

Chapter 6

Traffic Safety Facilities and Devices

6.1 Introduction

The traffic accident rate in Chiang Mai City is alarmingly high. Based on the collected accident data by the Province and City Governments, the fatality ratio of traffic accidents in 1997 was 40 per 100,000 persons, and the injury ratio was 2,353 per 100,000 persons. In Japan, the corresponding ratios were 7.6 and 760 per 100,000 persons respectively. Thus, comparing Chiang Mai to the national average of Japan, the fatality ratio is over 5 times greater and the casualty ratio is over 3 times greater.

(1) Hazardous Locations

Locations in Chiang Mai prone to traffic accidents are shown in Table 6-1 and Figure 6-1. Wat Chet Yod location stands out as the most dangerous spot with 106 persons injured or dead in 1999 due to traffic accidents. This location is an intersection between Super Highway and a minor road without signal control. Although right turn lanes for both right-turns and U-turns are provided, the numerous conflicting movements and the high speed of through traffic are the main causes of accidents. The table below shows the 10 most accident prone locations.

Among the 10 most accident prone locations, 6 locations are junctions on Super Highway.

Table 6-1 Top 10 Accident Prone Sites in The Study Area in 1999
(unit: person casualties)

Sites	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
1-Wat Chet Yod	25	24	0	4	2	2	10	2	11	8	10	8	106
2-Super Highway/ KawKlang	30	30	6	0	0	0	0	0	4	0	0	0	70
3-Super Highway/ Ch.Muang	0	15	15	5	0	4	0	4	3	7	0	7	60
4-Super Highway/ K.Nawarat	0	0	7	4	14	10	4	0	4	0	14	0	57
5-Super Highway/ Chotana	0	0	0	0	6	6	2	4	5	3	11	0	37
6-Ratanakosin/ M.Samut	0	8	0	3	4	3	2	2	2	5	0	0	29
7-Phra Sing	0	0	0	0	0	4	2	10	2	3	4	3	28
8-Hasadhi Sawee/ C.Puak 4	0	0	0	0	0	0	0	0	9	0	7	7	23
9-Back of Tapae Gate Jtn	0	0	0	11	0	0	3	3	0	0	0	5	22
10-Super Highway/ CMLand	-	-	-	-	-	3	8	4	0	0	0	0	15

Source: Ruam Jai Foundation (Au Paw Po Raw)

(2) Role and Responsibility of the Organizations Concerned with Traffic Safety Measures

A Committee for Land Traffic Management, under the leadership of the Provincial Government, was established with the participation of various public and with the aim of managing traffic in the Chiang Mai Province. This committee holds their meeting about 4 times per year.

Member of Committee

- Governor of CM Province (Chairman)
- Traffic Police
- Department of Highway
- Municipality
- Public Works
- Commercial Office
- Provincial Office
- President Office Provincial Industrial Congress
- Electric Authority
- Telephone Authority
- Water Supply Authority
- Technology Arts
- OCMLT

Main issues on traffic management

- Traffic Management Including Signal
- Road Planning Issue
- Road Construction Issue
- Traffic Regulation Issue
- Budget
- Others

Regarding traffic safety, there is an independent Traffic Safety Measures Team, comprising 15 members, which is responsible for traffic accident prevention activities.

The team members within this Traffic Safety Team and their main roles are shown in Table 6-2.

Table 6-2 Traffic Safety Team for Traffic Accident Prevention and Other Related Issue

Compose of Member	Main Project/Activity
Provincial Police	Traffic safety improvement
Provincial Government	Traffic regulation
Provincial Transportation	Traffic accident prevention
Chiang Mai Municipality	Accident prevention plan during Song Kran Festival
Provincial Public Health Bureau	Traffic congestion solving measures
Others Related Organization	Other related issues (Organization, budget, procedure plan etc.)

Source: This study

6.2 Pedestrian Signals and Pedestrian Crossings

(1) Present Situation

Development of pedestrian facilities in Chiang Mai City is still inadequate. Although there are a number of traffic signals for vehicles, there are only 7 pedestrian crossing signals including one pedestrian signal attached to the vehicle signal at Rama IX Bridge junction citywide. This situation is due to over emphasis on the development of infrastructure for vehicular traffic in the last decade, and which is still on a very rapid increase. It also reflects a lack of budget allocation for pedestrian facility development.

In many cities, pedestrian signals and pedestrian crossings are provided at most intersections. In Chiang Mai, however, most of the signalized intersections have no pedestrian signals, and pedestrian crossings (marking) are provided not at all intersections.

In the past when vehicle traffic volumes were low, crossing roads at any location was relatively easy and most residents developed the habit of crossing even major roads at leisure. With the increase in traffic volumes in recent years, pedestrians are now realizing that it is life threatening to attempt crossing some of the major roads, especially Super Highway and many of the multi-lane national routes. In the central area of the city, due to physical constraints, the narrow streets are converted into one-way operation. Although this has the advantage of increasing the efficiency of these roads, there is a negative impact in that drivers tend to increase their travel speeds and thus increase accident risk. Moreover, one way streets have a fewer traffic flow gaps wide enough for pedestrians to cross safely.

Chiang Mai City depends greatly on the tourism industry for employment and income. More than 3 million domestic and international tourists visit the city each year. Many temples and ruins are situated in the old city and together with the Night Bazaar, attract many tourists to the area. They often face difficulties in crossing the major streets, especially Taphae road, the old city moat roads, Rachatdanoen, Phra Sing Road, Chan Klang Road and Charoen Prathet Road.

In areas where there are concentrations of schools, such as Chan Klang District, hardly any pedestrian signals have been installed. Pedestrian signals are only installed at very specific locations, such as in front of the school-for-the-blind and a few kindergartens.

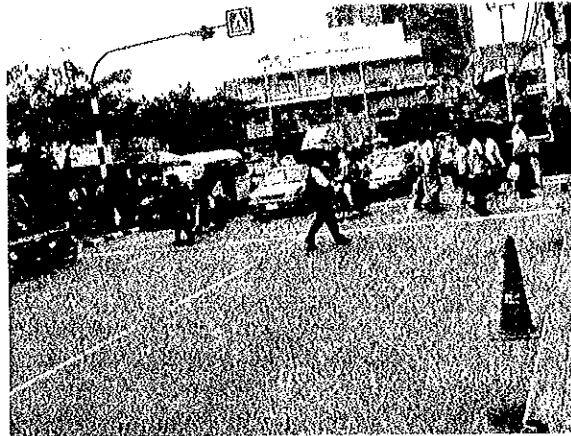
Figure 6-2 shows the installation locations of pedestrian signals in Chiang Mai and Table 6-3 summarizes their type and usage.

