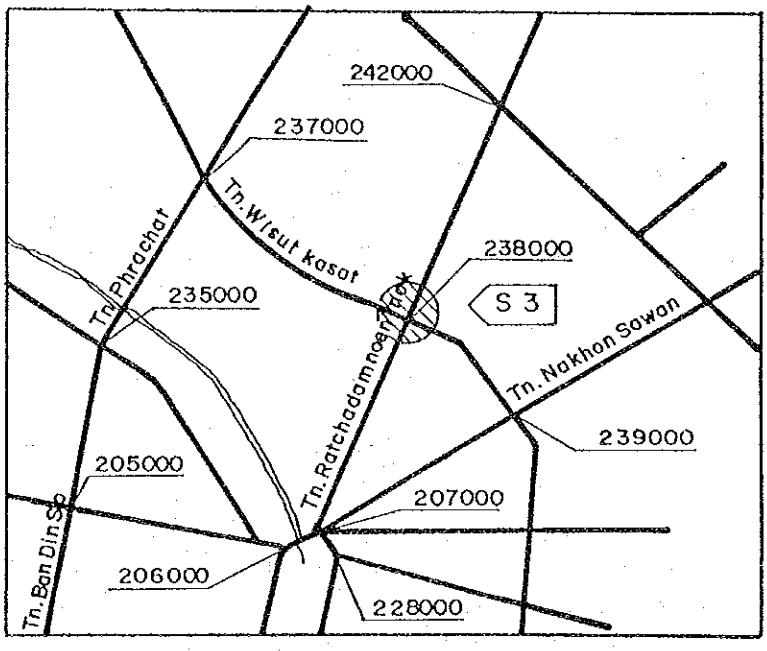

Figure 5.4.5 Road Segment for Safety Planning on Ratcha damnoen Nok Road (Yeak Jor Por Ror Intersection)

b) Accident patterns

Typical accident patterns are right turn collision, rear end collision and side contact. Particularly, a lot of right turn collisions are recorded related to the right turn vehicles from Ratchadamnoen Nok Road to Wisut Kasat Road.

c) Major problems

The major problems at this intersection are as follows;
- Poor visibility of traffic signals.
- Insufficient clearance time in traffic signal phases due to existence of wide outer separators and frontage roads.
- Disorderly traffic flows due to invasion on the right turn lane by through traffic and narrow lane width.
- Insufficient number of regulatory signs.
- Insufficient visibility of existing regulatory signs which are concealed by roadside trees.
- Disturbance for traffic flows by parked vehicles at approach sections of intersection.
- Complicated traffic flows due to the traffic on frontage road, even though left turn from the main roadway and right turn from frontage roads are restricted.

d) Safety measures

In order to simplify traffic flows at this intersection, it is desirable to demolish the outer separators and install the median instead on Ratchadamnoen Nok Road. This idea, however, might be difficult because Ratchadamnoen Nok Road is one of the symbol road in Bangkok, which leads to the National Assembly Hall and provides good environment by roadside trees on outer separators.

In this study, therefore, following safety measures are proposed as the immediate remedy works.
- Replacement of pedestal type traffic signals by overhang type traffic signals.
  At this case, suitable locations of signal displays are determined not only from traffic point of view but also from landscape point of view in order to preserve good environment on Ratchadamnoen Nok Road.
- Provision of exclusive signal phases for through traffic (including left turn) and right turn traffic in order to avoid conflict between through traffic and right turn traffic on Ratchadamnoen Nok Road.

- To secure sufficient clearance time by introducing all-red period in the signal phase.
- Improvement of pavement markings including guide lane-line marking for right turn and widening of lane width in order to clarify the right turn lanes and to ensure the orderly traffic flows.
- To secure the visibility of traffic signs by triming roadside trees.
- Installation of regulatory signs to prevent left turns from the main roadway of Ratchadamnoen Nok Road.
- Prohibition of parkings in vicinity sections of the intersection.

(4) Si Ayutthaya Road (S4)

a) General description

Figure 5.4.6 indicates the location of this segment. At this segment, Si Ayutthaya Road consists of 4-lane undivided main roadway, and an outer separator and 1-lane frontage road for each side, except at approach sections of two intersections with Phaya Thai Road and Ratchaprarop Road, where medians are provided instead of outer separators. There are openings of outer separators at 5 locations and one pedestrian bridge was recently constructed in front of the Phaya Thai School.

BMA has an improvement plan for the intersection with Ratchaprarop Road, which is a part of the new road construction between Ratchaprarop Road and Asok - Din Daeng Road, including widening of Soi Moren. If this new road will be constructed, traffic condition on Si Ayutthaya Road might be changed drastically.

