Traffic volume are measured at peak hours in the morning (6 am. - 9 am.) and evening (4 pm. - 7 pm.) for 6 hours in. The classification of vehicle types used in the survey is shown in Table 6.24.

Collision diagram* and accident-pattern statistics for 1981 and 1982 accident data have been prepared for each planning site. This provided a vital information to the appraisal of traffic safety measures and all design of safety plans.

6.3.4 Illustration of Safety Plans

This section describes the details of the safety plans for selected 17" safety planning sites" prepared by the Team. Table 6.25 shows the list of safety planning sites, road classification by type and the reference numbers to the respective maps.

The drawings are prepared using the 1/1,000 scale map and will be attached in the Volume II of Final Report.

The descriptions of the safety plans for each site will be composed of: (i) explanation of the results from the accident-pattern analysis and identified problems; and (ii) adopted safety measures for that section.

(1) Safety Plans for "S1", "S2", "S3" (Route 1)

Three safety planning section S1, S2 and S3 were selected along Route 1. Figure 6.8 indicates their locations and the description of safety measures. Existing conditions of safety planning site are summarized in the tables in Appendix.

1) S1, Route 1 (KP 19+000-22+000)
(Road type: Roadway; Tangent)

The results reported here were obtained from the detailed analysis on accident data. Examples of collision diagrams and accident-pattern statistics prepared for the analysis, are shown in Table 6.26 and Figure 6.9.**

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* The method for preparing collision diagram is explained in Chapter 3

** Appendix contains the equivalent diagrams and tables for the remaining planning sites.

Table 6.24 Classification of Vehicle Types used in the Traffic Survey for Safety Planning

Vehicle Type (Symbol)	Description
Bicycle & Tricycle (B/T)	2-wheel or 3-wheel vehicle without engine.
Motorcycle (M/C)	2-wheel vehicle with engine such as SUZUKI A100 and HONDA DT100
Motortricycle (M/T)	3-wheel vehicles with eingine such as so-called "Samlor"
Passenger Car (P/C)	Includes not only vehicles of personal use such as TOYOTA COROLLA and DATSUN 160J, but also 4-wheel-drived vehicles such as Land Rover, taxi and pickup truck used for personal use but not for freight transportation
Light Bus (L/B)	A simple adoption of pickup with longitudinal bench seats and canopy of canvas. The seat capacity is 10 in average.
Heavy Bus (H/B)	Range widely from modified 6-wheel medium trucks such as TOYOTA DYNA and ISUZU ELF with long bench seats to large tour buses such as ISUZU BD61 and HINO BF320. The seat capacity ranges from 20 to 30.
Light Truck (L/T)	Pickup truck for freight transportation such as TOYOTA HILUX and DATSUN 1500, with loading capacity of 2 tons.
Medium Truck (M/T)	6-wheel double axle truck such as TOYOTA DYNA and HINO KR320, with loading capacity up to 6 tons.
Heavy Truck (H/T)	10-wheel triple axle truck such as ISUZU TW80HJ and HINO KT20, with loading capacity of up to 13 tons.
Others (O)	Tractor, trailor and other vehicles

Table 6.25 Safety Planning Section, Road Classification by Type and the Reference Number to the Maps

Route No.	Site Locations	Section No.	Road Classification by Type	(Safety Planning Maps) Volume II of Final Report
1	Figure 6.2	S 1	Roadway; Tangent Small Intersection	Figure - A1
		S 2	Large Intersection	A2
		S 3	Roadway; Tangent	A3
32	Figure 6.5	S 4	Small Intersection	A4
304	Figure 6.6	S 5	Roadway; Tangent/Crest Small Intersection	A5
323	Figure 6.7	S 6	Large Intersection	A6
302	Figure 6.9	S 7	Roadway; Tangent	A7
306	Figure 6.10	S 8	Medium Intersection	A9
		S 9	Roadway; Curve	A10
		S10	Roadway; Tangent	A11
336	Figure 6.11	S11	Roadway; Tangent Medium Intersection	A12,13,14
3113	Figure 6.12	S12	Roadway; Tangent	A15
11	Figure 6.13	S13	Medium Intersection	A16
1141		S14	Medium Intersection	A17,18
2	Figure 6.15	S15	Large Intersection	A19
		S16	Medium Intersection	A20
205	Figure 6.16	S17	Roadway; Tangent/ Narrowing	A21

Many pedestrians are involved in the accidents, especially when they are crossing the road other than pedestrian crossings. Total number of vehicle-vs-vehicle accidents is also outstanding. Rear-end collisions and head-on collisions are occurred frequently.

The possible causes of the above accident patterns were investigated by a series of visits to the planning sites. Video tape recorders were used for the analysis. The followings are the summary of the results.

- Many pedestrians cross vehicle-carriageways due to the concentration of the shops and big markets along the roads.
- Difficulty of road crossing.
- High-volume and continuous vehicular traffic conflicts with the pedestrians on the pedestrian crossings.
- Insufficient walk spaces for pedestrians on the sidewalks due to the obstruction by street vendors. This causes the jaywalkings on the carriageway.
- Obstruction of bus movements by vehicles parked at the bus stops. This causes the disturbance to the main traffic.
- Obstruction of bus movements by vehicles parked at the bus stops. This causes the disturbance to the main traffic.
- Disturbance on main traffic caused by the vehicles pulling in and out of the road side parking space.
- Shortage of the sight distance due to the street vendors and parked vehicle at small intersections.

The major problems are identified as the insufficient consideration to pedestrian traffic, the unrestrained vehicles parking and illegal occupation of sidewalks by vendors.

Safety Measures

The following safety measures were proposed to cope with the above-mentioned problems.

- Construction of pedestrian bridge with slope. Pedestrian bridge is suitable in the roadway* which has high-volume of vehicular traffic

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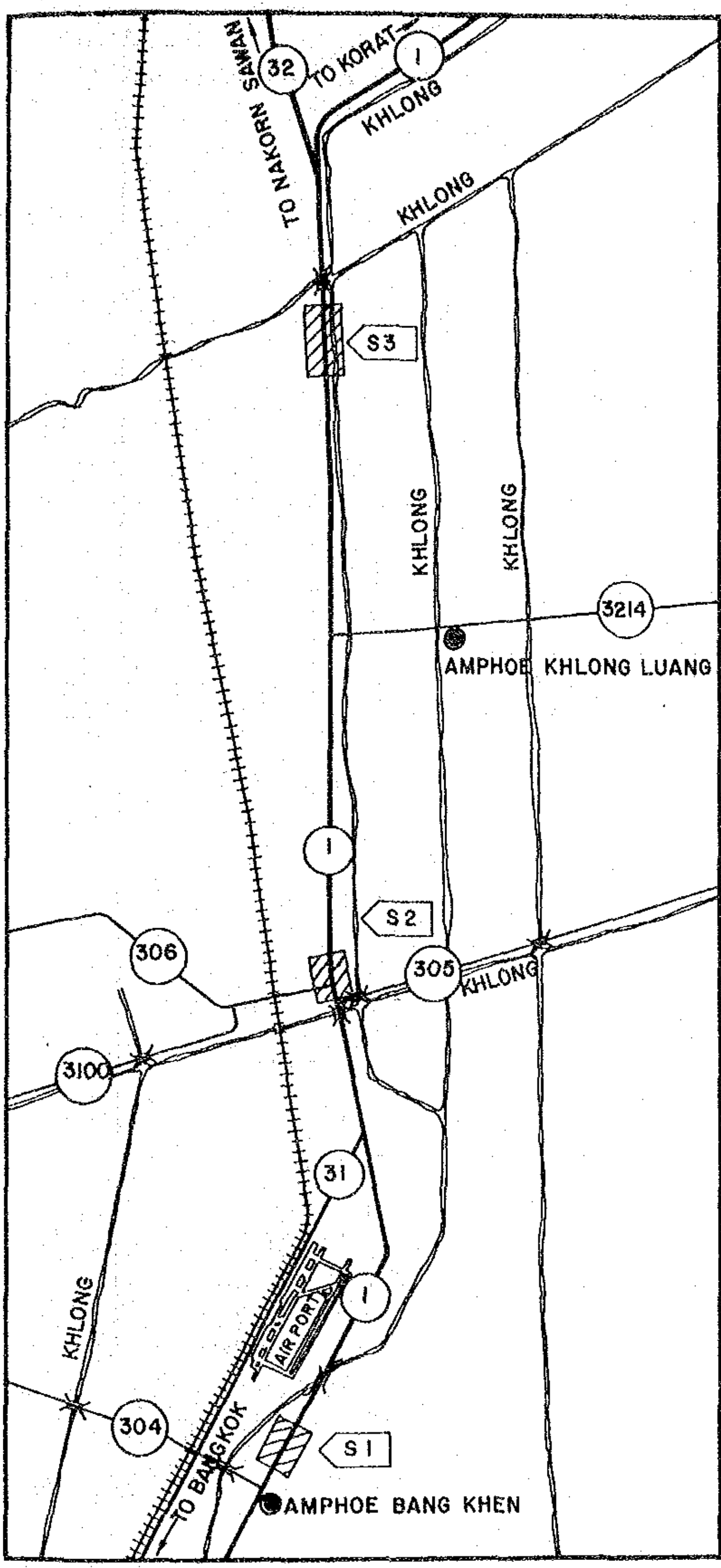
* Roadway means the section between intersections.



Main Countermeasure

S3 - Widening of width of lane lines and edge-line marking

S2 - Construction of "frontage road"
- Installation of traffic signals

S1 - Construction of pedestrian overpass
- Installation of guardfence
- Restriction of parking

Figure 6.8 Locations and Main Countermeasures, Route 1

Table 6.26 Accident-Pattern Statistics for Section S1, Route 1

Accident Patterns	Numbers	Composition
10. Vehicle vs. Pedestrian	44	(30.1)
11. Hit pedestrian walking along carriageway	0	
12. Hit pedestrian crossing carriageway at intersection	0	
13. Hit pedestrian crossing carriageway at crosswalk	0	
14. Hit pedestrian crossing carriageway other than crosswalk	44	
15. Hit pedestrian emerging on carriageway	0	
16. Hit pedestrian playing on carriageway	0	
17. Others	0	
20. Vehicle vs. Bicycle	3	(2.1)
21. Head on collision	1	
22. Rear end collision	1	
23. Side collision during crossing	1	
24. Side collision during right turn	0	
25. Side collision during left turn	0	
26. Others	0	
30. Vehicle only	4	(2.7)
31. Off carriageway	3	
32. Collision with parked vehicle	1	
33. Collision with guard rail	0	
34. Collision with electric pole	0	
35. Collision with other objects	0	
36. Others	0	
40. Vehicle vs. Vehicle	94	(64.4)
41. Head on collision	15	
42. Rear end collision	29	
43. Side collision during crossing	4	
44. Side collision during right turn	10	
45. Side collision during left turn	10	
46. Side contact	3	
47. Others	23	
50. Unknown	1	(0.7)
TOTAL	146	100%

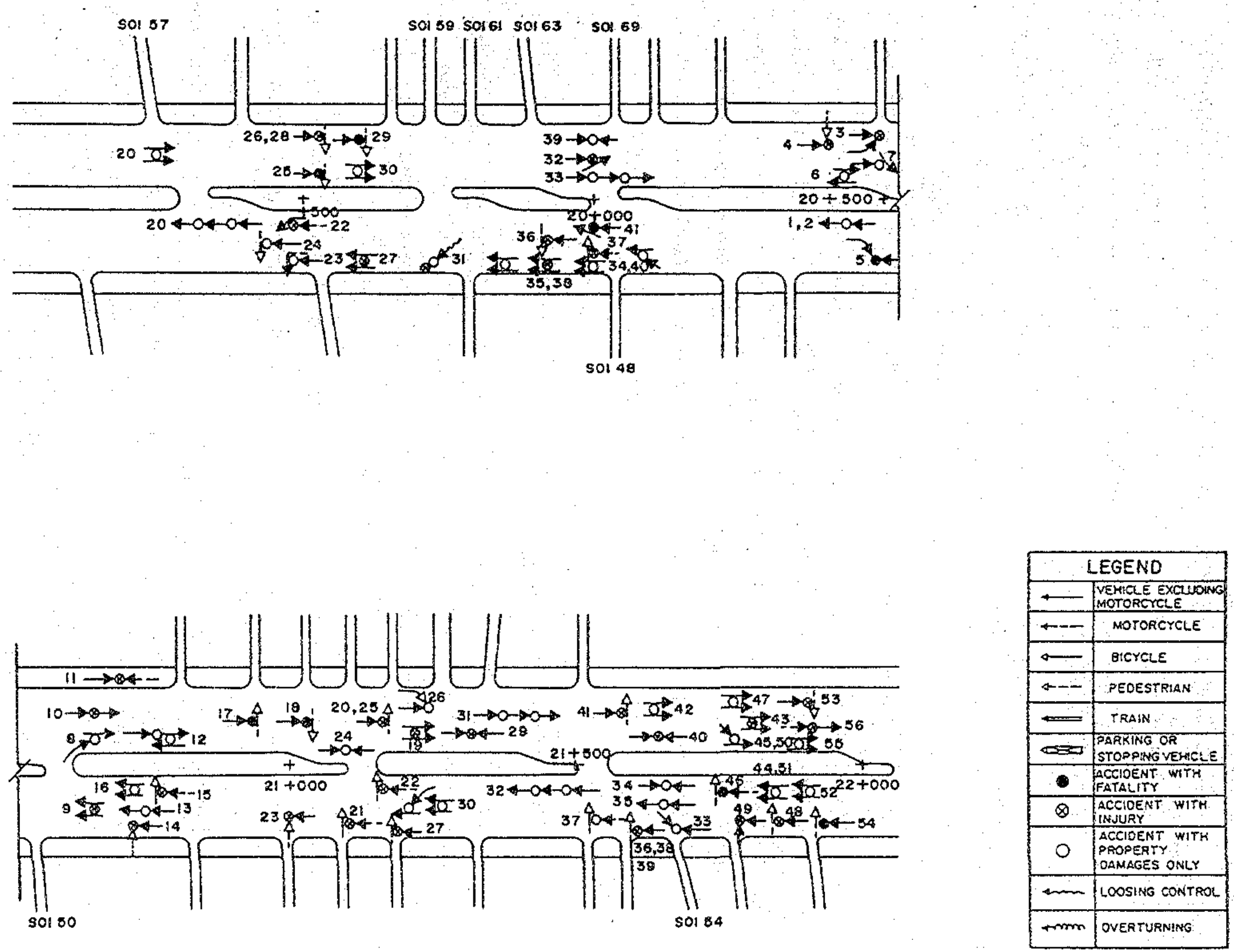


Figure 6.9 An Example of "Collision Diagram", Route 1

and pedestrian crossing the road. Slope should be provided for the peoples carrying goods by handcart.

- Installation of guardfences on the sidewalks to limit pedestrians for crossing as well as to prevent the jaywalking on the carriageway.
- Restriction of parking on the auxiliary lanes in order to secure the space for bus stop and to improve the sight distance near the intersection.

In parallel with the above-mentioned countermeasures, it is desirable to consider following means.

- Removal of the vendors from the sidewalk.
- Provision of parking places for the market and shops by their owners.

When wider application of safety measure is to be considered for a longer stretch of road section where many accidents are occurring, a measure comprising a series of crosswalks with co-ordinated signals to be installed in certain intervals on roadway and at intersections would prove to be effective for pedestrian safety and also for smooth flow of vehicular traffic.

2) S2, Route 1 (KP 29+500-32+500)
(Road type: Large intersection)

Typical accident patterns in this section are considered as follows: i) rear-end collisions, ii) vehicle-only accidents such as collisions with guardfences on roadways; and iii) rear-end collisions and side collisions during right turn near the intersection.

This explanation refers to the intersection* between the Route 1 and Route 306, and 300-meter-long section from this intersection facing towards Bangkok. There are many shops for about 20 meters away from the left-hand-side shoulder of Route 1. This space is not separated from the carriageway and utilized as bus stops and parking area.
Many buses stop at this bus stop. The following list summarizes the major problems in this section.

- Complication of the traffic flow near the bus stop.

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* Description concerning the roadway part will be made in 6.3.4, (1), 3), because both sections, roadway parts of S2 and whole part of S3, possess similar characteristics.

- Traffic conflicts (see, Figure 6.10) between the through traffic and parking vehicles.

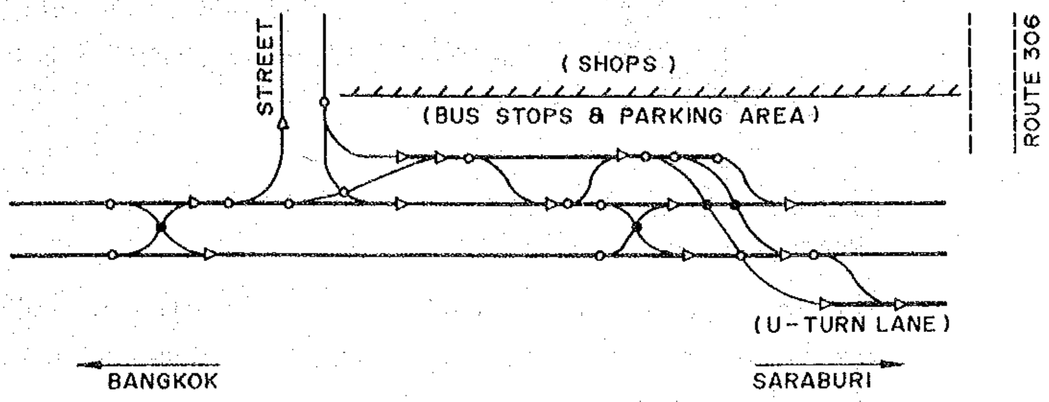


Figure 6.10 Traffic Flow and Conflict Points

- Insufficient weaving length for buses pulling in and out at the bus stop.
- Insufficient bus-lane and bus-stop signs on the right hand side of the road.
- Confusion of traffic flow at the intersection with Route 306. There is a high percentage of turning vehicles.
- In sufficient carriageway width for U-turning of heavy vehicles.