Table 6-3 Location and Usage of Existing Pedestrian Signals

No.	Location	Signal Types and Functions	Usage
1	Huai Kaew Rd.in front of CM Polytechnics School	<ul style="list-style-type: none"> • Pedestrian signal at mid block, push button with twin lanterns type and buzzer for the blinds 	<ul style="list-style-type: none"> • Many users • Highly responsive to push button demand. • Buzzer sound is loud.
2	Suthep Rd.in front of Maharaj Hospital	<ul style="list-style-type: none"> • Push button and twin lanterns type with buzzer • Accompanied with green signal count down display in seconds. 	<ul style="list-style-type: none"> • Many users
3	Arrak Rd. in front of Northern school for the blind	<ul style="list-style-type: none"> • Push button and twin lanterns type with buzzer 	<ul style="list-style-type: none"> • Few users • Drivers sometimes do not stop their cars when signal light turns to red.
4	Chang Loh Rd.in front of Suan Phrung hospital	<ul style="list-style-type: none"> • Twin lanterns type with push button. 	<ul style="list-style-type: none"> • Few users. • Push button out of order on the hospital side.
5	Rattanakosin Rd. Rama IX Bridge west side signal Intersection	<ul style="list-style-type: none"> • Attached to vehicle signals. 3 lanterns type. • No buzzer . 	<ul style="list-style-type: none"> • Few users
6	Phuak Rd.In front of Gowit Thamrong school	<ul style="list-style-type: none"> • Not activated except during school hours. 	<ul style="list-style-type: none"> • Few users • Usage time limited to school hours
7	Maneeoparat Rd.In front of Chang Phuak Gate	<ul style="list-style-type: none"> • Not in use. 	<ul style="list-style-type: none"> • Although there are many potential users, it is not functioning.

Source: This study

There are a significant number of non-signalized pedestrian crossings (zebra crossings) around the city. These are often located mid-block and accompanied by wayside pedestrian crossing traffic warning signs. At six special locations (where tourists traffic is high, such as Chang Klan Road, Moonmuang road) internally illuminated pedestrian warning signs on high poles are installed, accompanied by blinking lights (see Figure 6-3)



Source: This study

Figure 6-3 Mid-Block Pedestrian Crossing and Illuminated Pedestrian Warning Sign

Seven pedestrian overpasses have been installed in the city. Although such overpasses are found mostly near schools for the students to cross streets, on the whole, there are few users. User resistance toward overpasses is high in Chiang Mai most probably due to the height and steep steps when accessing them (see Figure 6-4).



Source: This study

Figure 6-4 Pedestrian Overpass with Steep Steps (Charoen Prathaet Road)

(2) Problems for Pedestrian Traffic

Traffic accidents involving pedestrians accounted for only 3.5 percent¹ of all traffic accidents in 1999, which is a relatively low rate when compared to about 10 percent in Japan.

This, however, is partly due to the lower rate of pedestrian traffic in Chiang Mai compared to Japan. At places where many people tend to congregate, such as markets and

¹ According to the data of Ruam Jai Foundation, 52 casualties (3.5%) are involved in approximately 1,500 traffic accidents.

the Night Bazaar, pedestrian traffic is still not significant and many are actually occasional tourists. The low pedestrian traffic in Chiang Mai may be due to the following reasons:

- high average temperature and humidity; and
- inadequate pedestrian environment including lack of pedestrian crossings, comfortable/safe sidewalks, and shade.

For these reasons, pedestrian traffic tends to be limited or confined to very small areas within residential areas during the morning and evening hours only.

Problems faced by pedestrians in Chiang Mai can be summarized as:

- insufficient pedestrian signals and pedestrian crossings;
- some installed pedestrian signals are not functioning effectively;
- drivers lack awareness in giving way to pedestrians at crossings; and
- stop lines for vehicles at signalized pedestrian crossings are too close to the crossing areas.

The result is a high occurrence of jay walking and an environment that is not conducive to pedestrian activity.

Lack of Appropriate Driver Education

Most drivers and motorcyclists in Chiang Mai are not accustomed to observing pedestrian crossing signals at road sections. On many occasions, even when the signals for the vehicles have turned to 'red,' drivers do not stop their vehicles at the stop lines. They do so only when there is a policeman on duty at the crossing.

In general, drivers in the city do not pay much attention for the need to give way or priority to pedestrians on roads. It is therefore necessary for the Traffic Police and the City Government to initiate traffic safety campaigns to educate the public, particularly drivers, on the need to give-way to pedestrians. This is particularly important as many drivers do not care the basic etiquette of yielding to pedestrians when turning at a signalized intersection. At the same time it is equally important for the Municipality to install more pedestrian signals around the city.

(3) Pedestrian Signal Equipment

There are two types of lantern arrangement for pedestrian signals in Chiang Mai: the twin lantern and 3 lantern types.

For the 3 lantern type, "wait" (in Thai) is displayed in the middle lantern between the usual red and green lanterns. In international usage, the twin lantern type is the norm. For consistency, it is recommended that Chiang Mai adopt the twin lantern type with pedestrian figure display.