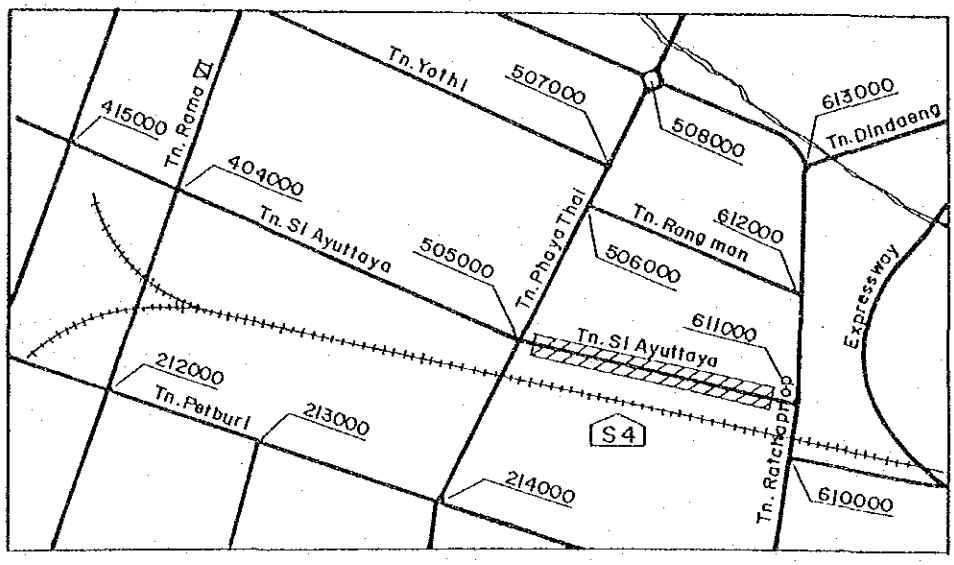

Figure 5.4.6 Road Segment for Safety Planning on Si Ayutthaya Road

b) Accident patterns

Major accident patterns at this segment are side contact and rear end collision, and also accidents involved pedestrians shows high percentage, especially at the crosswalk in front of the Phaya Thai Hospital.

c) Major problems

The major problems at this segment are as follows;

- Disorderly traffic flows caused by weaving, right turn and U-turn vehicles at the openings of outer separators. This leads to sudden brakings and changing lanes by vehicles running on the main roadway.
- Short distances between openings of outer separators.
- Many conflict points at the openings of outer separators due to the complicated turning movements.
- Disturbance of traffic flow by parked vehicles, buses and street vendors on frontage roads near to openings of outer separators.
- High speed vehicles due to a good straight alignment on the main roadway. From the result of running speed survey, 85 percentile speed at this segment is 66 km/hr.
- Difficulties of crossing the carriageway by pedestrians due to the high speed vehicles and continuous traffic flow.

d) Safety measures

In order to simplify the turning movements and ensure the ordery traffic flows, provision of median instead of the outer separators is desirable. However, since royal palm trees planted on the outer separators create the good scenic view, demolition of outer separators seems to be difficult as an immediate action. Therefore, demolition of outer separators can be considered if the new road will directly connect Si Ayutthaya Road and Asok - Din Daeng Road.

In this study, therefore, the following safety measures are proposed based on the existing road conditions with outer separators, as shown in Figure 5.4.7.

- Restriction of turning movements at 2 openings of outer separators. Effects on turning movements by this measure is estimated and illustrated in Appendix 5.4.4.
- Installation of overhang type traffic signals in front of the Phaya Thai Hospital, in order to secure orderly turning movements as well as safety of pedestrians.
- Prohibition of parkings at approach sections of openings of outer