Safety Measures

Extension plan of Route 306 is being prepared by DOH, in which Route 306 overpass Route 1 and is connected with Route 305. After implementation of this plan, accidents at the intersection will be reduced.

In this study, however, the safety plan is prepared to cope with the problems in the present condition without modification of road network and new road construction, and following safety measures are proposed.

The main emphasis was placed on the improvement of the problems caused by bus movements, and right-turn and U-turn vehicles at the intersection. The contents of the plan include that:

- the construction of the "frontage road" (2 lanes) at left hand side of the section facing towards Saraburi - this secures the bus maneuvability and orderly flows of traffic generated locally;

- clear marking of bus lanes at the left-hand side of the road facing towards Bangkok; and
- installation of the traffic signals at the intersection with Route 306. The signals shall be designed to provide a phase for U-turn traffic from the frontage road.

3) S3, Route 1 (47+500-51+000)
(Road type: Roadway; Tangent)

A typical type of vehicular accidents around this site is the collisions with guardrails and running off the carriageway. Rear-end collisions also occupy a high percentage.

The characteristic and condition of this site are similar to the roadway of Section S2, so that safety measures described here are also applicable to that site. The problems are identified as follows.

- Excessive speed of vehicles.
- Heavy vehicles driving over the lane-line marking causes the pressure on the vehicles driving along the adjacent right-hand lane, and obstructs sights of other vehicles.
- Some road shoulders are occupied by street vendors.

Safety Measures

At this planning section, guardfences at the median and lightings are installed, and the number of pedestrians and bicycles are not so large and they are using the paved shoulders.

This section, however, has above mentioned problems and the disorder of traffic movement is suspected to be a cause of accidents.

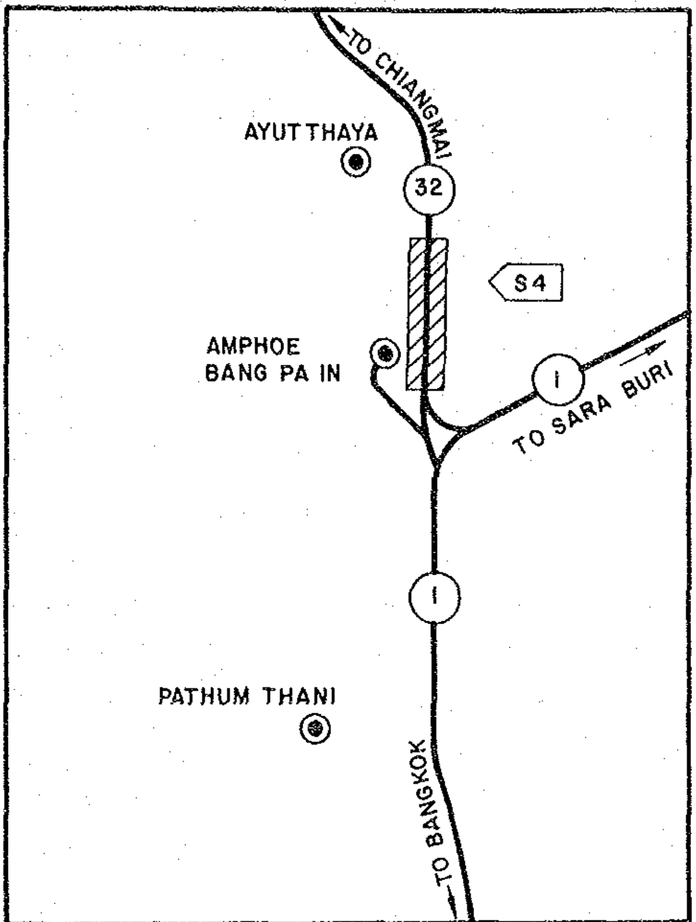
In order to solve the above mentioned problems, it is desired to confine the vehicles within the path of lanes and to keep the speed of traffic at acceptable level. Following this policy, the following countermeasures were considered.

- Widening of the width of the lane lines and edge line marking.
- Remove street vendors.

(2) Safety Plan for "S4" (Route 32)

(Road type: Small Intersection)

Figure 6.11 indicates the location (KP 52+500-69+500) and the description of safety measures. Route 32 has the function of by-pass road for Route 1 and is a toll road with two lanes. The traffic volume on Route 32 is close to its traffic capacity.



Main Countermeasure

- Provision of center line marking
- Installation of chatter-bar

Figure 6.11 Location and Main Countermeasures, Route 32

Safety Measures

DOH has already prepared the plan for widening of Route 32 to a divided four-lane highway. The planned divided four-lane highway will be effective for reducing this type of accidents. In this study, however, following safety measures are proposed as immediate actions to be taken.

- Provision of pavement markings of center line and intersection indicators*, and installation of chatterbars at four small intersections in order to elucidate the existence of small intersections and to reduce running speed of through vehicles.
- Painting of stop lines on crossing roads to clarifying the priority.

A number of accident have been experienced mainly because of excessive speeding and improper passing. A sudden appearance of a vehicle from a small crossing road is also suspected to be a cause to accidents to some extent.

The typical types of vehicular accidents at this section were head-on collision and rear-end collision.

(3) Safety Plan for "S 5" (Route 304)

(Roadway; Tangent/Crest, Small Intersection)

Figure 6.12 indicates the location (KP 64+500-67+000) and the description of safety measures.

Although the average number of accidents on Route 304 is relatively low, frequent accidents have been reordered on a bridge and its approaches. This could be attributed to the substandard vertical alignment on approaches to the bridge and an unpaved small crossing road located in an immediate vicinity of the bridge. The poor vertical alignment causes insufficient sight distance and speeding on steep downgrades. These situations are made more critical by the existence of small intersections. The soil carried in from the unpaved crossing road covers the pavement markings on the main road and makes its surface slipperly.

Safety Measures

The following safety measures are proposed:

- Installation of warning signs to inform drivers of existence of the substandard vertical alignment and small intersections ahead;
- Provision of pavement markings of intersection indicators and continuous center line to prohibit overtaking;
- Realignment of the crossing road so as to intersect with the main road at right angle; and
- Pavement of the crossing road.

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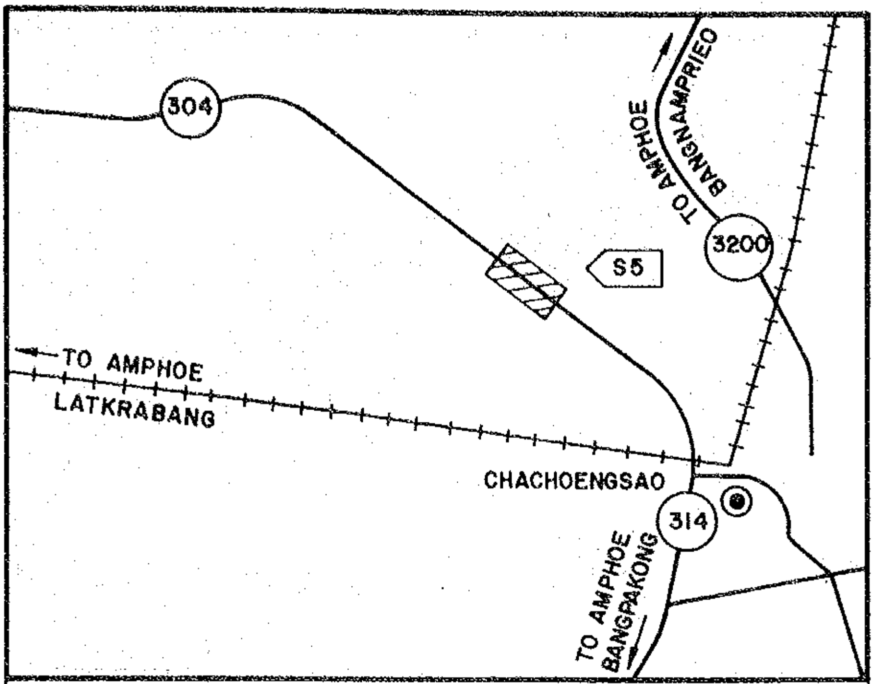
* New type pavement marking proposed by the Team.



Main Countermeasure

- Installation of warning signs "steep gradient"
- Provision of continuous center line marking

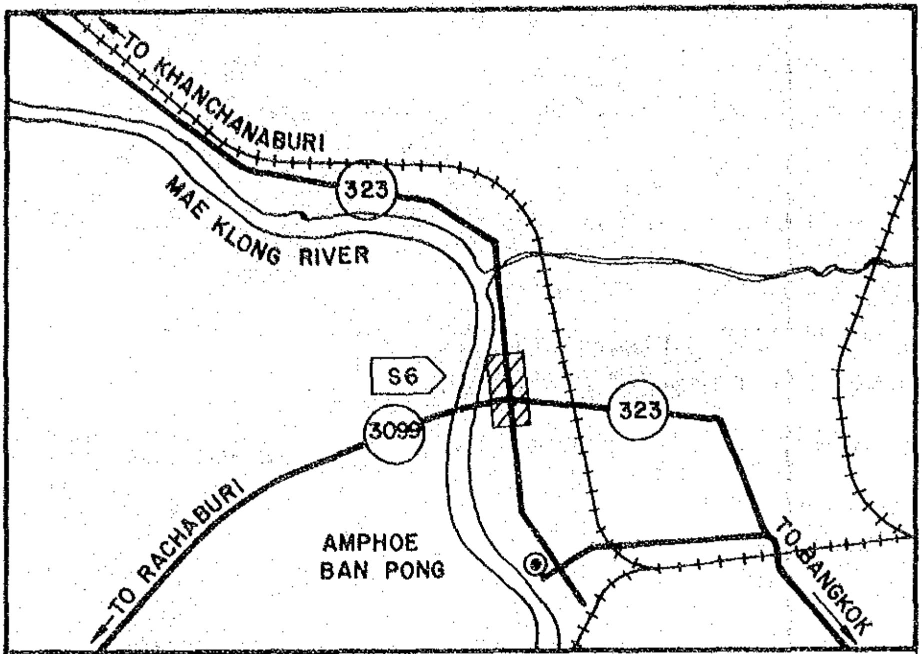
Figure 6.12 Location and Main Countermeasures, Route 304

(4) Safety Plan for "S 6" (Route 323)
(Large Intersection)

Figure 6.13 indicates the location (KP 79+500-80+000) and the description of safety measures.
the side collision during crossing (or side collision during right turn).

The major problems are as follows:

- Difficulty in establishment of priority of traffic flow - at this intersection, major traffic flow on Route 323 between Bangkok and Kanchanaburi makes right turn, while the through traffic volume also is high. The drivers approaching to this intersection, therefore, fail to appreciate priority or given-in.
- Excessive speeding by through traffic; and
- Traffic congestion by heavy trucks during the sugar cane harvest season.
- Difficult in crossing the road for pedestrians for wide carriageways.



Main Countermeasure

- Installation of traffic signals
- Provision of crosswalk

Figure 6.13 Location and Main Countermeasures, Route 323

Safety Measures

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

- Installation of traffic signals; and
- Provision of pedestrian crossings.

In this intersection, to clarify the priority and to ensure the smooth traffic flow for right turn traffic (from Bangkok to Kanchanaburi) is important and effective to reduce the accidents.

In order to accomplish this aim, the following are possible alternative plans.

Alternative 1

Separating into two intersections shown in Figure 6.14. This plan, however, requires the land aquisition and reconstruction. When the through traffic (A-B) is high, this plan is not applicable.

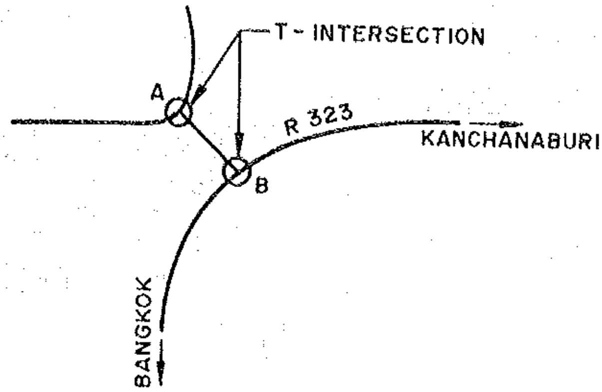


Figure 6.14 Separating of Intersection

Alternative 2

Installation of traffic signals. Traffic signals are effective to ensure the orderly traffic flow coupled with the existing safety measures of left and right turn lanes, raised channelized islands and median.

The Alternative 2 plan seems suitable and realistic for this planning section.

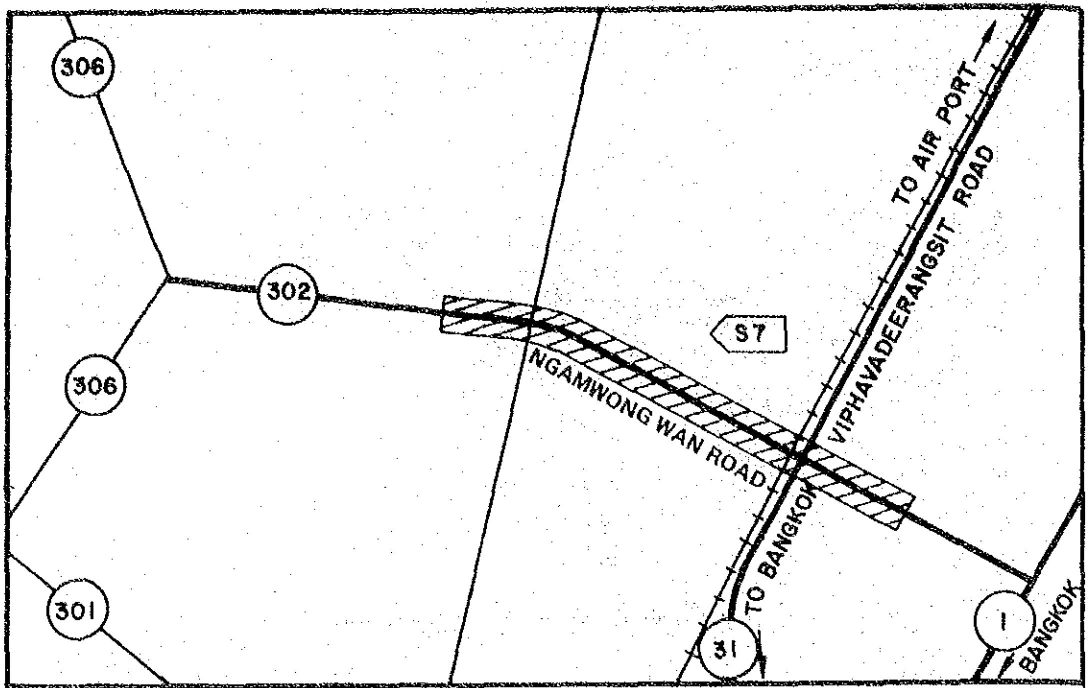
(5) Safety Plan for "S 7" (Route 302)
(Road type: Roadway; Urban-Tangent)

Figure 6.15 indicates the location (KP 1+000-4+000) and the description of safety measures.

Route 302 is an urban road with undivided four lanes. The characteristics of accidents at this section are listed as follows:

- High frequency of vehicle vs. vehicle accidents;
- Among these accidents, rear-end collisions is the highest followed by head-on collisions and side collisions during right turn; and
- The number of pedestrians involved in the accidents when crossing the road also is high.

This section can be divided into 3 parts in view of traffic safety measures, i.e. intersection, the part in highly commercialized areas and the part in high density areas. Concerning to the intersection with Route 31, an improvement plan has been already prepared by DOH. For the part in the high density areas, accident patterns, road conditions and traffic conditions are similar to



Main Countermeasure

- Construction of frontage roads
- Installation of medians
- Construction of pedestrian overpass

Figure 6.15 Location and Main Countermeasures, Route 302

those of Section 10 of Route 306, hence the safety measures proposed for Section 10 are applicable for this section. Therefore, the safety measures only for highly commercialized areas are proposed here.

The major problems at the highly commercialized areas are as follows:

- Disturbance on the main traffic flow caused by many vehicles pulling in and out of roadsides and buses;
- Insufficient provision of pedestrian crossing facilities; and
- Disorderly movements of vehicle - many vehicles travel striding over the center line.

Safety Measures

In order to reduce accidents, following safety measures are prepared for this section.

- Construction of frontage roads to separate buses and vehicles related to commercial areas from through traffic vehicles;

- Installation of medians; and
- Construction of pedestrian bridges - one pedestrian bridge was constructed by DOH recently, but it is yet insufficient.

(6) Safety Plans for "S8", "S9", "S10" (Route 306)

Along Route 306, three sections, S8, S9, and S10 are selected for safety planning. Figure 6.16 indicates the location of the sites and brief comments on the adopted safety measures.

1) S8, Route 306, (1+200-2+000)
(Road type: Medium Intersection)

The half of the accidents are in the category of "vehicle-vs-vehicle", and among them, the rear-end collision shows comparatively high value. The collisions involving parked vehicles also shows comparatively high value.

The accidents relating to the signalized intersection cause the following problems.