6.3 Pedestrian Sidewalk

(1) Characteristics of Pedestrian Traffic

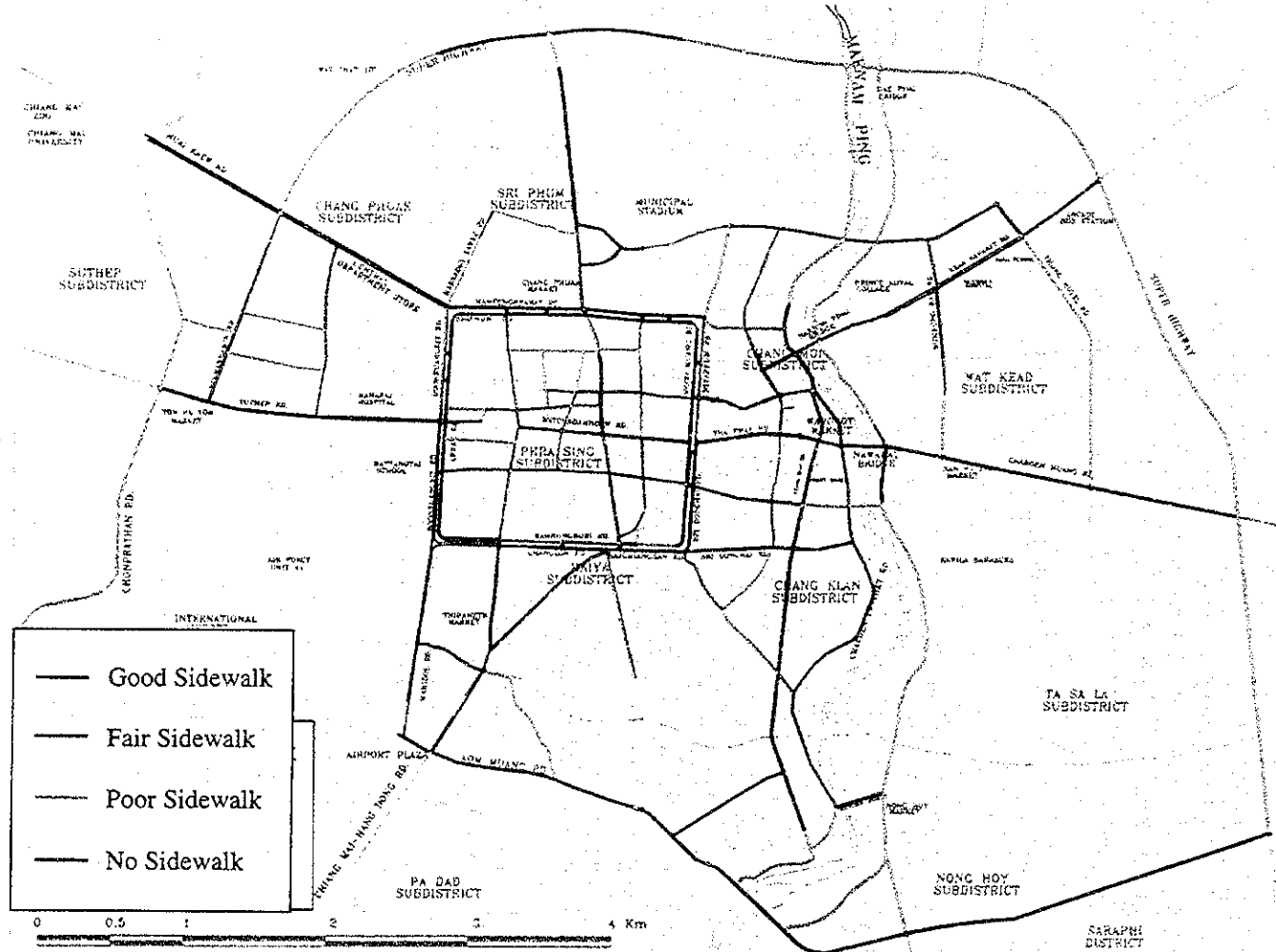
In many cities all over the world, urban dwellers have come to realize the negative impacts of over dependency on automobiles for their daily movements. Increased traffic has over the years brought about deterioration of the living environment. Air is polluted and acid rain destroys ground cover, precious ancient relics, and damages crops and buildings. The trend in many cities is to promote non-polluting modes of transport, such as walking and bicycles, while at the same time encouraging the sharing of vehicles to reduce the number of vehicles on the streets.

Pedestrian traffic has the following characteristics and should be considered in planning for pedestrian facilities:

- Pedestrian movement is highly flexible. People can move in any direction, change route and stop anywhere along the way.
- Passage is guaranteed and many perceive it to be enjoyable if the quality of the walk can be assured.
- Average trip length of pedestrian varies among countries, averaging about 400 m in Japan. Trip length is influenced by the trip purpose, the prevailing weather and the infrastructure conditions.
- Pedestrian traffic is closely related to the land use or local character of an area such as important institutions or buildings located there. The pedestrian walking space can therefore be perceived as an extension of the space from that building.

(2) Condition and Improvement of the Sidewalk

Pedestrian facilities in Chiang Mai is generally inadequate. An investigation was carried out on the condition of pedestrian walkways along selected major roads around the city. The condition of pedestrian sidewalks are surveyed and examined in this study, as shown in Table 6-4 and Figure 6-5. The total length of major roads investigated including sections of Super Highway is 110 km (99 km excluding Super Highway).



Source: This Study

Figure 6-5 Conditions of Pedestrian Sidewalks along Major Roads

Table 6-4 Condition of Pedestrian Sidewalks along Major Roads

	Good	Fair	Poor	No sidewalk	Total
One side (meter)	640	17,130	10,510	11,120	39,400
Both side (meter)	0	31,060	9,800	19,030	59,890
Total length (meter)	640	48,190	20,310	30,150	99,290
Share (%)	0.6%	48.5%	20.5%	30.4%	100.0%

Notes: does not include Super Highway

1. Surveyed roads are shown in Figure 6-5. Road length is measured from drawing.
2. Sidewalk situation is classified according to the following standard.
 - Good: situation under which 3 or more persons abreast can walk pleasantly.
 - Fair: situation under which 2 persons abreast can walk.
 - Poor: situation under which only 1 person can walk on the pavement.

Source: This study

From the survey, it was found that about 71 percent of the surveyed roads have pedestrian sidewalks. Pedestrian sidewalks are provided generally along major roads. However, there are very few sidewalks that allow the comfortable walking of 3 or more persons abreast (0.6 percent). Although 48.5 percent of the surveyed sidewalks allow for two persons to walk side by side, much of these are constantly interrupted by the presence of sign posts, telegraph poles, roadside trees, and telephone booths, which were installed in the center of these sidewalks. This situation is particularly serious if the sidewalk is narrow allowing only one person to pass at a time. In avoiding such obstacles, pedestrians have to walk on the roadway, disrupting traffic flow and causing danger to the pedestrians. If this category is combined with the 'no sidewalk' category, then more than 50 percent of the major roads surveyed can be said to have no proper pedestrian sidewalks.

(3) Sidewalk Width

The sidewalk widths along the selected main roads were investigated at 53 locations. The investigation shows that most sidewalks measure 2 meters or less in width, and only 5 locations have a sidewalk width exceeding 2 meters. Table 6-5 shows the surveyed sidewalk widths categorized into 1.0 meter up to 2.2 meters or more. There is clearly no consistency or continuity of sidewalk width along any major road. The width also differs between both sides of the road. The average sidewalk width was found to be only 1.49 meter.

According to Road Design Requirements practiced in Japan, the minimum space (width) required for one pedestrian to walk is 0.75 meter, and, in the case of a wheelchair, 0.9meter. For this reason, the minimum width of a sidewalk should be 2.0 meter. At this width, two persons walking, or one person walking with another in a wheel chair will be able to proceed along the sidewalk comfortably. If a bench is to be provided on such a sidewalk, an additional 1.0 meter must be added. An additional 1.5 meter is to be added if roadside trees are to be planted.

In Chiang Mai City, the effective sidewalk width that can be used for walking is extremely narrow, when considering that spaces are taken for the installation of various facilities.