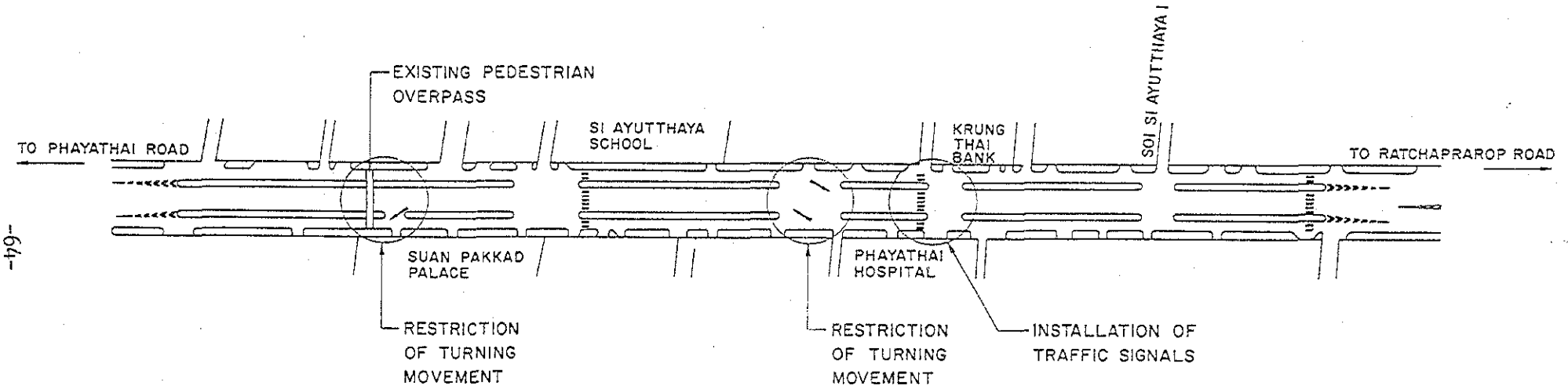

Figure 5.4.7 Proposed Safety Plan for Si Ayutthaya Road

separators and the main roadway.
- Provision of the continuous center line to prohibit overtaking.

Regarding to the safety measure for the restriction of turning movement at openings of outer separators, 3 alternatives shown in Appendix 5.4.5 are compared and Alternative 1 is proposed at this stage by the following reasons.

. Alternative 2 is a better plan from the traffic safety point of view compared with Alternative 1, however, this plan is economically unfeasible according to the results of preliminary economic evaluation.

. For Alternative 3, it is difficult to provide either sufficient weaving length or sufficient storage length, since distance between the intersection with Ratchaprarop Road and the entrance of Soi Si Ayutthaya 1 is not long enough.

(5) Phaya Thai Road (S5)
(Ratchathevi Intersection/with Petburi Road)

a) General description

Location of this road segment is shown in Figure 5.4.8. At this intersection, the flyover crossing over Phaya Thai Road exists and one way system is adopted for both Phaya Thai Road (except for working days between 4.00 p.m. and 7.00 p.m.) and Petburi Road.

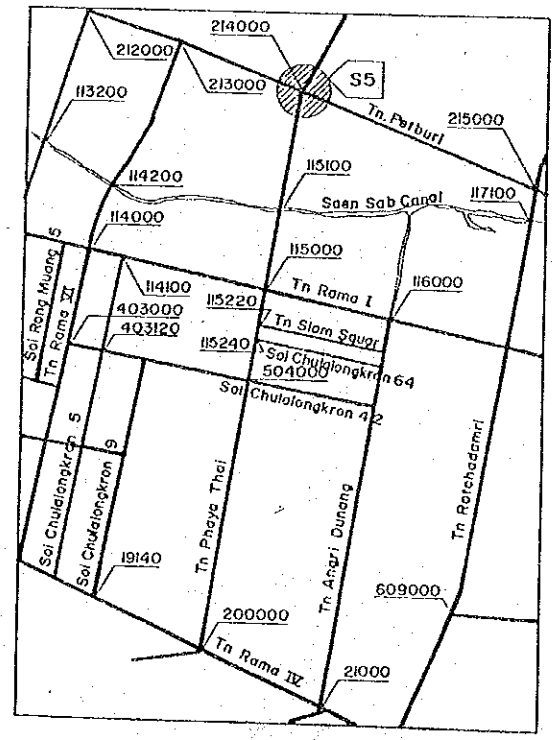

Figure 5.4.8 Road Segment for Safety Planning on Phaya Thai Road (Ratchathevi Intersection)

b) Accident patterns

Typical accident patterns at this intersection are rear end collision and right turn collision. Accidents of pedestrian vs. vehicle also occur frequently.

c) Major problems

The major problems identified are as follows;
- Poor horizontal alignment.
- Complicated traffic flows caused by medians and one-way system (Refer to Figure 5.4.9).
- Conflicts between through traffic on Petburi Road and left turn traffic from Phaya Thai Road.
- Disturbances for the through traffic flow on Phaya Thai Road caused by buses and parked vehicles at the approach section of this intersection.
- Difficulties of crossing road by pedestrians.