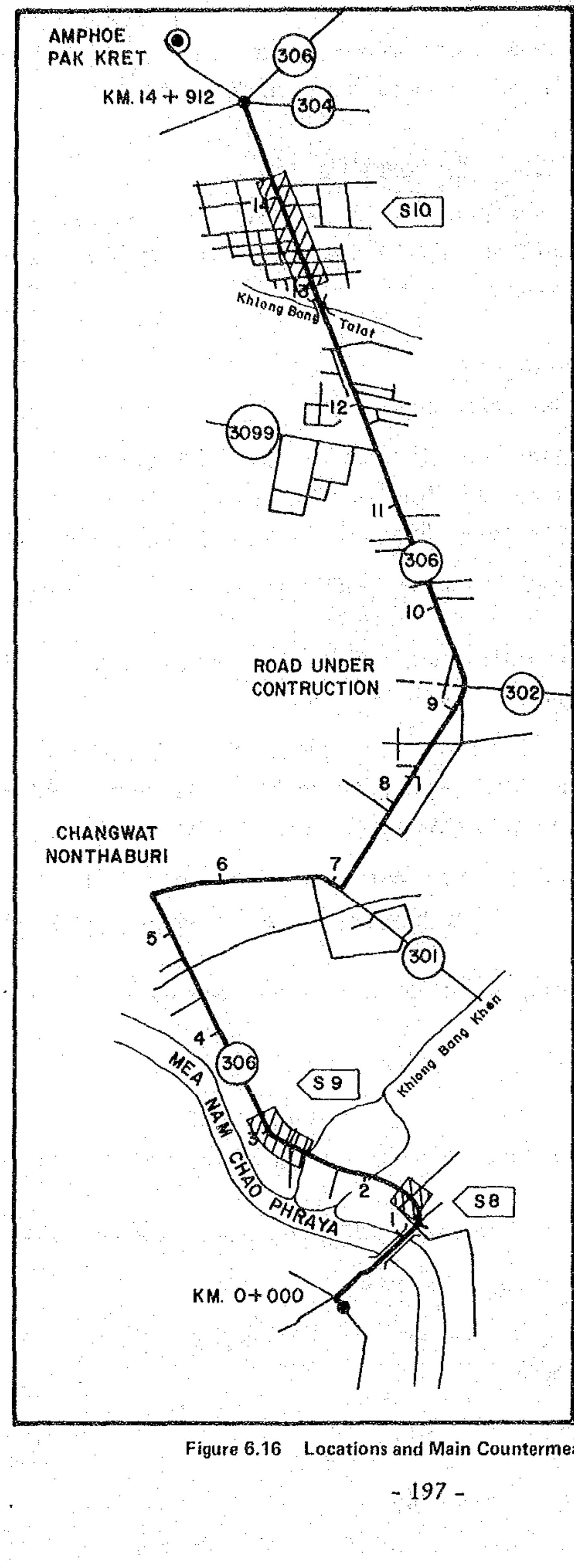
- Congestion and traffic flow confusion due to unclear lane markings, and the road shoulder that is too wide.
- Confusion of traffic flow, especially the right turning. This results from the unnecessarily wide space in the center of the intersection and the mixed use of right-turn and through lanes.
- Difficulty faced by the pedestrians due to heavy left-turning traffic, and inadequate marking of edge line at the corner and pedestrian crossing.

The above points may be summarized as the complication of traffic at this intersection.

Safety Measures

The following safety measures were prepared to cope with the above problems:

- reduce the size of intersection using smaller radius of curvature;
- provide exclusive right-turn lanes;
- provide left-turn lanes to increase the capacity of the approach from Rama VI bridge;



Main Countermeasure
S10: - Construction of refuge island - Provision of sidewalk - Relocation of bus stops
S 9: - Installation of chatter-bars and delineation
S 8: - Reduction of size of intersection - Provision of turning lane - Installation of crosswalk and guardfence

Figure 6.16 Locations and Main Countermeasures, Route 306

- provide markings at the center of intersection to guide the right-turning vehicles;
- install pedestrian crossings; and
- install guardrails in the space obtained by the reduction of the size of intersection, and provide waiting space for pedestrians.

2) S9, Route 306 (2+700-3+100)

(Road type: Roadway; curve)

The characteristics of the accidents in this section cannot be clarified because there is not enough records available.

This section has a sub-standard curve (radius R = 82 m, superelevation i = 4.3%). At present, there are guardrails, road studs, delineators and traffic signs, but according to the interview with local people, the running speed of vehicles is quite high at the curved section, and any accidents occurred due to the loss of control.

Major problems at this site are:

- high running speed at the small-radius-curve - it is suspected that many vehicles drive at 60 to 70 Km/h, whereas the speed for stable driving is estimated as 45 Km/h;
- the transition curve has not been used;
- insufficient provision of visual guidance - such as road studs and delineators;
- not enough consideration is made to the widening of lane width at the curved sections - this results in the difficulty of the large vehicles to turn;
- insufficient road markings;
- insufficient super elevation; and
- parking vehicles near the curve section.

Safety Measures

In order to reduce the accidents, the improvement of horizontal alignment is judged to be effective. In this study, however, the improvement in visual guidance is considered as an immediate action to be taken. This included the followings:

- The installation of Chatter-bars and the delineators with higher reflective quality, at the tangent- and curve-sections. The delineators should be effective for the both directions.
- The restriction of parking near the curved section to exclude vehicles which reduce the visibility.

3) S10, Route 306 (13+000-25+000)

(Road type: Roadway; Tangent)

The accident involving pedestrians occurs frequently in this section mainly due to the frontage land use which includes hospital, school and other public institutions. As high as 59% of total accidents are the pedestrian accidents on the road other than pedestrian crossing.

At this safety planning site, accidents involving pedestrians were regarded as a high priority issue to be tackled. The following explains the detail of the problems.

- Too wide carriageway (4 lanes) for the pedestrians to cross it easily. The pedestrians have to stop and to be exposed to danger at the central part of the carriageway.
- Insufficient walking space along the road, which forces pedestrians to walk on shoulders and carriageway.
- High running speed of vehicles.

Safety Measures

The following countermeasures were prepared for the pedestrian accidents.

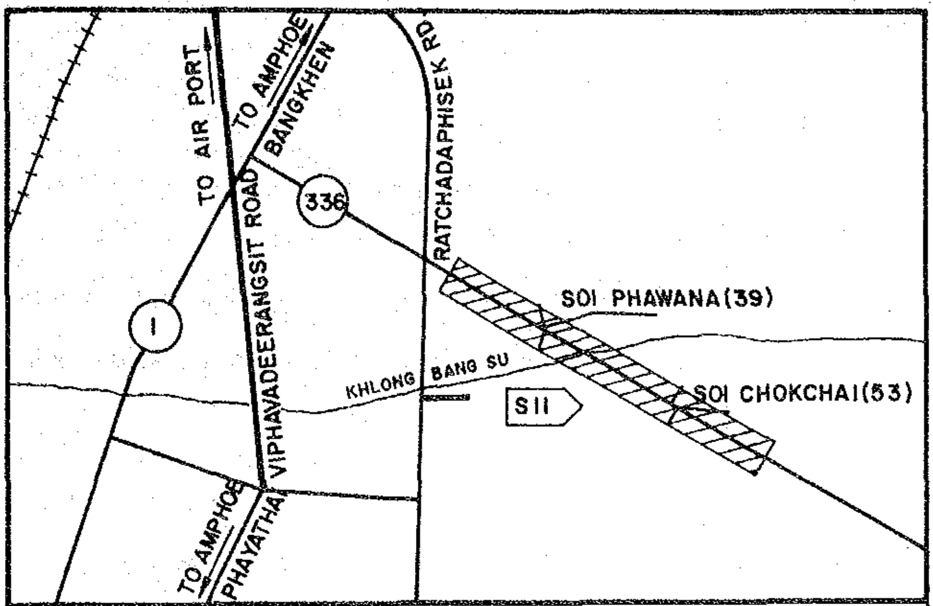
- Construction of a refuge island in the center of the carriageway within the pedestrian crossing to secure the waiting space for pedestrians.
- Clear pavement markings of pedestrian crossings.
- Provide warning signs (road marking) indicating the existance of pedestrian crossings ahead.
- Provide sidewalks for pedestrians between bus stop and pedestrian crossing by installing curbs. This separates them from the vehicular traffic.

- Relocate the bus stops in consistent with pedestrian flows, in order to avoid buses' intrusion into pedestrian crossing, and to secure sufficient bus stopping space.

(7) Safety Planning for "S11" (Route 336)

(Road type: Roadway; Tangent, Medium Intersection)

The section S11 on Route 336 (KP 2+000-5+000) is selected for safety planning. Figure 6.17 indicates the location and the description of safety measures.



Main Countermeasure

- Restriction of turning movement
- Installation of traffic signal for vehicles and pedestrians

Figure 6.17 Locations and Main Countermeasures, Route 336

There are many "rear-end collisions" and "side collisions during right tern". A number of accidents involving pedestrian accidents occurred at the road sections other than pedestrian crossings.

- Frequent accidents involving right- and U-turn vehicles at the median opening occurred. This results from the vehicles driving in and out of "Sois" - sudden stops and difficult weaving take place frequently. The frontage land use (residential) creates many right-turning movement, and the fact that the high traffic volume in Route 336 worsens the traffic confusion at the site.

- Insufficient pedestrian-crossings facilities. (Two pedestrian bridges are under construction but it seem to be not enough).
- Obstruction of pedestrian visibility by parked vehicles on the bus lane.
- High speed running vehicles due to a straight alignment.

Safety Measures

The following measures were prepared in order to rectify the problem caused by turning and weaving movements, and high-speed vehicles, and they should protect pedestrians.

- Restrict turning movement by closing the median openings and install traffic signals at two intersections.
- Provision of right- and U-turn lanes at the newly signalized intersections with the exclusive phases for right-turning and U-turning.
- Provision of the pedestrian signals at the newly signalized intersections.
- Co-ordinate the new signals and the existing one in order to lower running speed.

(8) Safety Plan for "S12" (Route 3113)

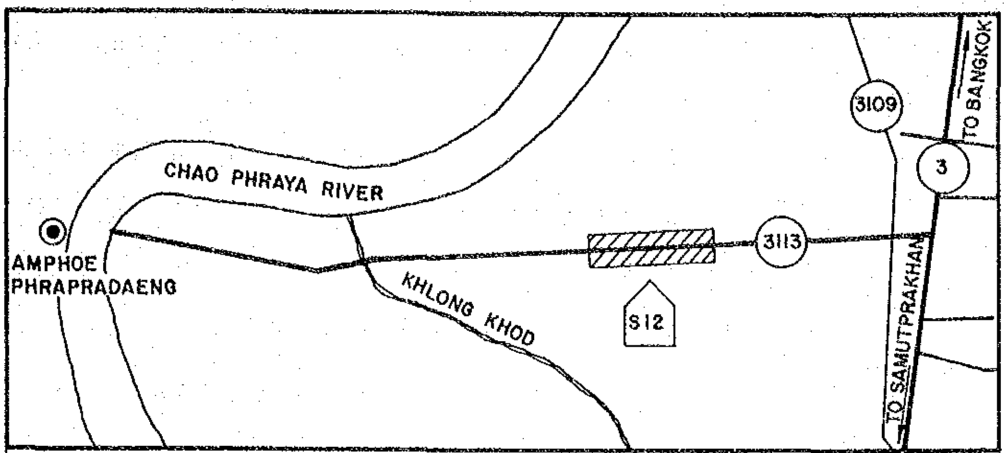
(Road Type: Roadway; Tangent)

Figure 6.18 indicates the location (KP 1+800-2+800) and the description of safety measures.

At this section, the accidents involving pedestrians are occurring frequently. It is noteworthy that more than 80% of total accidents are during the night.

The following problems are pointed out at this section:

- Many pedestrians are walking along and crossing the road even in the night;
- Insufficient road crossing facilities for pedestrians;
- Disturbance to the main traffic as well as pedestrians by vehicles parked on the shoulder during loading and unloading;
- Excessive speeding vehicles, especially during the night; and
- Improper passing.



Main Countermeasure

- Construction of sidewalks and pedestrian overpass
- Provision of guardfence
- Installation of chatter-bars
- Provision of parking lanes

Figure 6.18 Location and Main Countermeasures, Route 3113

Safety Measures

The following safety measures are proposed to solve above mentioned problems:

- Construction of sidewalks and provision of guardfence to prevent pedestrians from random crossing;
- Construction of pedestrian bridges;
  Pedestrian bridge is more suitable than signal for pedestrian for such site which has heavy vehicular traffic and wide carriageway width as this planning section, and also effective to ensure the safety for pedestrians in the night.
- Installation of chatter-bars along the both sides of the existing rumbling median; and
- Provision of parking lanes to secure orderly parkings.

(9) Safety Plan for "S13" (Route 11)

(Road type: Medium Intersection)

Figure 6.19 indicates the location (KP 97+300-97+800) and the description of safety measures.

The typical accident patterns at this section (intersection between Route 11 and 107) are rear-end collision and side collision during right turn.

The major problems are identified as follows:

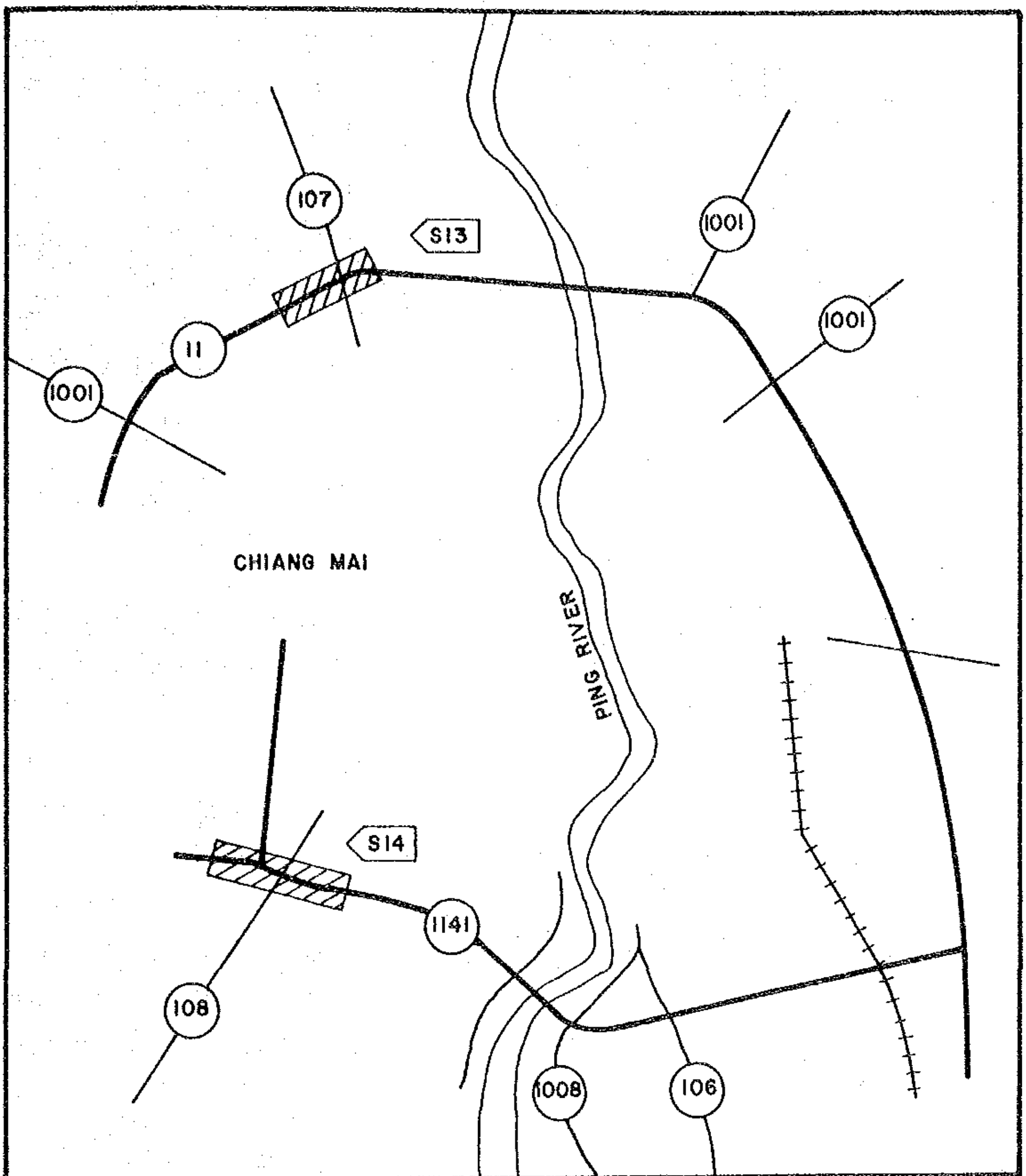
- Confused traffic flow due to unclear lane markings;
- Confused traffic flow caused by right turning vehicles and many bicycles as well as motorcycles; and
- Confused traffic flow at the merging section of the approaches to the intersection.

An improvement plan for this intersection was prepared by DOH. Under this scheme, widening of Route 107 to four lanes and provision of right turning lanes and bicycle lanes were proposed. After the implementation of this scheme, it is expected that most of major problems will be solved. However, in order to reduce the problems caused by bicycles and to ensure the effectiveness of this improvement plan, following safety measures are proposed.

Safety Measures

Installation of bicycle crossing within the intersection - since the movement and behavior of bicycles are different from those of vehicles and it causes the confusion of traffic flow at the intersection, it is desirable to control the flow line of bicycles as shown in Figure 6.20.
Introduction of this bicycle crossing, however requires a new provision in the Land Traffic Act.

Adoption of coloured pavement for bicycle crossing is desirable to clarify but is not essential.