Table 6-5 Range of Sidewalk widths at Survey Points

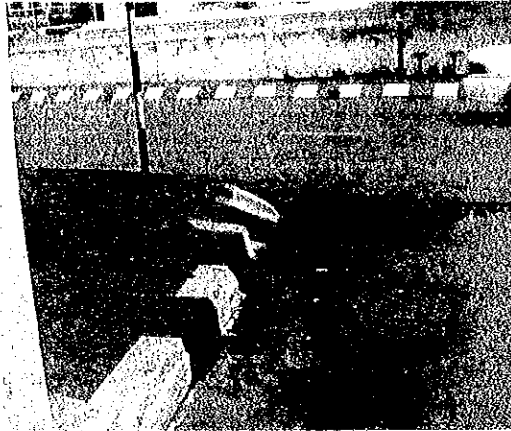
Width	None	1.0m.- 1.3m.	1.4m.- 1.7m.	1.8m.- 2.1m.	2.2m.or more	Average width (m)
Number of Survey Points	15	28	25	28	10	1.49

Source: This study

Problems regarding the existing pedestrian sidewalks in Chiang Mai can be summarized as follows:

- There is very little sidewalk space along which people can walk comfortably.
- The difference in elevation between the sidewalk and the roadway is quite substantial at many locations. This may pose a problem to senior citizens and handicapped persons. Due to this big difference, ramps at road corners are steep and therefore unsafe for handicapped persons (see Figure 6-6).
- Many structures and objects are erected in the center of the sidewalks. These include telephone booths, trees, bus stops, lamp poles, telegraph poles, and signal controller boxes (see Figure 6-7).
- Some of the sidewalks are paved with colored concrete blocks. Many are poorly constructed with the result that some blocks are missing or loosen. The surface of the pavement therefore is uneven (see Figure 6-8).

The maximum temperature often exceed 30 degrees Celsius in Chiang Mai during summer time. Due to this heat, pedestrian traffic is low especially during the mid day hours. Pedestrian traffic demand at the survey locations is classified into 4 categories. Such classification is based on the subjective judgment of persons who are familiar with the existence of major buildings or land use at these locations. These ranks are shown in Table 6-6.



Source: This study

Figure 6-6 High Level Difference and Steep Ramp Curb



Source: This study

Figure 6-7 Narrow Sidewalk with Obstacles



Source: This study

Figure 6-8 Collapsed Block Pavement dues to Poor Sand Compaction

Table 6-6 Results of Investigation on Pedestrian Sidewalks

No.	Road Name	Pedestrian Traffic*	Typical Cross Section Width (m)					
			North	South	East	West	N-West	S-East
1	CharoenMuang	A~C	1.80	1.50				
2	CharoenMuang	A~C	2.00	1.50				
3	Tha Phae	A	1.80	1.30				
4	Chiang Moi Tud Mai	C			1.30	1.00		
5	Chang Moi	A,C	1.20	2.00				
6	Charoen Prathet	C			1.60	1.80		
7	Chang Klan	A~D			2.20	1.30		
8	Chang Klan	A~D			1.50	1.50		
9	Chang Klan	A~D			1.70	1.10		
10	Chang Klan	A~D			2.00	1.60		
11	Chiang Mai - Lamphun	C,D			2.00	2.00		
12	Charoen Prathet	A			1.80	1.50		
13	Charoen prathet	C			1.30	1.60		
14	Charoen Prathet	D			1.30	1.40		
15	Charoen Prathet	D			1.30	1.80		
16	Tha Phae	B	1.60	1.40				
17	Loi Kroh	B	1.00	1.00				
18	Kham pangdin	C			0.00	1.20		
19	Kham pangdin	C			0.00	2.00		
20	Kham pangdin	C			0.00	0.00		
21	Sri Donchai	C,D	1.20	1.80				
22	Raj chiangsan	A,D	1.60	0.80				
23	Suriwong	D			1.50	0.00		
24	Tippamet	D			1.40	1.70		
25	Boonruangrit	BC			2.10	2.30		
26	Suthep	A~C	1.80	2.40				
27	Suthep	A~C	1.60	2.00				
28	NimmanHamin	C			1.30	1.50		
29	Huai Kaew	A~B	2.00	2.00				
30	Huai Kaew	A~B	2.00	2.00				
31	Maneenoparat	B~C	0.00	1.60				
32	Maneenoparat	B~C	1.20	1.80				
33	Wicha nonn	A	3.50	1.00				
34	Kaew Navarat	A					1.30	2.00
35	Kaew Navarat	A					2.00	1.70
36	Ratthnakosin	D	1.30	1.50				
37	Ratthnakosin	D	1.60	1.20				
38	Ratthnakosin	D	0.00	0.00				
39	Thaai Wang	A	1.20	1.80				
40	Ratcha wong	A			2.00	1.30		
41	Wang Sing Kham	A			0.00	0.00		
42	Tha Phae (West)	B			1.40	1.00		
43	Tha Phae (East)	A			0.00	3.10		

Table 6-6 Results of Investigation on Pedestrian Sidewalks (continued)

No.	Road Name	Pedestrian Traffic*	Typical Cross Section Width (m)					
			North	South	East	West	N-West	S-East
44	Ratchadamnoen	C	1.75	1.35				
45	Phrapokkiao	C			1.30	1.80		
46	in front of three king monument	B			2.00	7.10		
47	Rajwithi	A,C	2.50	1.20				
48	Ratchadamnoen	B	3.00	1.30				
49	Sam Larn	D			0.00	1.60		
50	Rajmakha	C	1.80	0.00				
51	Singharat	A-D			0.00	1.80		
52	Chang Phuak	B			1.30	1.30		
53	Chang Phuak	B			2.20	2.40		

Note: A: High pedestrian traffic, such as along sidewalks in the Night bazaar area and major markets.
 B: Moderately high pedestrian traffic, particularly those on daily shopping trips for food, daily needs at stores and shops, etc.
 C: Moderate pedestrian traffic, at or near to a school where students may congregate during certain time zones when attending or departing from schools.
 D: Little pedestrian traffic.

Source: This study

(4) Pedestrian Sidewalk Improvement Plan

Improvement Plan Formulation Procedure

The proposed sidewalk improvement plan for Chiang Mai is formulated based on the following procedure:

- 1) Consideration of an effective sidewalk width for Chiang Mai;
- 2) Selection of target roads for the improvement;
- 3) Examination of selected target roads in meeting effective width requirements; and
- 4) Preparation of improvement plans.