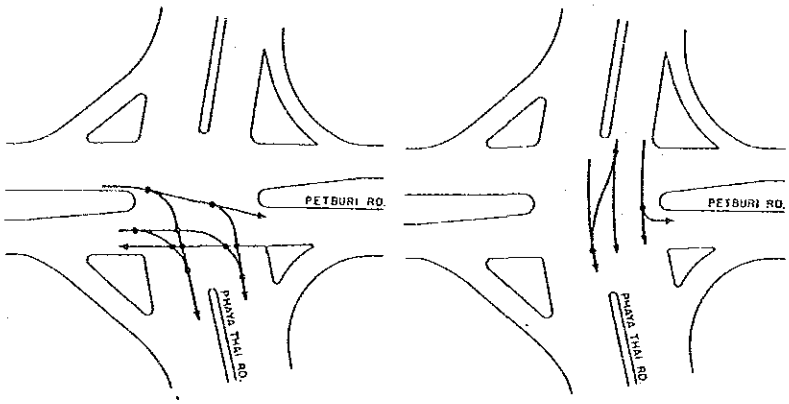

Figure 5.4.9 Turning Movements and Conflict Points at Ratchathevi Intersection

d) Safety measures

The following safety measures are proposed in order to reduce the accidents.
- Control the right turn movement from Petburi Road by guide lane-line markings and traffic signs.
- Improvement of channelization by pavement markings and chatter-bars.
- Improvement of horizontal alignment by lane-line markings.
- Provision of an exclusive signal phase for pedestrians to ensure the safety of pedestrians.

(6) Rama I Road (S6)

a) General description

Figure 5.4.10 indicates location of road segment for safety planning on Rama I Road. In this segment between Rama VI Road and Krung Kasem Road, two way system is adopted, while number of lane is diminished from 5-lane to 4-lane. There is a bridge cross over the main railway line (Kasatsuk Bridge) at the middle of this road segment.

Extension of Rama VI Road will be completed in the near future and traffic condition at this road segment might be changed. In this study, however, the safety plan is prepared based on the existing traffic condition as immediate actions to be taken.

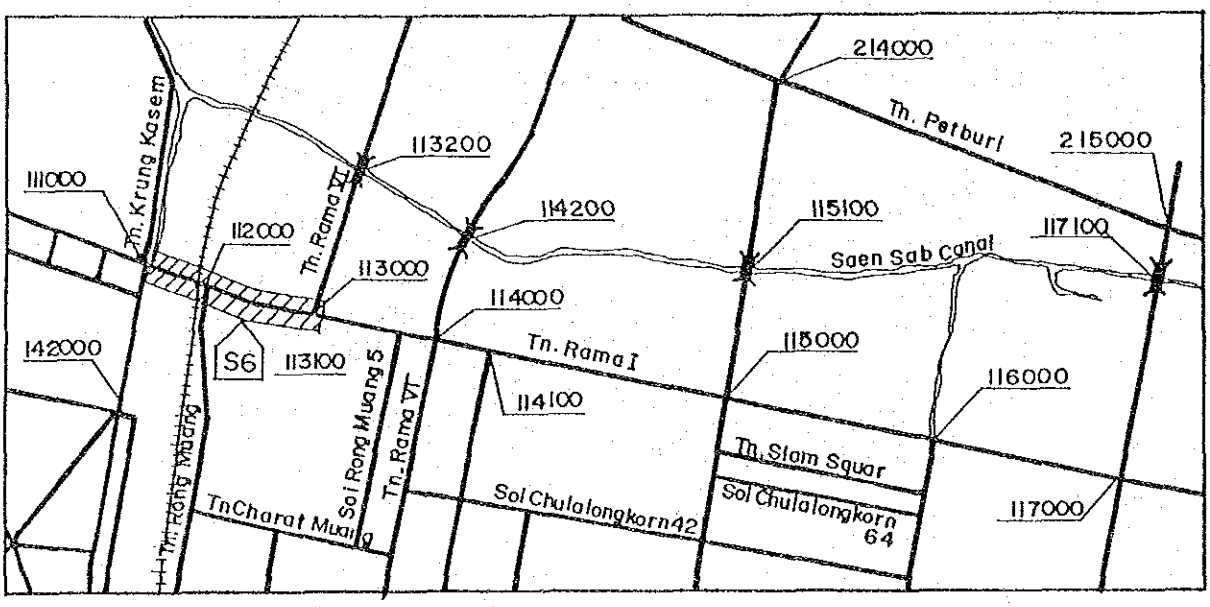

Figure 5.4.10 Road Segment for Safety Planning on Rama I Road

b) Accident patterns

Major accident patterns at this road segment are side contact, head on collision and rear end collision.

c) Major problems

Major problems at this road segment are as follows;
- Confusion of traffic flows at the section where number of lane is