Main Countermeasure

S13 : Installation of bicycle crossing

S14 : Clarification of priority by Channelization

Figure 6.19 Locations and Main Countermeasures, Route 11 and Route 1141

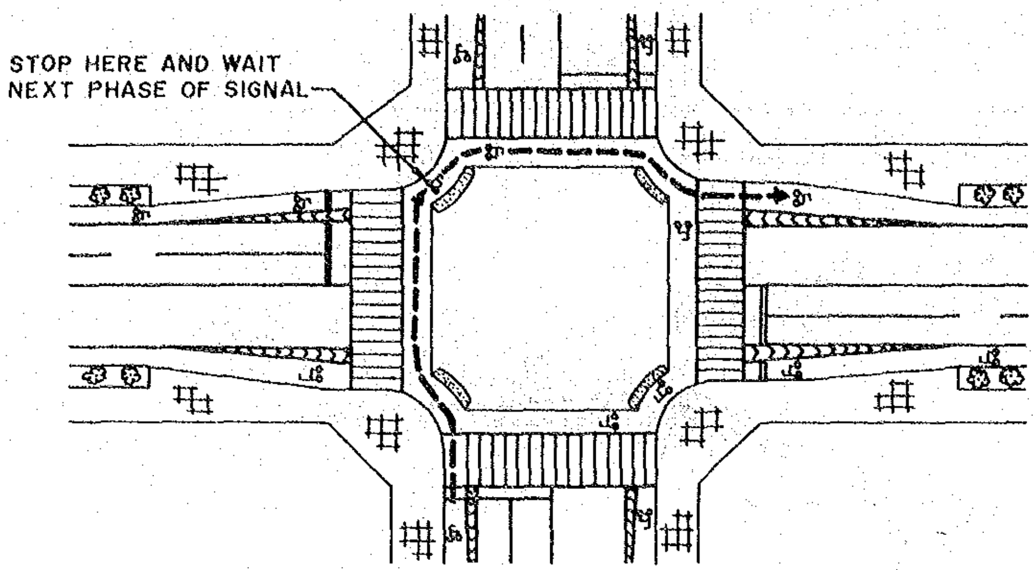


Figure 6.20 Bicycle Crossing

(10) Safety Plans for "S14" (Route 1141)
(Road type: Medium Intersection)

The section S14 on Route 1141 (1+000-1+800) is selected as the safety planning site. Figure 6.19 indicates the location of the site and the main countermeasures prepared by the Team.

At this site, the accidents concentrate on two intersections, and most of them are rear-end and head-on collisions.

There are two intersections at this site: one is T-Intersection (KP 1+300); and the other 4-leg Intersection (KP 1+500). The accident patterns at these intersections are almost the same, but a detailed investigation reveals that the problems and their causes are different. The following two sections explains the problems and the countermeasures of the two intersections.

1) At T-shaped Intersections (KP 1+300)

The result of a traffic survey shows that the main traffic at this intersection is the flow between River Ping and Chiang Mai, but the shape of the intersection obviously gives a priority to the straight part (River Ping - Airport). This causes accidents involving right-turn vehicles.

Safety Measure

Clarification of priority by channelization to the main traffic flow of River Ping and Chiang Mai.

2) At 4-leg Intersection (1K+500)

- The traffic volumes are almost same in all the approaches. Route 1141, however, possesses four lanes and geometrically obvious priority. The running speed is high on this road. This causes of rear-end collisions and other types of collisions.
- Both roads have no exclusive right-turn lane, but two rows of vehicles are forming at the intersection by utilizing 4.5 meter lane width. This induces accidents because of the complication of traffic flow.

Safety Measures

- Install traffic signals and give the right of way to all the vehicles in proportion to the volume of traffic flow in all approaches.
- Provide a right-turn lane to secure a smooth traffic flow.

(11) Safety Plans for "S15" and "S16" (Route 2)

Two safety planning sections S15 and S16 were selected along Route 2. Figure 6.21 indicates their locations and the description of safety measures.

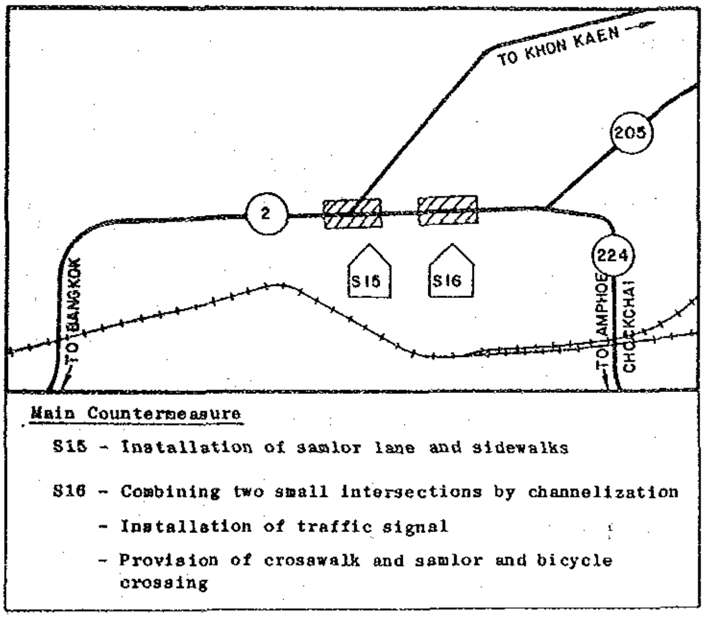


Figure 6.21 Locations and Main Countermeasures, Route 2

1) S15, Route 2 (KP 253+750-254+250)

(Road type: Large Intersection)

Rear-end collision is a typical accident pattern at this planning section.

This intersection is one of the typical T intersections with two-way turning carriageways forming divisional trianguler islands and its system is comparatively working well under the present traffic volume.

It is observed that there are many pedaled samlors in and around this planning section which are often used for short trips within community area.

The major problems at this planning section are as follows:

- Confused traffic flow caused by the mixed traffic of vehicles, pedaled samlors, bicycles and pedestrians;
- Insufficient space allocation for pedaled samlors, bicycles and pedestrians in the intersection.
- Confusion at the merging point due to right turning movement in rows (Khon Kaen - Saraburi).
- Inconspicuousness of barrier line on two-way two lane carriageway (Khon Kaen - Nakornrachasima).

Safety Measures

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

- Separation of pedaled samlors, bicycles and pedestrians from the main traffic flow by installing the samlor lane and sidewalks;
- Painting of clear lane markings and crosswalk;
- Reduction of lane number on right turning carriageway to ensure the orderly traffic flow and merging;
- Installation of chatter-bar on the two-way two lane carriageway; and
- Installation of guardfence and signs for the exclusive and proper use of samlor lanes and sidewalk.

These safety measure are prepared in compliance with the improvement scheme prepared by DOH.

2) <u>S16, Route 2 (KP 254+500-255+000)</u>
(Road type: Medium Intersection)

At this section, many accidents of vehicle vs. vehicle type are occurring. Major problems at this section are listed as follows.

- Confused traffic flow caused by the complicated shape of intersection which consists of two small intersections, and by mixed traffic;
- Random crossing by many pedaled samlors, bicycles and pedestrians at the intersection.

At this section, DOH also prepared a scheme for widening of carriageway and improvement of the intersection. Although traffic flow crossing the Route 2 might be prohibited under this scheme, the safety measures in this study are designed so as to allow all-direction traffic flow.

To reduce the accidents, simplification of intersection in shape and separation of traffic flow by time and space are necessary in this intersection.

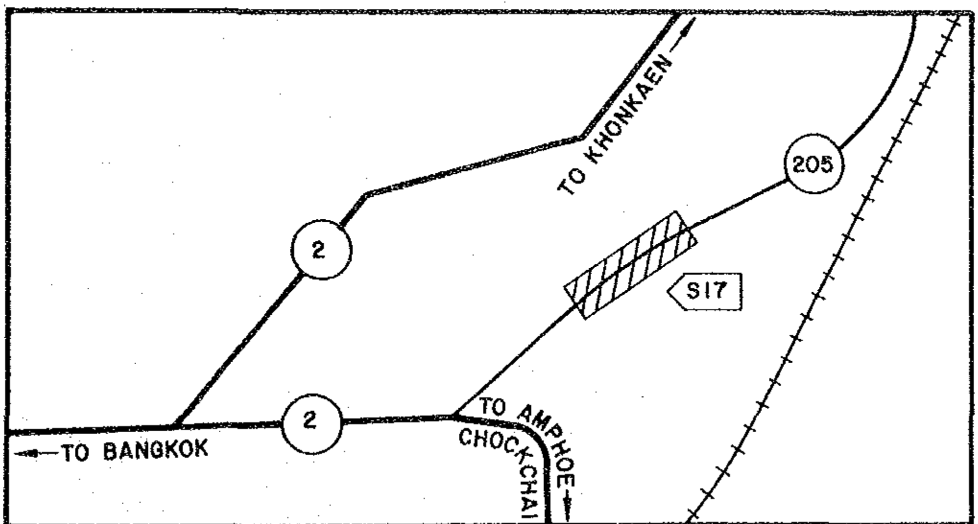
Following safety measures are proposed:

- Combining two small intersections by channelization;
- Installation of traffic signals; and
- Provision of crosswalk and samlor and bicycle crossing which are described in safety measure for S11.

(12) Safety Plan "S17" (Route 205)

(Road type: Roadway; Tangent/Narrowing)

Figure 6.22 indicates the location (KP 1+300-1+700) and the description of safety measures.



Main Countermeasure

- Smooth diminution of lane number

Figure 6.22 Location and Main Countermeasures, Route 205

At this section, it is hard to clarify the characteristics of accidents, because few accidents have been experienced. This section was selected to work out a demonstrative safety plan for the sections where road width suddenly changes from 4 lanes to 2 lanes.

This section is the transition section of carriageway width from four lanes to two lanes and contains the following problems:

- Insufficient transition rate of width; and
- Insufficient provision of markings, especially edge lines.

Safety Measures

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

- Smooth diminution of lane number with wider chevron markings at central part of carriageway;
- Provision of clear lane, edge line markings and deflecting arrows; and
- Installation of warning signs indicating the existence of a sharp reduction of carriageway width ahead.

Chapter 7

EXPERIMENTAL WORKS

Chapter 7 EXPERIMENTAL WORKS

7.1 Objective of Experimental Works

The experimental improvement works in this study, aim at obtaining the information regarding the remedial measures that are to be incorporated into the "Traffic Safety Plan" in Chapter 6. Its major objective is to clarify effectiveness of various safety measures through before-and-after survey of the experimental works and their assessments.

Figure 7.1 indicates the general study flow relating to the experimental works. The experimental works were implemented in February and March 1984. The before-survey for the effectiveness assessment on the experimental works was carried out for 2 months in December 1983 and January 1984, and the after-survey was executed for 2 months in April and May 1984.

Since the scope of the experimental works are, due to budgetary and time constraints, limited in number and variety in terms of remedial measures, the effectiveness assessment on some selected safety works which had been carried out by DOH, was conducted by the Team, to supplement the experimental works.

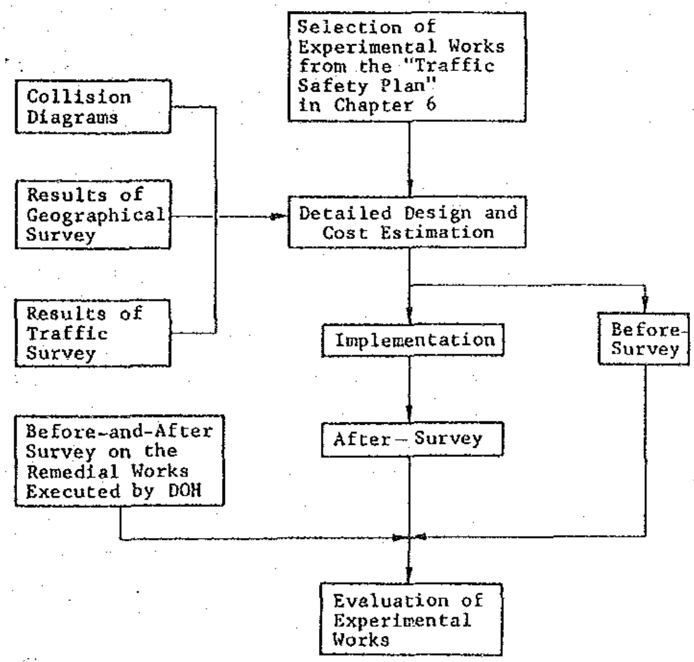


Figure 7.1 Flow of Experimental Works

7.2 Experimental Improvement Works

7.2.1 Selection of Improvement Works

A selection process of experimental works from the remedial measure plans proposed for 17 locations on DOH roads in Chapter 6 can be roughly divided into two stages: i.e. (i) selection of the remedial measures; and (ii) selection of the sites. The criteria established in this sub-section were used collectively for determination of the overall design of the experiments. The criteria are explained in detail in the followng two paragraphs.

(1) Criteria for Selecting Safety Measures

A set of criteria was required for the selection of safety measures, and they were different compared with the criteria for site selection. The following criteria for safety measures make this point clearer.

- The proposed measure is to be potentially effective in reducing the prevailing accidents at the concerned sites.
- It is to be appropriate in terms of the conditions such as traffic volume, and its flow characteristics around the concerned sites.
- It is to be adopted as a common measure within the "Road Safety Planning".
- It is to be applicable to many other similar occasions; in other words, the selected measure is not specific to a concerned site.

(2) Criteria for Site Selection

Upon choosing the work sites, the following points were taken into account.

- Consensus with relevant parties - eg. DOH, local people.
- High accident road sections.
- Relatively high traffic volume, so that the effects of the improvement can be measured with a high certainty.
- The environment surrounding the site is not a special one, so that the results from this experimental improvements hold a certain degree of generality.
- No overlap with the improvement plans by DOH.

Finally, five types of safety mesures shown in Table 7.1 were selected for the experimental works in this study.

Table 7.1 Location and Contents of Experimental Works

Safety * Planning Sect.No.	Route No.	Experimental Works	
	Location (KP)	Safety Measure	Contents
S3	Route 1 (48+000-49+000)	Improvement of Lane Line Marking	Widening Width of Line Marking
S9	Route 306 (2+900-3+200)	Improvement of a Sub-standard Curve by Visual Guidance	- Delineator - Chatter-Bar - Pavement Marking
S10	Route 306 (13+500-14+000)	Safeguard of Pedestrian	Sidewalk - Curb Pedestrian Crossing - Refuge Island - Marking - Warning Sign
S11	Route 336 (2+000-5+000)	Improvement of Turning Traffic by Signalization	Signalization - Signals for Vehicle Traffic - Signals for Pedestrians Channelization - Right-Turn and U-Turn Lanes at Signalized Intersections - Closure of Median Openings - Pedestrian Crossing - Marking
S14	Route 1141 (1+000-1+800)	Intersection Improvement by Channelization	- Channelized Island - Marking

Note ; * The "Safety Planning No" in this Table corresponds to Table 6.25 in Chapter 6.

7.2.2 Details of Experimental Works

The selected works are explained in detail in the following five paragraphs.

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

Most of DOH roads in rural area such as Route 1 are straight roads. On such roads, vehicles tend to run at high speeds and trespass to adjacent lane, and this leads to a serous traffic accidents. A clearer marking of lane lines encourages drivers to confine their vehicles within the driving lane to reduce rear-end and head-on collishion accidents. In this case, 20cm wide lane lines were introduced in place of the standard 10cm wide line on DOH roads.

For one-kilometer section (KP 48+000-49+000) of left carriageway on Route 1, 20cm wide "lane lines" and "edge lines" were painted, but the longitudinal intervals of broken line was same as the DOH standard (4 m solid line, and 8 m interval).

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

DOH roads are usually of acceptable standard, but sub-standard curves can be found at certain locations. DOH has already applied several countermeasures at these locations, but still they seem not to be enough.

In this study, the Team decided to introduce appropriate reflectors and signs that would lead the drivers' eyes effectively to the sharp curves, and would make the driving smooth and safe. "dolineators" were attached directly on to guardrails, and "chatter-bar" tubes inserted into center lines. This experimental improvement was carried out for the section between KP 2+900 and 3+200 on Route 306.

(3) "Safeguard of Pedestrian" (Route 306)

The construction of crosswalk with refuge island, was planned in this study in order to gain an increased safety for pedestrians.

"Refuge island" 20cm high and a 2-meter wide, was constructed at the center part of the crosswalk (see Figure 7.2). The curbs were also placed between carriageways and shoulders to separate pedestrians from the vehicular traffic and to induce pedestrians to the refuge island. The site of this experiment is at the section of KP 13+500 to 14+000 on Route 306. The improvement works were planned after an extensive study of vehicle and pedestrian movements.

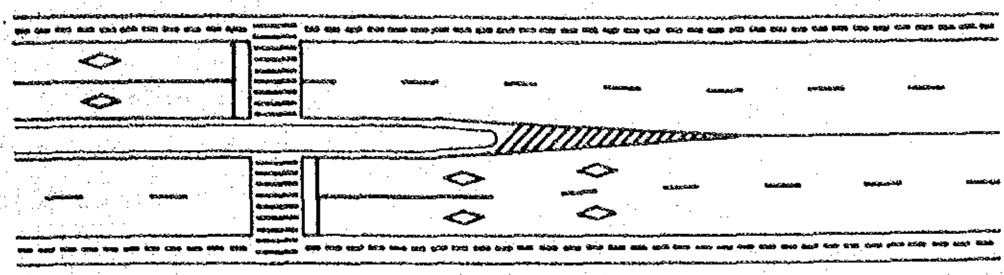


Figure 7.2 An Example of "Safeguard of Pedestrian"

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

The road network in Bangkok is composed of a set of straight roads associated with a number of side streets called "Soi", and many of them are cul-de-sac. The traffic disturbance which results from the vehicles accessing these side streets, is the major cause of frequent collision accidents. Such accidents are caused by sudden vehicle turnings and improper weaving.