Consideration of an Effective Sidewalk Width

When considering the appropriate sidewalk width, planners must first consider the fundamental space requirements of different types of users (i.e. pedestrians, handicapped persons in wheelchairs, etc.). The basic design requirements of these users are given in the table 6-7.

Table 6-7 Basic Space Requirement of Sidewalk Users

Category	Adult Pedestrian	Wheelchair User	Crutch User	Bicycle User (for reference)
Standstill Width	45 cm wide	70 cm wide	90 cm wide	60 cm wide
Moving Width	70-75 cm wide	100 cm wide	120 cm wide	100 cm wide

Note: Based on Japanese standards.

Source: This study

For roads in and near the city center, where sidewalk use is comparatively heavy, the width should be capable of providing a comfortable and sufficient space for users. However, even for those streets with relatively low traffic volumes, securing sufficient width where space allows is still important to facilitate safe passage of users without potential movement conflicts. Based on the above requirements, the minimum sidewalk width for roads in the city center with relatively high user volumes shall be at least 2.0 m, which should be sufficient to set aside a secure and comfortable space for pedestrians, wheelchair users, etc. It must be noted here that the effective width refers to the overall width of the sidewalk, excluding space needed for electricity poles, telephone posts, traffic signs, and similar objects. If such facilities are needed to be installed on the sidewalk, additional width for these installations must be allowed for.

Selection of Street Segments for Improvement

The segments for improvement are selected based on the following criteria or factors:

- 1) The road is located in or near the city center and has a large user demand;
- 2) The road has insufficient width to meet the basic effective sidewalk width requirement; and
- 3) The road width is more than sufficient, and has relatively few traffic capacity problems.

The target roads for improvement are selected based on the above factors. In particular, some of those chosen have high user demand (such as near the Night Bazaar). The selected roads are shown in the table 6-8.

Table 6-8 Existing Conditions of Street Segments for Sidewalk Improvement

Street Name	Width Constitution (Sidewalk + C.W + Sidewalk)	Existing Traffic Conditions	Existing Sidewalk Environment
Tha Phae	(1.85+9.00+1.85) ~ (1.85 + 10.40 + 2.20) Three lane road in one direction.	A main East-West thoroughfare with a peak hour vehicle demand of 3,180 per hour. Pedestrian demand is 142 persons/hour. From Feb.3 rd , an experimental project turning this road into an exclusive pedestrian mall was implemented on Sundays for ten consecutive weeks.	Many temples and shops line the road. Many objects such as telephone booths, TAT tourist information boxes, and information signs clutter much of the sidewalk, seriously reducing effective sidewalk width. As the main road for reaching Thae Phae Gate via the Thae Phae square, which is a major historical symbol for the city, the sidewalk width is too narrow to ensure a good walking environment.
Charoen Prathet	(1.25+8.60+1.25) Two-lane road in one direction	Functioning as a pair of one-way streets with Chang Klan Road, vehicle traffic volume is high, but pedestrian demand is relatively small except near school	Sidewalk width is narrow. Effective width is particularly narrow where wayside trees exist.
Sri Donchai	(1.55+11.65+1.40) Four-lane road in both directions	Situated to the south of the Night Bazaar, traffic demand on section closest to the old moat is high at 44,000 veh/day. Traffic volume on the section east of the junction with Chang Klan is relatively small. Pedestrian volume is 100-200 person/hr.	There are many restaurants and tourists. Presence of trees, telephone boxes further exacerbate the narrow sidewalk width problem. The effective width is only 50-60cm.
Loi Kroh	(1.65+7.45+1.20) Two-lane road in one direction	At 600 veh/hour, traffic along this road is relatively low. However, wayside parking is common and many strolling tourists exist.	Many guesthouses and tourist souvenir shops are located along the road. Again the effective width of sidewalk is too narrow.
Changklan (from Thae Phae to Sri Donchai)	(4.0+11.1+3.0) Three-lane road in one direction	The main road in night bazaar area, peak hour traffic volume is 1,813 veh/hour. Pedestrian demand is very high at 1,000-1,500 persons/hr.	Hotels, tourist souvenir and service shops line this road. After 6 pm everyday, roadside stores line up on both sides of the sidewalks. Tremendous concentration of tourist shoppers at night. Walking environment is very poor.

Notes: Width sometimes varies by section.

Source: This study

6.4 Pedestrian and Bicycle Network

(1) Introduction

Cities all over the world are facing an ever worsening urban environment caused by pollution from excessive use of vehicles. As a simple measure to reduce this usage, non-polluting means of transport, such as walking and bicycling should be intensively promoted for short-distance trips. In many countries, the use of bicycle is promoted as an alternative to motor vehicles, which places little burden on the environment.

In Chiang Mai, the authorities have previously made an attempt to encourage the use of bicycles by installing bicycle lanes along some of the major streets in the city. However, due to the heavy vehicular traffic on these roads, the cyclist safety was suspect. Moreover, the lack of effective enforcement of curbside parking rendered such lanes ineffective. Today, most bicycle users in the city are foreign tourists, as few locals utilize this mode.

The Study Team proposes the creation of a bicycle/pedestrian network plan within the Old City to take advantage of the following factors inherent in this area: (i) the relatively low traffic levels in the area; (ii) the presence of numerous tourist attractions; (iii) the relatively abundant amount of open space (as the area is less built-up and dense as others), and (iv) the relatively good environmental characteristics of the area. These aspects are described in greater details below.

(2) Major Tourist Attractions in the Old City

Along the ancient moat surrounding the Old City, there are a total of five gates in the four cardinal directions (with two gates in the south). Each side of the moat is about 1.6 km, thus nearly forming a perfect square surrounding the ancient capital. At each corner, remnants of the old city wall can still be seen. Within the city, there are many historical structures, notably ancient temples, monuments, and other buildings. In addition, there are many old houses converted into tourist guesthouses. Thus, the Old City has a concentration of tourists who travel in these areas via foot or bicycle. Furthermore, there are also three local markets serving residents in and near the Old City, which have also become major tourist attractions in themselves.

Aside from a few major north-south and east-west thoroughfares in the Old City, where traffic is relatively high, traffic demand on other streets is comparatively light. In general, the safety for pedestrians and bicyclists should not be threatened by voluminous amounts of motor vehicle traffic. Although there is obviously some desire to promote a better walking environment by the authorities as manifest in the paving of colored interlocking blocks on some of the narrow lanes (or *soi*), on the whole, a comprehensive improvement plan for establishing a clear network of footpaths or cycle lanes for locals as well as tourists is lacking.

Figure 6-9 shows the existing pedestrian network (in terms of colored interlocking pavement blocks) within the Old City.