The prohibition of turning vehicles by closing open parts of median strips where a number of accidents had taken place, and the introduction of a traffic signal, were planned at some of the intersections to ameliorate the above problems. The improvements were made for the three-kilometer section (KP 2+000 to 5+000) on Route 336. Figure 7.3 presents the locations of the site.

The traffic signals were imported from Japan, and they were set based on Japanese practice. This decision was made to compare the visibility between the Japanese system and Thailand system which generally requires more signals than Japanese one (see Figure 7.4).

An extensive study of vehicle movements around the site area was conducted prior to detailed designs.

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

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

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

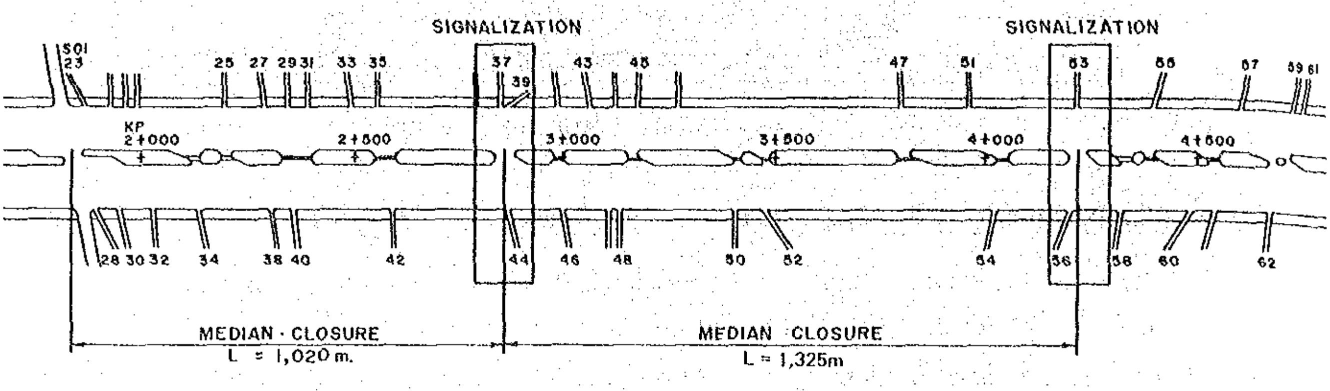


Figure 7.3 Outline of Improvement of Turning Traffic by Signalization

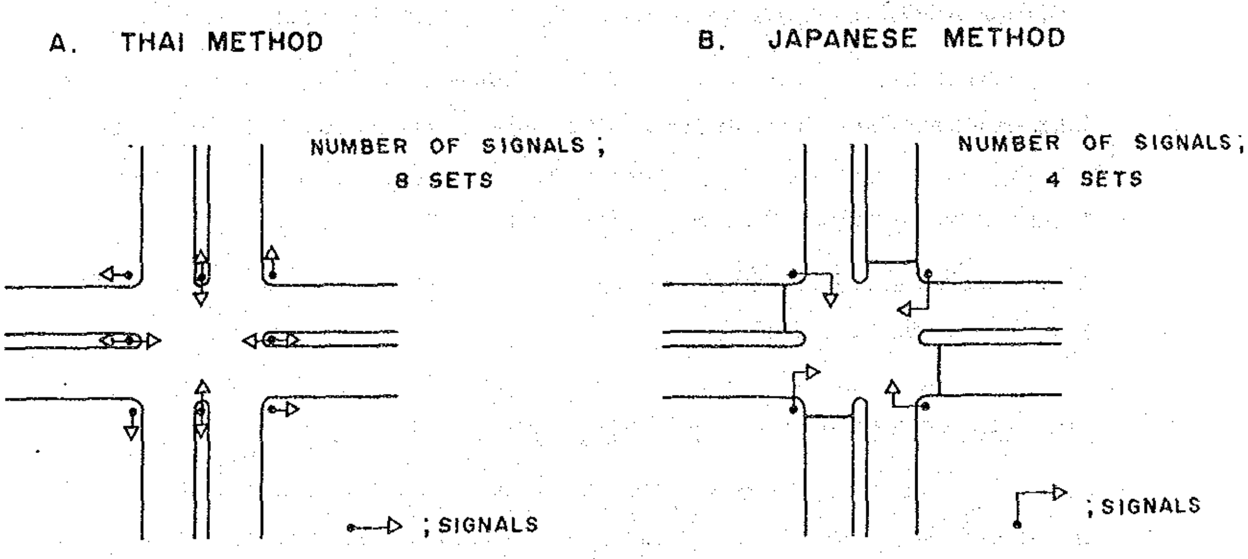


Figure 7.4 Number of Signals Needed at Intersection

7.2.3 Implementation

The experimental improvement works at five sites were implemented in February and March 1984. The estimated quantities of the experimental improvement works are tabulated in Table 7.2.

The works under the responsibility of DOH as shown in Table 7.2 were carried out by its own staff at the highway district offices, while the works on the part of the Team were divided into two contract packages: Experimental Works (I)* and Experimental works (II)* and executed by two local contractors who were selected among those recommended by DOH. The field works were executed under the joint supervision of DOH and the Team.

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* Experimental Work (I) : Georesources Co., Ltd.
  Experimental work (II) : Hiap Hong Co., Ltd.

Table 7.2 Estimated Quantity

Location (Kilopost)	Item	Unit	Actual Quantity
Route 1	Reflectorized Thermoplastic Markings	m^2	467
Route 306 (2+900-3+200)	Reflectorized Thermoplastic Markings	m^2	121
	Furnish and Install Chatter Bars	ea	82
	Furnish and Install Delineator	ea	17
	Raised Bar	LS	-
	Traffic Sign*	ea	9
Route 306 (13+500-14+000)	Roadway Excavation-Unclassified	m^3	24
	Embankment	m^3	20
	Asphaltic Concrete Base, 5cm	m^2	163
	Asphaltic Prime Coat	m^2	1795
	Asphaltic Single Surface Treatment	m^2	1632
	Asphaltic Concrete Surfacing, 5cm	m^2	163
	Concrete Curb, Type A & B	m	420
	Sodding	m^2	101
	Raised Bar	LS	-
	Reflectorized Thermoplastic Markings	m^2	463
	Traffic Sign*	ea	15
Route 336	Roadway Excavation-Unclassified	m^3	216
	Embankment	m^3	37
	Removal of Curb and Gutter	m	339
	Removal of Concrete Pavement	m^2	129
	Subbase	m^3	42
	Reinforced Concrete Pavement	m^2	554
	Concrete Curb	m	349
	Sodding	m^2	92
Route 336	Reflectorized Thermoplastic Markings	m^2	593
	Reflectorized Road Paint Markings	m^2	389
	Traffic Signal for Vehicle Traffic*	ea	9
	Traffic Signal for Pedestrian*	ea	10
	Pole of Signal*	ea	13
	Old Oil Drum**	ea	120
	Traffic Sign*	ea	9
Route 1141	Roadway Excavation-Unclassified	m^3	58
	Removal of Curb and Gutter	m	49
	Subbase	m^3	18
	Aggregate Base	m^3	18
	Asphaltic Prime Coat	m^2	115
	Asphaltic Concrete Surfacing	m^2	115
	Concrete Curb	m	397
	Concrete Slab	m^3	12
	Reflectorized Thermoplastic Markings	m^2	69
	Reflectorized Road Paint Markings	m^2	947
	Traffic Sign*	ea	22
	Chatter-Bar	ea	15

Note; <u>Allotment of Experimental Works</u>
* Material; Team, Installation; DOH
** Material and Installation; DOH
Others Material and Installation; Team

7.3 Effectiveness Assessment

7.3.1 Before-and-After Survey

(1) Objective-and-Procedure of the Survey

The effectiveness assessment under this study is to clarify the experimental works' effect on traffic safety. The typical approach to the effectiveness assessment is to compare traffic accidente between before and after implementation of planned improvements. The comparison were made as to number, severity, causes of accidents occurred during the survey periods.

In this study, the Team followed, in principle, the above general practice of assessment. As a traffic accident is an incidental phenomenon, to obtain statistically enough data, at least one year survey period both for before and after is said to be necessary. Under this experimental works' scheme, the Team was obliged to conduct only two-month period survey each for before and after.

Since the sites for the experimental works were selected from the road sections where frequent occurence of traffic accidents was experienced, some significant changes in traffic accidents were expected to appear during the relatively short survey period after completion of planned remedial works.

The Team, however, set out a supplement survey plan to see any difference, between before and after, in traffic behaviours which may contribute to a potential accient, if a thing goes wrong. On the traffic lbehaviour survey, the speed, placement of wheel and headway were measured with video tape recorder and even oscillograph.

Furthermore, the Team carried out another supplement survey to obtain the user opinion regarding the experimental works. This user opinion survey was executed through interviews at the improvement sites after the implementation of improvement works.

(2) Traffic Accident Survey

The site survey on traffic accident was conducted with views to obtain full and detailed data for 2 months period* both for before and after the

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* Although data for longer period for before are available, the 2 month-period survey has been aranged because the survey for after is available only for 2 months.

implementation of the improvement works. The accident survey was conducted at site for 12 hours in the day time, from 7:00 a.m. through 7:00 p.m. Appendix 7.1 shows the survey form used in this survey.

The before survey was carried out for 2 months in December 1983 and January 1984. The after survey was carried out for 2 months in April and May 1984. Appendix 7.2 shows the results of the traffic accident survey during these 2 month periods before and after the implementation, and the summary of the results is shown in Table 7.3.

(3) Traffic Behaviour Survey

It is an effective and a practical approach to evaluate the experimental works, based on the accident occurred for a fixed period of time before and after their implementation. However, in this study as mentioned earlier, a possible period for data gathering is as short as 2 months and seems insufficient to assess the effectiveness of the experimental works.

The Team, therefore, decided to undertake the traffic behavior surveys for the both periods before and after the implementation of the improvement works, to supplement the traffic accident data.

Since the experimental works at the five sites were planned and designed with different objectives, the survey items vary with experimental sites. The following are major survey items.

- running speed;
- headway;
- placement of travelling vehicle;
- pedestrians movement and its influence on traffic movements.

The set of survey items for each experimental work site are indicated in the "Survey Items for Traffic Behaviour Survey" in Appendix 7.3.

The survey hours for the traffic behaviour were set out in a manner to cover the period of the day in which the most accident are expected to occur according to the past accident records. In Appedix 7.3, the survey period for each experimental work site is shown.

To supplement an effectiveness assessment on the experimental works by direct comparison fo traffic accident data between before and after their

Table 7.3 Summary of Traffic Accident Survey

Improvement Type	Survey Area		Traffic Volume	Number of Accident			Number of Fatalities			Number of Injuries			Remarks
	Route	Kilometer Post		Before	After	Reduction Rate	Before	After	Reduction Rate	Before	After	Reduction Rate	
Improvement of Lane Line Marking	1	48+000-49+000	9,600	5	3	0.40	0	0	-	0	0	-	Over Speed Limit; Before 2, After 0 Rear End Collision; Before 3, After 1
Improvement of a Sub-standard Curve by Visual Guidance	306	2+900-3+200	15,700	6	3	0.50	0	0	-	7	2	0.57	Over Speed Limit; Before 2, After 0 Off Carriageway; Before 3, After 1
Safeguard of Pedestrian	306	13+500-14+000	17,700	6	2	0.67	0	0	-	5	0	1.00	Vehicle VS Pedestrian; Before 2, After 0
Improvement of Turning Traffic by Signalization	336	Soi 39 Soi 53	34,600	31	16	0.48	0	0	-	5	2	0.60	Immediate Crossing; Before 8, After 3 Rear End Collision Before 12, After 17
Intersection Improvement by Channelization	1141	1+000-1+450	9,200	11	5	0.55	0	0	-	8	3	0.63	Over Speed Limit; Before 6, After 1 Off Carriageway; Before 6, After 1

implementation, the Team analyses the data on the traffic behaviours quantitatively. The results of the traffic behaviour survey are shown in Appendix 7.4.

Table 7.4 shows the summary of results of analysis for placement of travelling vehicle and pedestrian movement. Conflicts in the Table 7.4 means that the numbers of road users' dangerous movement which potentially lead to traffic accidents. Table 7.5 shows the summary of observation result on running speed.

Table 7.4 Summary of Traffic Behaviour Survey (Conflict)

Improvement Type	Survey Area		Sample Number	Number of Conflict		
	Route	Kilometer Post		Before	After	Reduction Rate
Improvement of Lane Line Marking	1	48+000-49+000	300	92 (31%)	35 (12%)	0.62
Improvement of a Sub-standard Curve by Visual Guidance	306	2+900-3+200	300	131 (44%)	54 (18%)	0.59
Safeguard of Pedestrian	306	13+500-14+000-	300 (Pedes-trian)	44 (15%)	23 (8%)	0.48
Improvement of Turning Traffic by Signalization	336	Soi 39 Soi 53	Analysis period : 2 hours	66	13	0.80
Intersection Improvement by Channelization	1141	1+000-1+450	300	200 (67%)	99 (33%)	0.51

(4) <u>User Opinion Survey</u>

The user opinion survey, which was carried out, after the implementation of improvement works, aims at obtaining the supporting data for the effectiveness study.

Table 7.5 Summary of Traffic Behaviour Survey (Running Speed)

Improvement Type	Survey Area		Traffic Volume	Direction	Average Speed			Standard Deviation		
	Route	Kilometer Post			Before	After	Reduction Rate	Before	After	Reduction Rate
Improvement of Lane Line Marking	1	48+000-49+000	9,600	From Bangkok	60.0	59.1	0.02	16.4	11.5	0.30
Improvement of a Sub-standard Curve by Visual Guidance	306	2+900-3+200	15,700	To Rama 6 Bridge	46.7	51.3	-0.10	8.7	9.9	-0.14
				From Rama 6 Bridge	44.9	47.3	-0.05	12.8	6.1	0.52
Safeguard of Pedestrian	306	13+500-14+000	17,700	From Bangkok	49.4	40.7	0.18	15.1	12.0	0.21
				To Bangkok	53.5	57.4	-0.07	15.2	14.8	0.03
Improvement of Turning Traffic by Signalization	336	Soi 39	34,600	To Bangkapi	45.6	32.2	0.29	12.3	8.2	0.33
				From Bangkapi	50.9	37.2	0.27	12.9	10.9	0.16
		Soi 53		To Bangkapi	48.4	35.5	0.27	15.7	11.6	0.26
				From Bangkapi	46.3	38.7	0.16	15.7	10.8	0.31
Intersection Improvement by Channelization	1141	1+000-1+450	9,200	From Airport	44.3	43.8	0.01	9.7	6.8	0.30
				To Airport	42.4	42.7	-0.01	7.4	7.4	0.00

Since the experimental works at the five sites were planned and designed with different objective, the survey items vary among the experimental sites. The following are major survey items;

- opinion on improvement works
- Driving situation (for drivers)
- Crossing situation (for pedestrian)

The interview survey was conducted at the five improvement work sites for 2 months in April and May 1984. The results of data compilation of the survey are shown in Appendix 7.5. The summary of the results is shown in Table 7.6.

Table 7.6 Summary of User Opinion Survey

Improvement Type	Survey Area		Sample Number	Improvement Works	
	Route	(Kilometer Post)		Good	Bad
Improvement of Lane Line Marking	1	48+000-49+000	240	88%	12%
Improvement of a Sub-standard Curve by Visual Guidance	306	2+900-3+200	303	100%	0%
Safeguard of Pedestrian	306	13+500-14+000	(381)	(95%)	(5%)
Improvement of Turning Traffic by Signalization	336	Soi 39 Soi 53	455 (560)	57% (64%)	43% (36%)
Intersection Improvement by Channelization	1141	1+000-1+450	106	72%	28%

Note ; ( ) : Pedestrian

7.3.2 Evaluation by Experimental Work Site

This paragraph evaluates each experimental work based on the result of traffic accident survey, traffic behaviour survey and use opinion survey carried out before and after the experimental works. The result of evaluation is explained in detail in the following five paragraphs.

(1) Improvement of Lane Line Marking

This experimental work is to increase visibility of lane line and discourage drivers to trespass onto next lane with wider lane line of 20cm (existing line is only 10cm). The result is as follows.

- According to the result of traffic accident survey, the number of accidents decreased from 5 to 3 (reduction rate 40%). No accidents due to over speed limit occurred, while there were 2 cases before the experiment and the number of rear end collisions decreased from 3 to 1.
- According to the result of traffic behaviour survey, the number of vehicles which were running in the outer lane first and forcibly cut into the inner lane despite of the existence of other vehicles in the lane, decreased from 31% to 12% (reduction rate 62%). However, driving speed remained unchanged.
- According to the result of user opinion survey, 88% of users found this experimental work effective.

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

This experimental work is to delineate sharp curve section with "delineators" and "chatter-bar", to attract the drivers' attention to the sharp curve alignment and to advise them to drive at reasonable speed without trespasing onto opposite lane. The results are as follows.

- According to the result of traffic accident survey, the number of accidents decreased from 6 to 3 in all (reduction rate 50%). The number of off-carriageway accidents has decreased from 3 to 1.
- According to the result of traffic behaviour survey, cutting into inner lane despite the existence of other vehicles has decreased from 44% to 18% (reduction rate 59%). However, driving speed has increased about 10%.

- According to the result of user opinion survey, all users recognized remarkable improvements of the delineation at the sharply curved sections.

(3) Safeguard of Pedestrian

This experimental work is to eliminate pedestrians' random crossing by providing a crosswalk with refuge island at its center. The both side shouders were paved for pedestrian. After the implementation of the experimental works, the random crossing became almost none and all pedestrians cross the 4 lane road only at the crosswalk.

- According to the result of traffic accident suvey, the number of accidents decreased from 6 to 2 (reduction rate 67%). No vehicle vs pedestrian accidents occurred after the improvement works, in spite of 2 accidents before the works.
- According to the result of traffic behaviour survey, improper crossings of carriageway by pedestrians decreased from 15% to 8% (reduction rate 48%). However, it is observed that driving speed in right cariageway has increased by about 7%. This seems to have resulted from the smoother driving attributable to separation of pedestrian from vehicles.
- According to the user opinion survey, 95% of the interviewed appreciated this experimental work.

(4) Improvement of Turning Traffic by Signalization

This experimental works is to introduce a traffic signal at two intersections and to close the open parts of median strips between the two intersections, in order to prevent accidents to be caused by sudden vehicle turning movement and improper weavings. The results of this experimental works are summarized as follows.

- According to the result of traffic accident survey, the number of accidents decreased from 31 to 16 in all (reduction rate 48%). However, the number of rear end collision increased from 12 to 13. The increase of rear-end collisions is a general tendency which is experienced immediately after installation of new traffic signals (until the time when drivers get used to the existence of signals).

- According to the result of traffic behaviour survey, the number of disorderly movements in the major traffic flow decreased to from 66 times to 13 (reduction rate 80%).
- According to the user opinion survey, 57% of the users found the experimental works effective, but the remaining 43% appreciated no improvement.
- The reason of this seems that, as the signals are imported from Japan and they were installed based on Japanese practice, drivers could not be accustomed to them. It is necessary before a final conclusion, that further studies shall be continued for a considerable length of period at the respective sites.

(5) Intersection Improvement by Channelization

This experimental work is to clarify priority of right-of-way at T-intersection where traffic flow on geometrically inferior alignment is higher than superior alignment, by constructing channelizing islands.

At this intersection, right-turning vehicles are supposed to have priority because of its high traffic volume. The following are the results of the before-and-after survey.

- According to the traffic accident survey, the number of accidents decreased from 11 to 5 (reduction rate 55%). The number of accidents due to excessive speed decreased from 6 to 1, and the number of off-carriageway accident decreased from 6 to 1, too.
- According to the result of traffic behaviour survey, the number of disorderly movements occurred in the traffic flow at the intersection decreased from 67% to 33% (reduction rate 51%).
- According to the user opinion survey, 72% of users assessed this experimental work to be effective.

(6) Conclusive Remarks on Experimental Works

The following are conclusive remarks confirmed through the experimental works at the hazardous locations of DOH roads. They are well worth to be incorporated in the future traffic safety planning for DOH roads (summary of the effectiveness assessment of the experimental works are tabulated in Table 7.7).

Table 7.7 Summary of Effectiveness Assessment on Experimental Works

Location KP	Safety Measures	Contents	Accident Reduction Rate(%)	Reduction Rate of Conflicts (%)	Support Rate of User Opinion (%)
Route 1 (48+000-49+000)	Improvement of Lane Line Marking	Widening Width of Line Marking	40	62	88
Route 306 (2+900-3+200)	Improvement of a Sub-standard Curve by Visual Guidance	- Delineator - Chatter-Bar - Pavement Marking	50	59	100
Route 306 (13+500-14+000)	Safeguard of Pedestrian	Sidewalk - Curb Pedestrian Crossing - Refuge Island - Marking - Warning Sign	67	(48)	(95)
Route 336 (2+000-5+000)	Improvement of Turning Traffic by Signalization	Signalization - Signals for Vehicle Traffic - Signals for Pedestrians Channelization - Right-Turn and U-Turn Lanes at Signalized Intersections - Closure of Median Openings - Pedestrian Crossing - Marking	48	80	57 (64)
Route 1141 (1+000-1+800)	Intersection Improvement by Channelization	- Channelized Island - Marking	55	51	72

Note ; ( ) : Pedestrian

a) Widening Width of Line Marking

20cm width of lane line markings and edge line markings for one-kilometer section were found very effective to improve lane visibility and keep orderly traffic flow on tangent section where sometimes disorderly traffic flow with high speed is apt to result in serious accidents. Although the painting cost of lane line markings increases in proportion to their width, the wider lane lines at hazardous sections will compensate higher cost with benefits expected from reduced accidents.

b) Delineator

Delineator with higher reflective uality, which were installed at 8 meters to 24 meters intervals along the outer side of the shoulder, were effective to attract the drivers' attention to the sharp curve and to warn them to drive carefully and safely. Therefore, it is highly recommendable to install delineators at sub-standard curve sections, in accordance with the "Technical Guidelines" of chapter 5 in this report.

The present DOH guide post with its top painted with retroreflective materials, when properly placed, will provide effective visual guidance to drivers.

c) Chatter-bar

Chatter-bars on center line, which were set with intervals of 3 meters at the Surve section and 4 meters at the straight section, were effective in order to restrain vehicles from center line invasion.

Therefore, it is desirable to introduce the chatter-bar, in accoreance with the "Technical Guidelines", at sections where center line invasion by vehicle should be strictly prevented.

d) Refuge Island

Refuge island for crossing pedestrians, which is 20cm high, 2-meter wide and 75-meter long and constructed on 4-lane carriageway without median, was effective to prevent pedestrian accidents while crossing wide roads. Therefore, it is desirable to construct refuge islands at hazardous locations on wide but undivided road with more than 4 lanes, where neither pedestrian signal nor pedestrian overpass will be justified.

It was recognized, however, that there is a possibility to increase vehicle accidents due to the change of road condition. Therefore, adequate countermeasures for the vehicular traffic particularly at and around the tips of refuge island, should be considered so as to inform drivers of the existence of island.

e) Traffic Signal

Traffic signals, horizontal and overhang type, were found as effective as the prevailing traffic signal in Thailand (vertical and posted on pole). The horizontal and overhang type requires generally less number of signal faces and is recognizable from a distance. This type of signals costs less than the vertical type.

The numbers of rear end collision, however, has increased. Installation of two or more signal faces for each approach together with advance warning signs will be able to prevent such collisions.

f) Channelization

Improvement in order to give priority to right-turning vehicles was useful to prevent traffic accident at T intersection. On DOH roads in rural areas, there are many T intersections. At these T intersections, sometimes traffic volume of turning right are more than those of straight traffic. Therefore, it is desirable to introduce this improvement positively at T intersection such as above.

The experimental work at the T intersection on Route 1141 proved very successful to reduce conflicts between the right turn vehicles (major traffic flow) and through vehicles (minor traffic flow).

Where the priority of right of way at an intersection is not clear from the alignment of crossing roads, and the traveled way is wide enough to allow vehicles free movements, channelization by islands are adequate countermeasures to improve traffic safety when it is properly designed.

However, as it is the case with the experimental work, it is recommendable to construct a channelizing islands with temporary meterials (e.g. sand bags) first anf then replace them with permanent materials when found effective.

7.3.3 Effectiveness Assessment for Remedial Works Executed by DOH

In order to supplement the information as to effectiveness assessment, the Team made a survey of traffic accident numbers on road sections where DOH carried out some remedial works between 1979 and 1981. The survey was made for 126 road sections (Appendix 7.6 shows the number of the sections classified by improvement work types).

The traffic accident data in 1978 (the year before remedial works) and 1982 (the year after remedial works) were collected from the DOH traffic accident records. The data contained the number of traffic accidents and casualities, and traffic volume for the above two years.

Table 7.8 shows the survey results for 17 road sections where more than 5 traffic accidents occurred either before or after the implementation of remedial works. The remaining 108 road sections had records of less than 4 traffic accidents and were deleted from the assessment to secure reliability.

Table 7.8 Summary of Effectiveness Assessment on Remedial Works Executed by DOH

Improvement Type	Location (Kilometer Post)	Traffic Volume		No. of Accident			No. of Casualties			Remarks
		Before	After	Before	After	Reduction Rate	Before	After	Reduction Rate	
Shoulder Improvement	Route 3 (81-93)	20,039	18,640	56	28	0.50	75	23	0.69	-Accident at Roadway 54(Before),19(After)
	Route 12 (2-7)	2,060	2,343	5	4	0.20	23	8	0.65	-Accident by Single Vehicle 3(Before), 0(After)
	Route 323 (101-126)	5,067	5,799	12	4	0.66	21	8	0.62	-Accident at Roadway 12(Before), 4(After)
	Total			73	36	0.51	119	39	0.67	
Overlay	Route 1 (126-129)	3,512	3,578	13	11	0.15	7	10	-0.43	
	Route 1 (65-108)	11,983	12,630	118	115	0.03	130	159	-0.22	-Vehicle and Vehicle Accident 14(Before),57(After)
	Route 2 (107-144)	7,064	8,168	80	96	-0.20	124	265	-1.14	-Vehicle and Vehicle Accident 26(Before),52(After)
	Route 108 (4-29)	3,815	5,437	5	4	0.20	14	4	0.71	-Accident Caused by Improper Passing 0(Before),4(After)
	Route 304 (38-77)	5,340	4,808	8	16	-1.00	12	68	4.67	
	Total			224	242	-0.08	287	506	-0.76	
Seal Coat	Route 1 (203-214)	3,498	3,609	1	8	-7.00	1	19	-18.00	-No.of Heavy Trucks Involved 1(Before). 14(After)
	Route 2 (180-194)	5,372	5,997	4	9	-1.25	11	25	-1.27	-Accident by Single Vehicle 2(Before), 7(After)
	Route 3 (356-400)	3,042	3,490	14	0	-	30	0	-	-Accident Caused by Speeding 8(Before), 0(After)
	Route 24 (0-20)	2,282	3,313	3	5	-0.67	5	18	-2.60	
	Route 304 (3-16)	8,220	4,630	0	5	-	0	52	-	
	Total			22	27	-0.23	47	114	-1.43	
Patching	Route 11 (66-79)	3,531	3,763	11	2	0.82	31	2	0.94	-Accident by Passenger Car 5(Before), 1(After)
	Route 311 (3-30)	1,567	851	6	1	0.83	43	0	-	
	Route 315 (37-48)	3,881	3,983	15	2	0.87	17	5	0.71	-Accident at Roadway 14(Before),1(After)
	Route 324 (6-23)	1,871	1,245	6	1	0.83	16	16	0	
	Total			38	6	0.84	107	23	0.79	

7.4 Accident Reduction Rates by Safety Device

Although many countermeasures have been executed in the past to prevent the traffic accidents, it is difficult to quantify their effects because the effects of accident prevention varies largely depending on the place of execution and circumstances.

However, a number of researches have already been carried out in Japan and other countries and there are many literatures on traffic safety countermeasures. Form those literatures as well as experimental works in this study it is possible to grasp quantatively the degree of magnitude of effectiveness of traffic safety countermeasures. The objective of this section is to quantify the effects of accident prevention by each traffic safety device which shall be incorporated in the information for planning master plan in Chapter 8. However, the accident reduction rates in the following paragraphs do not guarantee the effectiveness of each safety device but should be interpreted as general information applicable to macroscopic analyses.

Table 7.9 to 7.10 show the accident reduction rates by each traffic safety device for roadway and intersection, respectively. Among these safety devices, the reduction rates for the followings were decided with reference to the results of experimental works carried out in this study.

- Refuge island
- Visual guidance

And the rates of the following were decided with reference to the data of remedial works executed by DOH.

- Improvement of surface
- Shoulder treatment

The reduction rates of the devices other than the above have been decided with reference to the results of the researches which seemed to be comprehensive and objective. Most of data referred to, are the results of the researches in Japan, but when deciding the rates, the data of other countries have also been taken into consideration. Appendix 7.7 is the summary of main data which have been referred to.

It should be noticed that the reduciton rates obtained from the researches in Japan and other countries were attained not only with traffic safety devices but in association with strict law enforcement and road users' education.

Table 7.9 Accident Reduction Rates by Safety Device: (Roadway)

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

Table 7.10 Accident Reduction Rates by Safety Device (Intersection)

Safety Devices	Reduction Rate of Number of Accident	Remarks
Traffic Signal	50	Experimental Works
Lighting	30	
Channelization	50	

Chapter 8

INFORMATION FOR MASTER PLAN

Chapter 8 INFORMATION FOR MASTER PLAN

8.1 Introduction

Traffic accidents have long been regarded as the problem of major concern to both the public and traffic safety executing agencies in every country. In Thailand, as indicated in previous chapters, number of vehicles has shown quite a high increase in recent years. In proportion to the high increase in number of vehicles, road traffic accidents have also increased, in spite of various safety measures taken by the agencies concerned.

Traffic accident will give very severe adverse impact to the life of the general public as well as to national economy by means of casualties and property damage. In recent years, the number of casualties by traffic accident exceeds the total number of people suffering from contagious diseases in Thailand.

The traffic accident problem should be solved by combination of various countermeasures as discussed in the next sub-section. This chapter will, however, focus its efforts to countermeasures from the approaches of road improvement and safety devices.

Since the traffic accidents are complex and their solution requires ceaseless efforts, they should be solved based upon realistic and long term programs, together with sound engineering expertises.

In the preceding chapters, the engineering subjects regarding traffic safety are discussed in detail. They are data analysis, method for identification of hazardous locations, technical guidelines for safety planning. These are, in particular, essential to plan out specific remedial work at a given location as well as long term plans.

This chapter, therefore, mainly aims at presenting information which may contribute to preparation of long term plan for traffic safety on DOH roads from engineering approaches.

Besides the general remarks as to the need of comprehensive safety measures, and the current traffic safety policy in Thailand, contained in the information are;

- a method for development of long term plan,
- case study of long term plan, and
- a methodology for preparing a medium term plan based on a long term plan.

8.1.1 Need of Comprehensive Safety Measures

(1) Promotion 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 realized and accomplished when the undermentioned three measures would act on in complete harmony.

a) Creation of adequate environmental conditions to the road traffic from engineering viewpoint, like improvement of safety devices.

b) Popularization of traffic safety consciousness and observance of the traffic rules and laws among the general public, through training of driver and education of children and through safety campaign to the general public.

c) Intensive and extensive enforcement of traffic laws and ordinances by the traffic police.

Moreover, for the effective implementation of above measures, it is indispensable that all governmental agencies concerned should have close coordination among them for promotion of safety improvement programmes.

(2) Current Traffic Safety Policy in Thailand

In the Fifth National Economic and Social Development Plan (1982 - 1986), the Government of Thailand sets forth following targets to realize steady reduction of traffic accidents which have been increasing in proportion to the expansion of road network and increase of traffic volume.

a) To reduce the rate of road accident by three (3) percent per annum.

b) To reduce the mortality rate by one (1) percent per annum.

The National Safety Council also issued the National Plan for Prevention and Control of Road Traffic Accident in April, 1982. This Plan pointed out several existing problems to be solved, namely the problem on road user, vehicle itself, road and transportation system, and traffic environment.

In the Fifth National Economic and Social Development Plan, in order to resolve the above problems, following policy guidelines were set up.

a) Strict enforcement of traffic laws will be under-taken.

b) Research on traffic accidents will be promoted, together with creating a sense of responsibility among government officials and road users.

c) Road accident will be prevented through proper engineering design of roads.

d) 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 cases.

On the other hand, DOH formulated the highway development plan within the framework of the Fifth Planand has been undertaking an important role in the implementation of the road traffic safety improvement as a part of his road maintenance works. In terms of the budget of remedy works for traffic safety in 1982, the expenditure in DOH was 17.2 million Baht, which is about 18 percent up over the previous year and stands at 1.14 percent of the budget allocated for the road maintenance. It is expected that the budget to be allocated to the traffic safety in DOH shall be considerably increased to meet with the requirements.

(3) Approach from Engineering Improvement

The foregoings refer to the discussion on the needs of comprehensive safety measures to reduce road traffic accident effectively.

In this study, however, traffic safety plan is discussed mainly from engineering approaches with an assumption that enforcement of traffic law and training and education needed for traffic safety are to be coordinated by the respective agencies concerned.

Since the traffic accident problem should be persistently tackled based on a well developed and realistic programs, the information for DOH to prepare traffic safety master plans for engineering approaches is presented in the following sections.

8.1.2 Definition of Master Plan in the Study

(1) Basic Concept for Master Plan

There are no established definitions as to master plan for the traffic safety. The definitions vary with the purposes of plans. In a broad sense, the master plan for the road traffic safety is not only to formulate the direct remedy works for safety, but also shall include the improvement of road networks, major construction works like grade-separated intersections, overlaid pavement, etc.

In this report, however, the scope of a master plan is clearly defined to the safety remedy works which are to be implemented on the existing roads. Moreover, this report does not aim to present a master plan itself, but the information needed for formulation of a master plan and indication of the process to work out a master plan through case study. From the planning period, the master plan can be classified into two types of plans, i.e. a long term plan and medium term plan in accordance with its main purpose.

(2) Long Term Plan

A long term plan will be developed so as to determine the basic policy to traffic safety on entire DOH roads, taking into consideration of the financial resources and the effects of investment from the engineering viewpoint.

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

(3) Medium Term Plan

A medium term plan is worked out so as to identify highly hazardous locations from the long term plan, which need for more urgent implementation of the traffic safety measures, and to select the proper measures for the hazardous locations. In the medium term plan, a realistic investment plan shall be also set forth, since it has a nature of action plan.

As the medium term plan requires substantial amount of detailed data including field information at the hazardous locations and possible investment amount as well as the government policy, it could be prepared only by those who have got the best access to the necessary information and data.

In the report, therefore, only the concept to select hazardous locations with higher priority is introduced.