(3) Colored Interlocking Pavement Sections

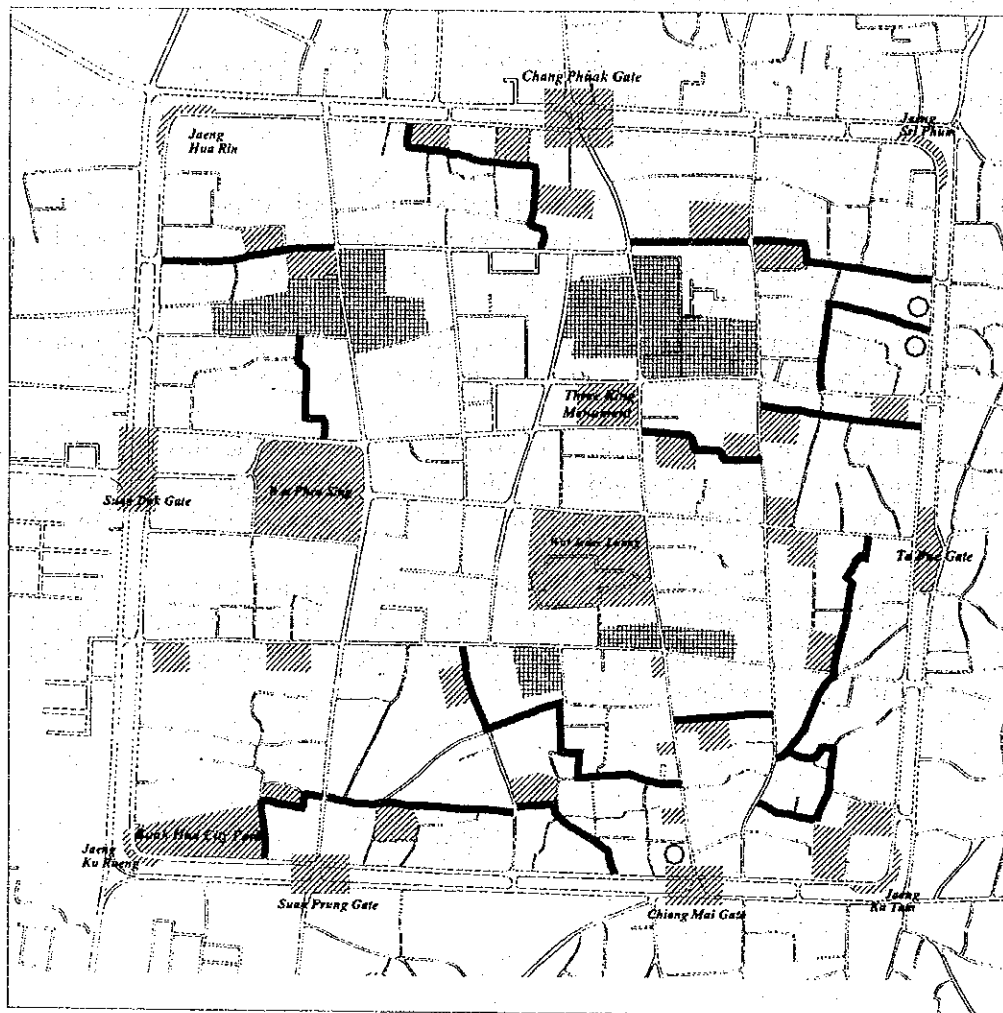
The present pavement improvement using colored interlocking blocks is confined to only the narrow access roads (or *soi*) and not to the major roads. These colored paved roads extend from the moat towards historical sites like temples and parks.

Along these sections, colored interlocking blocks are used to pave over the entire roadways, except for the drains; furthermore there are almost no sidewalks. The width of these paved sections varies from 2.0 - 5.7 meters with an average of about 3.0 meters.

Although one-way regulation is enforced along some sections, traffic regulation signs hardly exist. Meanwhile, vehicular traffic is still allowed, yet it is very low.

Most users of these paved roads are local residents and tourists, who stay at guesthouses along these *soi*. No information boards or route maps are posted near or at the entrances to these paved roads to give information or directions leading to the historical attractions.

The Chiang Mai Municipality is currently planning to adopt such colored block pavement to Ratchdamnoen Road/Phra Sing Road (from Thae Phae Gate to Phra Sing Temple), which is a major road in the Old City in the east-west direction. This plan is expected to be adopted within the 2002 Fiscal Year.



Legend

- Ancient Area
- School Area
- Market
- Existing Colored Pavement

Source: This study

Figure 6-9 Existing Pedestrian Network in Old City

6.5 Street Lighting Facility

Street lighting is an important traffic safety device as it facilitates observation of various traffic safety regulations at night, and thus ensures safe and smooth flow of traffic. With adequate street lighting at night, drivers are able to capture a wide view along the road. All the objects, including road surface are evenly illuminated with little shadows. When there is no street lighting, a driver may still be able to spot an obstacle using the headlight, but only bright objects with good reflectance show up clearly to him. By the time he spots a dull object, it may be too late to avoid and this may cause an accident.

Street lighting in Chiang Mai is generally well provided along Super Highway and major roads. Lighting along the minor access roads (*soi*) is less.

Street lighting improvements have been continuously undertaken in the last 20 years or more. Low pressure sodium or mercury vapor lamp type of lighting is now installed at major intersections and major roads, while the fluorescent lamp type is commonly used for the other roads. At all the studied intersections, adequate street lighting is observed. The installation situation of main roads is shown in Table 6-9.

Table 6-9 Installation Situation of Street Lighting

Road Class	Support System	Arrangement system	Light source type
Super Highway	Pole lighting system	Facing arrangement	Low pressure sodium lamp
Main road	Telegraph pole attach-on system or Pole lighting system	Single-sided arrangement	Low pressure sodium lamp Mercury vapor lamp
Other Road	Attachment lighting system	Single-sided arrangement	Fluorescent lamp

Source: This study

Sensors are installed to detect light and dark, hence turning on the streetlights automatically when darkness falls. Similarly, streetlights are turned off in the morning. This efficient usage of streetlights works not only for ensuring traffic safety, but also for crime prevention.

6.6 Road Sign and Road Marking

Road signs have the function of conveying information to the driver on traffic regulations or to warn of other road users or hazards ahead. Signs are all aimed at promoting traffic safety and ensure smooth traffic flows. Road markings, comprising painted lines, signs, symbols, characters on the road pavement or curbs, are for the purpose of guiding the driver in his maneuver and supplementing the message conveyed by the road sign or traffic signal.