8.2 Method for Development of Long Term Plan

8.2.1 Procedure

There are two basic approaches for DOH to formulate a long term plan for traffic safety from road engineering practices. The one is to mobilize the district engineers and let them find out hazardous locations and work out adequate remedy work plans for the selected locations together with quantities of the required works and cost estimations. Then, at the headquarters all remedy work plans throughout the country are to be integrated to a certain form of long term plan. Thus made long term plan could be directly put into practice, since it consists of specific remedy work plans at the specific hazardous locations.

This approach, however, requires engineers well experienced in traffic safety, otherwise the plans prepared by them will not be reliable at all. Another problem with this approach is that the individual remedy work plans are inclined to be worked out subjectively by the respective engineers and, thus the final long term plan is rather subjective and lack in uniformity both in accuracy and the degree of improvements, even if the plans were made based on detailed guideline issued by the headquarters.

Moreover, a long term plan, by its nature, does not necessarily need to locate all hazardous locations and specify detailed remedy work plans to the locations, but to indicate the approximate number of hazardous locations with the breakdown of road pattern (intersection, roadway and lane number) to prepare remedy works and traffic volume which are minimum information to estimate implementation cost and its effect in accident reduction.

On the other hand, the other approach is to prepare a long term plan macroscopically and systematically at the headquarters utilizing the data from the district offices. In this approach, hazardous locations could be screened by the identification methods (for detail, see Chapter 4), and remedy works for each hazardous location, could be automatically worked out, applying a mix of standardized traffic safety measures applicable to classified road patterns.

This approach will be more effective when utilized in combination with the former approach, that is, firstly to prepare a long term plan macroscopically, then to seek for comments on the plan from the district engineers in a general manner, and to finalize it with adequate revisions if found necessary to do so.

A process to formulate a long term plan macroscopically is shown in Figure 8.1, and based on the flow chart, formulation steps are described as follows:

a) to select hazardous road locations by indentification methods,

b) to classify the selected hazardous locations by road patterns (intersection-roadway, number of lane, traffic volume, and land use if possible)

c) to prepare standardized remedy work plans corresponding to the above road patterns (mix of prototype plans),

d) to apply the mix of prototype plans to the locations as classified by road patterns, and to map out a macroscopic remedy work plan,

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

f) meanwhile, to determine accident reduction rate by the road patterns (due to the limitation of available information and data in this study, the accident reduction rates are unavoidably a guess work to some extent, and should not be interpreted as guarantee of the effectiveness of the planned remedy works). The accident rates for the mix of the prototype plans shall be determined based on the effectiveness assessment on each safety device which are discussed in Chapter 7.

g) to forecast accident reduction (number of accident, casualty-fatality, injury) from the macroscopic remedy work plan and the above accident reduction rates, and

h) to evaluate the <u>macroscopic remedy work plan</u> from the viewpoint of the available financial resources and if necessary from economic viability such as B-C, B/C ratio, etc.

For the evaluation of effectiveness on the long term 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 long term plan from the other factors such as national interest and humanitarianism.

For the formulation of a long term plan, it is also important to verify the quantity of the existing safety devices and to work out the budget needed for replacement, repair and maintenance of the safety devices.

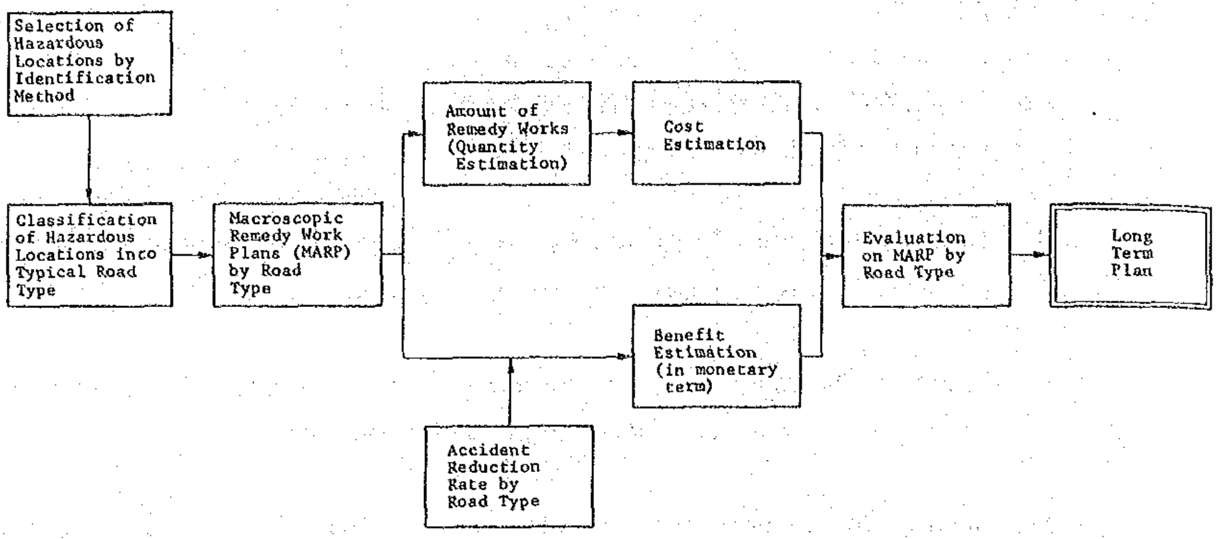

Figure 8.1 Process to Formulate a Long Term Plan

8.2.2 Determination of Locations to be Remedied

The hazardous road locations for the program of a long term plan are to be determined by the identification methods which are discussed in Chapter 4. The identification methods are only applicable to the roads where traffic accident and traffic volume data are available. At present, periodic traffic accident data are available only for the roads in the HPD area (about 15,700 km) where HPD is responsible for investigation.

For the remaining DOH roads (28,300 km), no accident data except those investigated by DOH are available. Therefore, to prepare a complete master plan for the entire DOH roads, in the future, data collection for the accidents on the roads in the LPs is prerequisite. In this study, the Study Team collected accident data for the roads in the LPs area in 6 Changwats to supplement the HPD's data which mainly cover the traffic accidents on rural roads.

8.2.3 Macroscopic Remedy Work Plan

(1) Standardized Remedy Works

To prepare the mix of the standardized remedy work plans, the hazardous road locations shall be classified into a certain number of road patterns, for each of which a set of safety devices can be applicable effectively.

The road patterns are to be classified taking into account the traffic volume, number of carriageway and land use in the case of intersections, which are main road factors to accidents. In the case of roadways, the road patterns are classified by the element of the lane number, alignment and land use. Since the number of lane represents traffic volumes more or less, traffic volume may not necessarily need to be taken into account.

The standardized remedy work plan for each of the road patterns can be prepared based on the various information contained in the foregoing chapters. The remedy work plan shall include quantity of remedy work by devices, estimated cost and anticipated accident reduction rate.

(2) Maintenance of Safety Devices

The safety devices are effective when properly placed, operated and maintained. For formulation of a long term plan, besides the initial costs for the installation of safety devices or road improvements, the operation and maintenance expenditures also should be incorporated in the plan.

8.2.4 Evaluation

(1) Evaluation Method

The evaluation of a traffic safety plan is a complicated and controversial issue. The complexity arises mainly from the difficulties to estimate the effectiveness of safety remedy works, while assessment on value of human lives of traffic casualties is always controversial, because there is a sentiment to criticise putting a value on a human life.

However, when available fund for traffic safety is limited, an evaluation on a traffic safety plan is unavoidable to attain the best use of allocated budgets. Although there are no universal evaluation methods, undermentioned are possible and practical methods to evaluate a safety plan, namely;

- Reduction in Number of Accident:

  In this method, the effectiveness is evaluated either on the number of traffic accident or related number of casualty to be reduced by implementation of the safety plans in question.

  It is the simplest way of effectiveness evaluation, and the greater the number in reduction, the more effective the plan is.

- Cost-Effectiveness Evaluation

  In this method, the evaluation is based on the reduction rate of traffic accident or casualty against a certain unit cost required for implementation of the safety plan. In other words, the evaluation is to be made on how many traffic accidents or casualties are to be reduced against a certain unit cost needed for the safety plan, and the greater the reduction rate, the better the plan is.

- Benefit/Cost Evaluation

  In this method, the effectiveness evaluation is to be made with the comparison of the expected benefits to be derived from the implementation of the safety plan and the costs to be required for the said plan. For application of this method, the benefits stand for the monetary values of the saved life, prevented injury and property prevented from damage attributed to the traffic accident. The effectiveness in this method is judged by the value of the net benefits (total benefits-total costs) and benefits/cost ratio.

For effectiveness evaluation of the long term safety plan practised in the case study to be followed, aforesaid benefit/cost evaluation method is adopted, because it is one of the most objective evaluation methods and will provide decision makers with concrete and clearcut information quantitatively.

(2) <u>Investment Amount</u>

The estimation of the total budget for the proposed long term safety plan shall consist of the following:

a. Cost for installation of the safety devices

b. Maintenance and operation expenses

Although the benefit/cost evaluation method seem. proper one from economical analysis point of view, it is to be pointed out that in conjunction with the effectiveness evaluation, the safety plan in question shall be reviewed and cross-checked with the following aspects;

a) Whether the safety plan is within the framework of the overall socio-economic development plan of the country and in line with the traffic accident prevention policy and strategy set forth in the national plan.

b) Whether the scale of the costs required for the implementation against the total budget of the responsible executing authority, availability of the funds and the implementation schedule.

8.2.5 Long Term Plan

A long term plan among others shall consist of:

- target of the plan (accident reduction);
- amount of remedy work by type of device; and
- financial need and resources.

(1) Target

In formulating a long term plan for traffic safety, the first step is to set up a target as to what extent the prevailing traffic accidents are to be reduced by application of the planned safety measures. It can be said that the more the safety measures are implemented, the less the traffic accident occur, but the proportional effect can not be expected. It is the general rule that the greater the target is, the more the cost and expenses are needed for implementation of the plan.

Besides, it is to be said that there is not universal standard for evaluation of the effectiveness of the safety plan. In this context, the target shall be set up in conjunction with the overall policy and strategy for the road traffic safety of the country. Also, in line with such policy and strategy, the target for the specific safety plan such as to pedestrians and motorcyclists is to be set up.

(2) Amount of Remedy Work by Type of Devices

In the preparation work for a long term plan, it is necessary to grasp the total work volume of each safety measure or device as described previously.

When compilation is made for each safety device out of the standardized safety measure mix for each classified roadway or intersection, the total quantity or each device under the plan can be obtained.

(3) Financial Need and Resources

The financial need to implement a long term plan can be estimated from the above amount of remedy works by type of devices and prevailing unit cost foreach remedy works. Thus, the estimated financial need for the proposed long term plan or in other words, the amount of investment to achieve the above target shall be endorsed by sound financial resources. Therefore, to finalize a long term safety plan, financial resources for the plan should be reviewed in-depth and secured for. In this study, however, this aspect will not be discussed, because it is an internal issue of the concerned governments.

8.3 Case Study for Long Term Plan

8.3.1 Objectives of Case Study

There are various methods to establish a long term plan for road traffic safety and in the preceding sections, a macroscopical method to prepare a long term plan is presented. In this section, a case study for DOH roads, applying this method has been undertaken. The general flow chart for the case study is shown in Figure 8.2. To work out nationwide road traffic safety programs, besides national policy, a bulk of information and data, and judgements by concerned engineers and officials are needed. The case study in this study has been carried out with limited data and information and the study is also based on a number of judgements and assumptions made by the Team. Therefore, the objective of the case study is to demonstrate the macroscopical method but not to propose a conclusive long term plan.

8.3.2 Determination of Locations to be Remedied

In the long term plan of the case study, the road locations which need safety remedy works, are selected by the identification methods which have been established in Chapter 4 in such a way to select high risk locations in terms of traffic accidents.

The identification methods require traffic accident data and traffic volume data, which are available only for the roads in the HPD area at the headquarters of DOH. For the roads in the LPs area, no necessary data are virtually made available except for the roads in 6 Changwats where the Team conducted a supplemental data collection from the original traffic accident records at local police stations (see Chapter 3 for further details).

According to various information such as the number of registered vehicles and the ratio of total accidents on all kinds of highways in the 6 Changwats against the total of the whole nation, the traffic accidents on the DOH roads in the LPs area in the 6 Changwats can be assumed to have a share of approximately 20 percent to the total accidents on all DOH roads in the whole LPs area in the country (see Appendix 8.1). Thus, the number of the road locations in the LPs area which need safety remedy works has been estimated as follows;

- to determine hazardous locations for the roads in the LPs area in the 6 Changwats.
- to expand the above results by multiplying by 5 (because the traffic accidents in the 6 Changwats are assumed to account for 20% of the whole country as aforementioned).

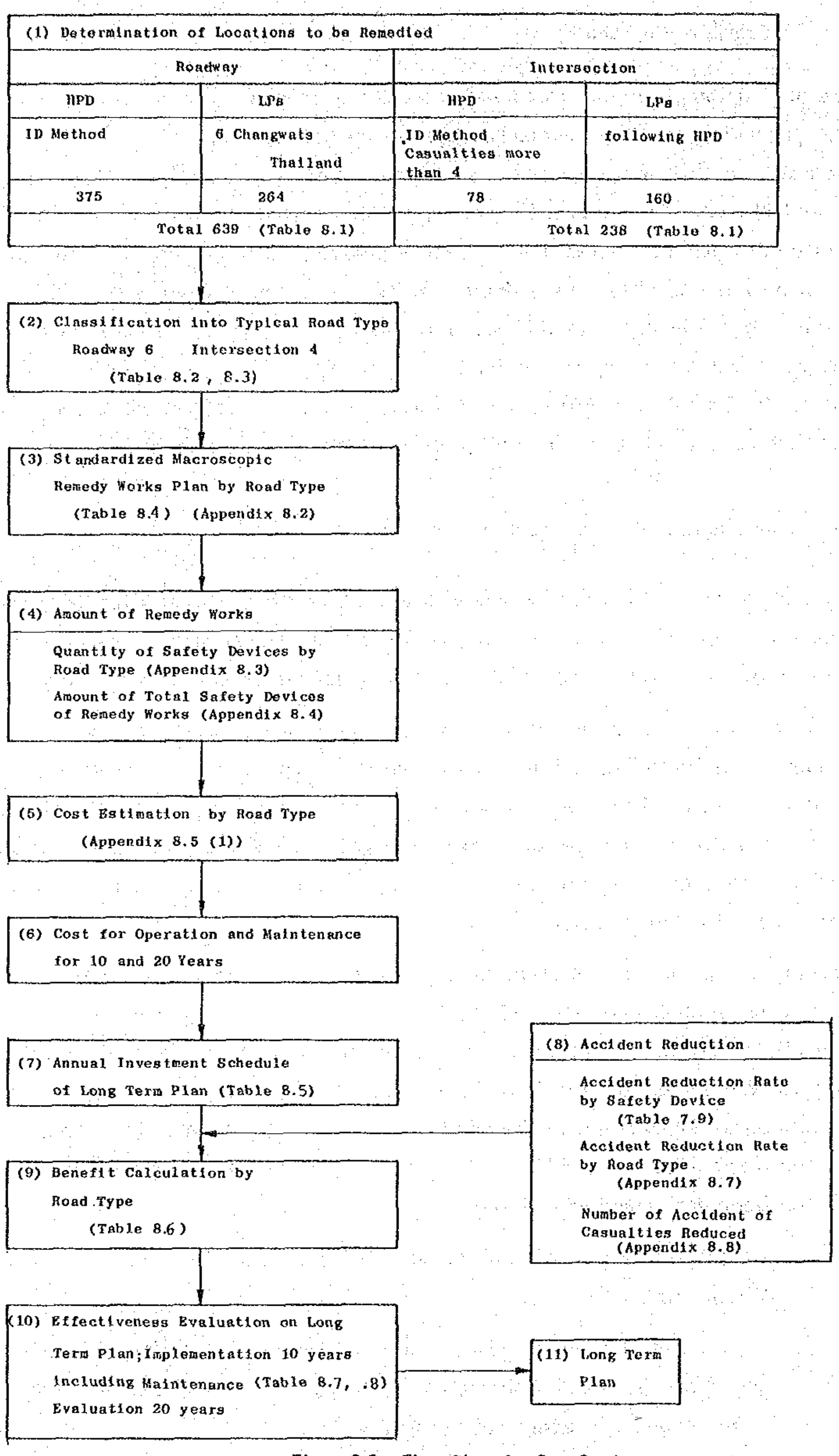

Figure 8.2 Flow Chart for Case Study

In the case study, another assumption to the effect that the accident patterns in the road networks on all roads in the LPs area follow those of the 6 Changwats, also was made.

The road locations to be remedied have been determined separately for roadways (road sections between intersections) and intersections.

(1) Roadway

For the roads in the HPD area, 375 sections (unit length of section is 3Km* (see Chapter 4)) have been found hazardous and require remedy works. For the roads in the LPs area, 264 sections have been assumed to be hazardous.

In total, 639 locations are assumed hazardous on roadway, and Table 8.1 summarizes the number of hazardous sections and the number of casualties at the sections, which should be incorporated in a long term plan.

Table 8.1 Number of Hazardous Locations

Area	Road Length (Km)	Roadway		Intersection	
		Number of Sections to be Remedied	Number of Casualties	Number of Intersections to be Remedied	Number of Casualties
HPD area	15,700	375	4,470	78	341
LPs area	28,300	264	3,050	160	991
Total	44,000	639	7,520	238	1,332

(2) Intersection

For the roads in the HPD area, 78 intersections have been found hazardous by the identification method in Chapter 4 which selects intersections where traffic accidents involving more than 4 casualties in a year occurred.