Signs can be categorized into 4 different groups: guide signs, regulatory signs, warning signs and direction sign. Auxiliary signs supplementary to the contents of these signs may also be installed. A *guide sign* normally displays the direction of a road, the name of a place and provides geographical guidance to road users. A regulatory sign accords to a certain traffic regulation or law. This may be a traffic restriction such as a stop sign, speed limit sign, no entry sign or no parking sign. A *warning sign* is chiefly to warn drivers of the conditions of the road section ahead and of any potential hazards so that they may take appropriate actions or precautions. Some examples are sharp bend signs, narrow bridge or road ahead signs, and road construction in progress signs. A *direction sign* displays directions of a U-turn, a priority road, a pedestrian crossing, etc. Road signs and markings and their installation standards can be found in the DOH road design standards. Road signs and markings are considerably improved along the national routes and Super Highway which are under the jurisdiction of the DOH. Signs and markings on the city streets however are still lacking or inconsistent.

A driver may not be able to recognize the road signs or markings if they are not sufficiently illuminated. Visibility of signs and markings at night are important to ensure traffic safety.

(1) Existing Road Sign Situation

This section discusses the existing situation in Chang Mai and possible improvements to the road signage and markings in the study area.

Super Highway

Directional and Warning signs: Road signs are generally well designed and installed along Super Highway based on the design standards practiced by DOH. Guide signs, regulatory signs, warning signs, and direction signs are generally clear, well located and suitable. Upstream of a road crossing, warning signs of the crossing ahead are provided. In addition, guide signs with the name of intersection or place and directions are also given. Warning signs are installed 200m upstream of U-turn lanes, and direction signs are installed at the U-turns.

Warning signs on weaving traffic from the service roads, presence of slip roads to the service roads however, are not provided on the main line.

Regulatory sign: Speed limit regulatory signs are not visible along Super Highway. Since the design speed of Super Highway is 90 kph, speed limit regulatory signs for that

speed should be generously displayed along Super Highway. Without such signs, the speed limit cannot be enforced by the Traffic Police and many drivers violate the safe speed limit.

Super Highway has many at grade intersections with radial roads. Since the speed limit enforced by the city is 45 kph on all city roads, speed limit signs lower than the 90 kph on the main sections of Super Highway must also be displayed near the intersections with the radial roads. Near to such intersections, speed limit signs at 60 kph should also be installed.

Along the north-eastern section of Super Highway, service roads are provided on both sides of the highway. Again, speed regulation signs are not displayed along these roads. Drivers are therefore unaware that the speed on such roads should be lower than the main roadway. Most traffic on such roads was observed to be at about the same speed as that of the main line. Since such service roads are directly connected to city streets, a speed limit of 45 kph should be enforced and appropriate regulatory signs provided.

Large trucks are prohibited from entering the central area within Super Highway. The regulatory signs to ensure this are only displayed at the main intersections along Super Highway. Such regulatory signs should be displayed at all entry points to the city.

Tha Phae Road

Traffic signs are important to inform drivers of street regulations. Particularly within city area, some problems with traffic signs may be observed; these problems are listed below:

- “No Entry” sign does not exist at exit of Chang Moi soi 2.
- There is an excess in the number of parking prohibition and speed limit signs installed along certain road sections. Furthermore, as the majority of these signs are small, excess signs should be removed.
- Unneeded poles have not been removed. Furthermore, there are no regulations regarding advertising signs along the road. These poles and signs restrict pedestrian space and degrade the aesthetics of the street.

As a study example, traffic regulation signs along Tha Phae Road (for about 1 km) were investigated. The table below describes some of the traffic regulations found in this area and the problems associated with them.

Table 6-10 Existing Traffic Regulation Signs along Tha Phae Road

	Type of sign	Number of Signs on		Comments
		Left side	Right side	
Regulation sign at necessary locations	Pedestrian Crossing	6	4	There are 8 pedestrian crossings. Lacks signs.
	Left turn (or Right Turn) Prohibited	2	1	Lacks the sign-at the exit of Chiang Mai Soi 2(Oneway)
	Left turn (or Right Turn) Permitted		1	Lacks the sign at the entrance of Kuangmane Road..
Regulation sign for mid-block	Speed Limit Sign: Maximum Speed 45 kph	11	13	Overabundance
	Parking Prohibition	19	9	Overabundance
	Bike lane	4	2	Both side
Total		42	30	There is a sign at 24(33) m intervals on left (right) side of the road.

Remarks : Length of Tha Phae Rd. from Charoen Prathet Rd.to Tha Phae Gate:1km

Source : This study

Other Roads

Guide sign: There are few guide signs along the main roads in the city and systematic maintenance is not performed on such signs. Guide signs showing road names are provided at most road crossings.

Regulatory sign: Parking regulatory signs are adequately installed in the city. Speed regulatory signs (45 kph) are installed along the old city moat roads (a pair of one way streets) and Charoen Muang Road. Such speed regulatory signs are however seldom installed on other city roads. Stop lines and stop signs are particularly needed for the approach of a minor road to an intersection with a main road that is not signalized. However, these have generally not been implemented.

About 30 roads intersect the old city moat roads (a pair of one-way roads around the old city for about 6 km each). At such intersections, although traffic is required to stop before entering the one way streets, stop signs are only installed at some of the intersections. Furthermore, many of these are not clearly visible to drivers, as they are either obscured by telephone poles or wayside trees. At some locations, the sign plates are missing leaving only the poles. Maintenance of such signs is unsatisfactory. The U-turns on the one-way roads on both sides of the old city moat at intervals of about 200m-300m are functioning well. Guide signs for such U-turns are also sufficiently provided.

Warning sign: Warning signs are not installed although they are required upstream from sharp road curvatures, such as the corners of the old city moat. Warning signs are particularly needed to warn drivers of the direction changes of roads ahead during the night. Installation of delineators is also necessary to provide direction guidance at night

near to such road sections. Warning signs for pedestrian crossings are adequately installed in the city.

Others: Most road signs are not reflective to car headlights and visibility of such signs at night is therefore poor. Reflective sheets are available for road signs and contain tiny glass beads for reflection on the surface. Many such reflective sheets are used in Japan to improve visibility of road signs at night. Considering the number of traffic accidents that occur at night, it is desirable to make greater use of reflective materials on road signs in Chiang Mai city.

(2) Road Marking Situation

Super Highway

Road markings on Super Highway are installed according to the installation standards of DOH.