For the roads in the LPs area, firstly hazardous intersections in the 6 Changwats were selected by the identification method and the total number of

* The hazardous section does not imply that the whole length of road in the section needs safety remedy works. In the case study, safety remedy work for each hazardous section is to be planned for 1 Km, taking into account the findings from the questionnaires to district engineers which reveal that an average road length at one hazardous location is about 1 Km.

hazardous intersection has been estimated by expanding the selection result of the 6 Changwats into the whole roads in the LPs area in the same way as the roadways. Accordingly, 160 intersections in LPs area have been assumed hazardous, and in all 238 intersections were selected as hazardous (Table 8.1).

8.3.3 Macroscopic Remedy Work Plan

(1) Classification by Road Types

To work out a long term plan for the hazardous locations (639 roadway sections and 238 intersections) systematically and macroscopically, the hazardous roadway sections have been classified into 6 typical road types by road conditions, and 4 typical types for the hazardous intersections.

The roadway sections have firstly been classified into 3 types, that is, divided 4-lane road, undivided 4-lane road and 2-lane road. Then, each type has been divided into two (2) by horizontal alignment, i.e., tangent and curve. The intersections have been classified into 3 types by number of lanes of crossing roads (4-lane x 4-lane, 4-lane x 2-lane, and 2-lane x 2-lane). The intersections of 2-lane x 2-lane type has been further divided into two(2) by traffic volume (high volume and low volume).

The road type classification, the number of hazardous locations and casualties by classified road type are summarized in Table 8.2 and 8.3.

Table 8.2 Road Type Classification; Roadway

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

*; Sections which have curve segments within each hazardous section

Table 8.3 Road Type Classification; Intersection

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

(2) Standardized Safety Measures for Classified Road Types

Based on the analyses of accident features and the information presented in the preceding chapters in this report, a set of standardized safety measures for macroscopical remedy work plan has been prepared for each type of classified roads and summarized in Table 8.4, while the schematic drawings of the standardized safety measures are shown in Appendix 8.2.

The figures on the shoulders of the dotted circles in Table 8.4 indicate the rates (in percentage) of actual installation of respective safety devices against the total hazardous locations for each road type. For example, in the case of 4-lane divided tangent road type (RT-1), at 15% of 98 hazardous road sections, guardfence shall be placed.

The figure of 15% in this case was estimated on the ground that at about 33 sections (about 30%) out of the 115 hazardous road sections (tangent 98, curve 17), off-carriageway accidents occurred, and on the assumption that the most curve sections are prone to off-carriageway accident. This leads to presumption that off-carriageway accidents were experienced at 17 curve sections and 16 tangent sections which are about 15% of the total tangent sections (98). The other figures for various safety devices in the table were estimated in the same manner as the case of guardfence.

The quantity of the safety devices by road type are tabulated in Appendix 8.3.

(3) Amount of Remedy Works by Safety Devices

The total amount of safety devices for remedy works for the hazardous road locations under the long term plan has been quantified by using Table 8.2 and

Table 8.4 Standardized Safety Measure

Road Type / Safety Devices	Roadway						Intersection			
	4 - lane				2 - lane		4 x 4	4 x 2	2 x 2	
	Divided		Undivided							
	Tangent	Curve	Tangent	Curve	Tangent	Curve	H	H	H	L
	RT-1	RC-2	RT-3	RC-4	RT-5	RC-6	I-1	I-2	I-3	I-4
Marking	○	○	○	○	○	○	○	○	○	○
Traffic Sign	○	○	○	○	○	○	○	○	○	○
Delineator	○	○	○	○	○	○				
Raised Pavement Marker			◌ 60	◌ 60		○				
Median			◌ 40	◌ 40			○	○	○	
Guardfence	◌ 15	○	◌ 15	○	◌ 15	○	○	○	○	
Crosswalk	○		○		◌ 50		○	○	○	○
Lighting	◌ 15	○	◌ 15	○		◌ 50	○	○	○	
Traffic Signal							○	○	○	
Right-turn Lane							○	○	○	
Sidewalk	◌ 30	◌ 30	◌ 20	◌ 20	◌ 10	◌ 10	◌ 30	◌ 20	◌ 10	
Pedestrian Overpass	◌ 60		◌ 60							
Total Number of Section to be remedied	98	17	63	11	382	68	25	24	42	147

Note ○ ; To be installed for every corresponding sections

◌ ; Figure shown on the shoulder of the dot circle indicate the rate of actual installation of respective safety device against total sections

8.3 (Road Type Classification) and Appendix 8.3 (Quantity of Safety Devices by Road Type). The results are shown in Appendix 8.4 by road type as well as by safety device.

8.3.4 Cost Estimation

(1) Procedure

After the calculation of quantity of the safety devices applicable to each type of road classified among the selected hazardous locations, cost estimation consisting of installation cost and replacement/maintenance costs is to be carried out with the following procedures.

1) Determination of each unit cost.

2) Determination of service life of each safety device, so that the time for replacement of such device can be estimated during the plan period.

3) Estimation of installation cost for each safety device pattern, multiplying the unit cost by the required quantity, and obtain the total installation cost for the long term plan.

4) Estimation of the replacement and maintenance cost for each safety device for the plan period.

(2) Estimation of Installation Cost

The cost estimation to install the safety devices has been made with unit costs at the estimated 1985 year's price which were derived from the prevailing unit costs in Thailand. The unit cost for each safety device and the estimated installation cost in the long term plan are shown in Appendix 8.5.

The total cost (exclusive of maintenance and replacement costs of the safety devices) is about 960 million Baht of which, 770 million Baht is for roadway sections and 190 million for intersections. The divided 4-lane tangent road type (RT-1) shares the largest amount of the needed cost among the classified road types, followed by the 2-lane tangent road type (RT-5).

(3) Estimation of Replacement and Maintenance Cost

To ensure the original function of the safety devices, they have to be replaced and maintained properly. A long term plan should include the expenditure for the replacement and maintenance of the proposed safety devices. In this study, the case study long term plan has been assumed to be implemented over the period of 10 years between 1985 and 1994*. The replacement and maintenance expenditure for the safety device between the year of 1985 and 1994 has been estimated in accordance with their expected durable years which are shown in Appendix 8.6. The durable year for each safety devices has been determined mainly based on the experiences in Thailand. The total expenditures for the replacement and maintenance of the safety devices for 10 years has been estimated at about 340 million Baht. It should, however, be noted that the necessary cost for the replacement and maintenance of safety devices depends on the length of a period of the plan*.

The annual investment schedule for the installation/construction of the safety devices and their replacement and maintenance is tabulated in Table 8.5.

8.3.5 Accident Reduction

To evaluate the proposed long term plan, expected accident reduction should be forecast. Although there are a number of researches and studies on accident reduction effectiveness for an individual safety device, it is hard work to estimate the effectiveness of a set of safety devices installed at a road location. The accident reduction rate of the set of safety devices (standardized safety measures) for each road type has been determined based on the various information and data which are presented in Chapter 7 in this report, as well as the empirical judgement of the Team. Thus determined accident reduction rates by road type or set of safety devices are shown on the bottom line of Appendix 8.7.

When the implementation of the long term plan has been completed, about 3,800 casualties will be saved per year and this accounts for approximately 43 percent of the present yearly casualties suffered on the selected hazardous road locations in the long term plan. The details of the number of accidents and casualties to be saved owing to the long term plan are presented in Appendix 8.8.

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* The economic evaluation of the long term plan has been made for the period of 20 years between 1985 and 2004.

Table 8.5 Annual Investment Schedule of Long Term Plan

Unit : Million Baht

Year	F.Y.	Investment		
		Cost of installation/ construction	Cost of replacement/ maintenance	Total
1	1985	48.23	0.95	49.18
2	1986	62.47	2.80	65.27
3	1987	76.63	5.44	82.07
4	1988	91.40	17.55	108.95
5	1989	105.84	24.07	129.91
Sub-Total		384.57 (40%)	50.81	435.38
6	1990	108.95	30.28	139.23
7	1991	112.09	46.54	158.63
8	1992	115.44	60.01	175.45
9	1993	118.52	68.09	186.61
10	1994	121.73	86.40	208.13
Sub-Total		567.73 (60 %)	291.32	868.05
Total		961.30 (100%)	342.13	1,303.43
11 20	1994 2004	0	1,267.91	1,267.91
Total		961.30	1,610.04	2,571.34

8.3.6 Estimation of Benefits

As described in para. 8.2.4, the benefit/cost evaluation is attempted for determination of effectiveness of the long term plan in this case study.

Although there are many discussions and arguments on this type of evaluation method which is obliged to place a certain value to the life and injury of humban being, this method is regarded as one of the practical ways of evaluation for a traffic safety plan.

(1) General Principles

1) Basic Concept

There are numerous concepts and approaches for performing economic analyses, but it is generally agreed that analysis identifying annual benefits and annual costs is acceptable for safety improvement evaluations. Consequently, the relative merit of the safety improvement is measured by its net annual benefit or benefit/cost ratio.

Therefore, the total merit of the safety improvement worked out in the long term plan can be scaled by total net benefit accumulated by the number of years within a suitable evaluation period and its benefit/cost ratio.

2) Evaluation Components

Information needed for practising the analysis includes;

- Number of casualty (fatality and injury)
- Reduction rate of casualty and property damage
- Investment cost with annual allocation
- Values assigned to fatality, injury and property damage

It is to be mentioned that the net benefits calculation is practised with the constant price at 1985 for costs and benefits with the assumption that price escalation rate is same for both costs and benefits, and that the number of casualty adopted in this case study is fixed at 1982 level for the practical convenience, although it might be possible to adopt the number of casualty based on the projection with annual increase for the plan period.

3) Evaluation Process

The process of evaluation is to be roughly described as the following;

- Identification and calculation of annual benefit and cost for applicable years for evaluation periods, which comprise 1) each standardized safety measure, 2) number of casualty (broken down by numbers of fatality and injury), 3) investment amount by safety measure for each year, 4) reduction rate by safety measure for each year and 5) benefits for saved life, prevented injury and property prevented from damage by safety measure for each year.
- Accumulation of the gross benefit and gross cost for the years within the evaluation periods.
- Calculation of net benefit (B-C) and benefit/cost ratio for the long term plan.

(2) Estimation of Unit Value of Benefit

The monetary values of the person saved from fatality and prevented from injury and that of the property prevented from damage by implementation of the traffic safety improvement plan are considered as the benefits.

As to estimation of the economic value in accident reduction, if the applicable data are available, estimation of the value based on such elements as wage lost, medical expense, home and family care, and physical and mental pain can be made. There has not been reliable statistics and studies pertaining to above estimation in Thailand.

In this case study, therefore, the unit values of above are estimated as the following, with the data base by Auto-Sub-Committee of the General Insurance Association of Thailand and DOH Facts of Figures 1982.

1) Unit Value of Fatality: 0.3 million Baht

The estimation is made based on the factors that in Thailand an average amount insured per person for fatality caused by traffic accident in 1982 was ฿0.25 million, average annual compound inflation rate is calculated at 5.92% which leads growth rate for 1982 - 85 to 18.85% and consequently, the unit fatality value at 1985 is about ฿0.3 Million.

2) Unit Value of Injury: 0.03 million Baht

The estimation is made based on the factors that in Thailand an average amount paid per person for injury by traffic accident in 1982 was ฿0.025 million and the inflation rate and the growth rate for 1982 -1985 is similarly applied to arrive at the unit injury value in 1985 to be ฿0.03 million.

3) Unit Value of Property Damage: 0.0216 million Baht

This value is estimated by the factors that an average value per property damage against casualty in 1982 is calculated at ฿18,174 and by adopting the same growth rate with fatality and injury the unit property damage value is estimated at ฿21,600 in 1985.

The secondary benefits in monetary terms might also be estimated and included in the analysis if the adequate information and data are available. These secondary benefits would be identified with the concept that a traffic safety improvement may also affect other road users' and non-road users' benefits, such as the reduction in traffic congestion, fuel consumption and in wearing of the vehicle components, etc. However, these secondary benefits are not included in this case study due to lack of suitable data.

(3) <u>Benefit/Cost Computation</u>

With 8,852 casualties at 877 hazardous locations estimated in para. 8.3.3, reduction rate of each standardized safety measure determined in para. 8.3.5, investment cost in total and annual allocation estimated in para. 8.3.4, and the unit values of benefits estimated as above, computation of benefit/cost of the long term plan is tried in the following process. It is to be pointed out that in this long term plan the investment is assumed to be made all through 10 years from 1985, and the effects or the benefits of this investment should be created to the full extent in the following years after termination of long term plan. Therefore, the period of evaluation is set in the total of 20 years taking into account the necessary replacement and maintenance costs to be required for the next 10 years after completion of the long term plan period. For comparison purpose, the evaluation with 10 year period and the 1st year rate of return are also attempted. The 1st year rate of return can sometimes give useful information for the judgement of a safety plan with very simple data and calculation as the practical application.

1) Benefits of Each Standardized Safety Measure for Each Year

- Calculation of the numbers of persons saved from fatality and injury respectively in each standardized safety measure, by multiplying the progress rate of implementation of the plan (accumulated percentage of the investment amount in a certain year) and the number of expected fatality and injury when the safety plan is not implemented, which shall also be multiplied by the reduction rate of the safety measure.
- Calculation of the amount of property damage for the standardized safety measure, by multiplying the number of casualties and the unit value of property damage.
- Calculation of benefits on fatality and injury of the standardized safety measure, by multiplying the results of above calculations with the unit values of fatality and injury.
- Calculation of benefits on property damage, by multiplying the amount of property damage with the reduction rate.
- By summing up each benefit of fatality, injury and property damage, the benefits of the standardized safety measure of each year can be obtained.
- Total benefits of each year can be obtained by just summing up the benefits of each measure, and with comparison of the investment cost for each measure and for the year, the net benefits and benefit/cost ratios of certain year are to be obtained.

2) Benefits of the Safety Plan

- With all the results of calculations as described above, by summing up all the years within the evaluation period total numbers of persons saved from fatality and injury and their benefits, and the benefits for the property damage are to be obtained.
- With comparison of the total investment cost and the total benefits derived in above calculation, gross net benefits and the benefit/cost ratios of the long term plan can be obtained, together with those of each safety measure.

Tabulation of the respective figures applied in this evaluation and the process of calculation for the 1st year rate of return are shown in Table 8.6.

Table 8.6 Economic Evaluation; Benefit & Cost Calculation (1st year rate of return)

Unit: ②④⑤ : No. of persons
⑥⑦⑨ ⑩ ⑪ : Baht in million

Type of Measure		No. of Section		No. of Casualty		Unit Casualty	No. of Fatality	No. of Injury	Property Damage	Investment			Reduction Rate	Economic Benefits				B/C
										Inst.	Main.	Total		Fatality	Injury	Property Damage	Total	
		①	%	②	%	③	④	⑤	⑥	⑦			⑧	⑨	⑩	⑪	⑫	⑬
Roadway	RT-1	98	15.3	1,405	18.7	14.3	351	1,054	30.35	235.60	0	235.60	45	N 158 V 47.40	474 14.22	13.66	75.28	0.32
	RC-2	17	2.7	366	4.9	21.5	92	274	7.91	49.70	0	49.70	50	N 46 V 13.80	137 4.11	3.96	21.87	0.44
	RT-3	63	9.9	861	11.4	13.7	215	646	18.60	152.40	0	152.40	50	N 108 V 32.40	323 9.69	9.30	51.39	0.34
	RC-4	11	1.7	225	3.0	20.5	56	169	4.86	28.80	0	28.80	55	N 39 V 9.30	93 2.79	2.67	14.76	0.51
	RT-5	382	59.8	3,680	48.9	9.6	920	2,760	79.48	205.50	0	205.50	40	N 386 V 110.40	1,104 33.12	31.79	175.31	0.85
	RC-6	68	10.6	983	13.1	14.5	246	737	21.23	98.80	0	98.80	45	N 111 V 33.30	332 9.96	9.55	52.81	0.53
	Sub Total	639	100.0	7,520	100.0	11.8	1,880	5,640	162.43	770.80	0	770.80	(44)	N 822 V 246.60	2,463 73.89	70.93	391.42	0.51
Intersection	I - 1	25	10.5	153	11.5	6.1	38	115	3.30	53.60	0	53.60	50	N 19 V 5.70	58 1.74	1.65	9.09	0.17
	I - 2	24	10.1	130	9.8	5.4	33	97	2.81	45.80	0	45.80	50	N 17 V 5.10	49 1.47	1.41	7.98	0.17
	I - 3	42	17.6	235	17.7	5.6	59	176	5.08	66.90	0	66.90	50	N 30 V 9.00	88 2.64	2.54	14.18	0.21
	I - 4	147	61.8	814	61.0	5.5	204	610	17.58	24.20	0	24.20	30	N 61 V 18.30	183 5.49	5.27	29.06	1.20
	Sub Total	238	100.0	1,332	100.0	5.6	334	998	28.77	190.50	0	190.50	(37)	N 127 V 38.10	378 11.34	10.87	60.31	0.32
Total		377		8,852		10.1	2,214	6,638	191.20	961.30	0	961.30	(43)	N 957 V 284.70	2,841 85.23	81.80	451.73	0.47

Source : JICA Team Estimation
Remarks : 1. No. of Casualty is estimated at 1982 level.
2. The composition of fatality and injury is estimated at 25:75
3. The costs and benefits is calculated at 1985 price.
4. Unit values of fatality, injury and property damage are
1) fatality = 0.3 million Baht
2) injury = 0.03
3) property damage = 0.0216
5. Marks "N" + "V" in column 9 and 10 stand for
N : number of persons
V : monetary values