Other Roads

The present condition of road markings for other roads is listed as below:

- Many of the line markings are 10 cm in width or less, which is far narrower than the 15 cm commonly used in Japan. For this reason, visibility of such markings is low even in the daytime.
- Some markings are not suitable, such as direction marking showing arrows pointing in all directions on one single lane.
- Zebra crossing markings are sometimes not provided at pedestrian crossings.
- Many of the lane markings have worn out. Without clear lane markings, vehicles will travel in a haphazard manner.
- Many non-signalized intersections do not have stop lines at the approaches.
- Yellow lines prohibiting stopping or parking are sometimes found in front of buildings or non-signalized intersections. Such markings are rather confusing.
- Red and white markings on curbsides near intersection for the prohibition of stopping or parking are not provided at T-type intersections of the moat roads.
- Roads without median strips have two yellow lines and chatter bars in the center of the roads.
- Visibility of road markings in Chiang Mai is generally not satisfactory. Visibility of markings is particularly poor at night. Considering many accidents have occurred at night, materials with a high reflective quality should be used.

From the above observations on road markings, it is desirable that road markings be improved and used more effectively to improve traffic safety. Further investigation into this issue is deemed necessary in order to devise more specific measures or recommendations.

(3) Basic Considerations

It is essential that the importance of spot traffic regulation signs be considered. The most appropriate locations for installation must be considered carefully. For this purpose, the visibility of such spot regulation signs and their level of recognition must be improved. For instance, regulatory signs within specific section may be reduced via more effective use of road markings. Since traffic accidents at night are high in Chiang Mai, the use of road markings with good visibility must also be considered.

As a reference, some survey results on the installation of traffic regulation signs in Japan are given below.

Table 6-11 Survey Results for the Installation of Traffic Regulation Signs in Japan

Requests from Road Users ^{*1}	
Appropriately install signs at locations that can be clearly seen from the vehicles	51%
Use brighter type of reflectors or illuminated signs	41%
Do not cluster signs at single location.	37%
Use bigger signs	36%
Use bigger characters or figures in the signs	35%
Display similar regulatory signs in markings on road surface	25%
Repeat signs	19%
Change colors of the signs	12%
Measures taken by Road Management Agency ^{*2}	
Use large signs while installation intervals are increased	28%
Combine with usage of road markings, or change to use as regulatory signs	21%
Simplify and reduce the number of signs that tend to cluster at intersection	14%
Revise the installation interval for traffic signs	8%
Reduce the number of sign poles by mounting signs on electric power or light poles	7%
Use internal illuminated signs	6%
Reduce size of signs used along back streets	6%
Reduce number of signs by using changeable traffic signs	5%

Notes: *1) The percentage of requests computed from multiple answers

*2) The number of police departments implementing such measures (multiple answers)

Source: This study

6.7 Hazardous Locations

(1) Existing Situation

Hazardous traffic locations such as those listed below, were identified based on such factors like their poor road alignment, poor sight distances, dangerous unsignaled intersections, as well as treacherous sudden and drastic road width or horizontal alignment changes.

Immediate measures to avert potential traffic accidents at these locations usually takes the form of installing appropriate warning signs and road mirrors. In the long term, improvements to road alignment, provision of traffic control signals, and widening of narrow road sections must be planned and implemented.

The following hazardous locations were identified through the following steps:

- Initial selection of potential locations along major streets with heavy traffic demand;
- Discussions with traffic management persons in the related agencies (Traffic Police, Municipal Council); and
- Site observation surveys.

Table 6-12 Hazardous Locations

No.	Dangerous Location	Existing Condition
1	Charoen Raj Road near Wat Sri Klong	<ul style="list-style-type: none"> • A 300 m, 2 lane road section with two-way traffic operation. The horizontal alignment is poor with a sharp curve, the diameter of which is only 40-60 meters
2	Chiang Mai-Lamphun Road at the southern side of Kelkaram T-junction	<ul style="list-style-type: none"> • A T-junction with a sharp curved corner. Traffic volume is high during peak hours. The lack of a safe sight distance makes this a hazardous location.
3	Chiang Mai-Lamphun Rd. on the southern side of Tha Satoi Rd.	<ul style="list-style-type: none"> • A sudden narrowing of road section from 4 lanes to 2 lanes.
4	Chiang Mai-Lamphun Rd. and Rat Uthin Rd. Intersection	<ul style="list-style-type: none"> • A sharp curve and poor sight distance. • Existence of a big tree in the middle of the approach to the access road. • No stop sign provided in southern direction and traffic volume is high on the access road. • Poor street lighting with blockage by tree.
5	Northern Approach of Wang Sing Kham Road near Rama IX Bridge	<ul style="list-style-type: none"> • Sharp corner approach on Wang Sing Kam Road near King Rama IX Bridge, • A two-way road with 2 lanes, having a clear sight distance of only 10 meters. • Guardrail provided at curved section.
6	Southern Approach of Wang Sing Kam Road near Rama IX Bridge	<ul style="list-style-type: none"> • Sharp corner approach section • A two-way road with 2 lanes, having a clear sight distance of only 20 meters • Guardrail provided only at the beginning of the curve.
7	End of Southern Section of Chang Klan Road	<ul style="list-style-type: none"> • Sudden change from 4 lanes to 2 lanes and a sharp curve section. Sight distance is good along 4 lane section but the sudden change into 2 lanes with a sharp curve has no sight distance. • Guardrail provided for about 25 meters along the curved section.
8	Chang Klan Rd. near Aom Muang Intersection	<ul style="list-style-type: none"> • A Y-junction with no clear sight distance from connecting roads. • Centerline and edge markings have faded entirely.
9 10	Inner Circular Road along the Moat near Suan Dok Gate and Chiang Mai Gate	<ul style="list-style-type: none"> • Traffic bottlenecks due to sudden narrowing of road at the two gates. The road changes from 4 lanes to 2 lanes at Suan Dok Gate, then from 2 lanes to 1 lane at Chiang Mai Gate.

Table 6-12 Hazardous Locations (continued)

No.	Dangerous Location	Existing Condition
11	At the 4 corners of the Old City	<ul style="list-style-type: none"> • Very sharp 90° turns with diameters of only about 50 meters
12	Moat	<ul style="list-style-type: none"> • Buildings at corners blocking the sight distance within 50 meters.
13		<ul style="list-style-type: none"> • Road markings have largely faded and invisible at night,
14		<ul style="list-style-type: none"> • The edge markings of the pavement are not clear
15	The Southern End of Chotana Rd.	<ul style="list-style-type: none"> • The southern end of Chotana Road suddenly narrows from two to one lane with a sharp curve to Sanamkila Rd. • The curved section has no sight distance.
16	Prakot Rd., Chang Phuak Rd. along the East-West Direction.	<ul style="list-style-type: none"> • Two roads connect the east and west area, which is located at the northern part of Rattanakosin Rd. • There are many T-junctions connected to these two roads. • Traffic accidents occur at the junctions due to lack of sight distance

Source: This study

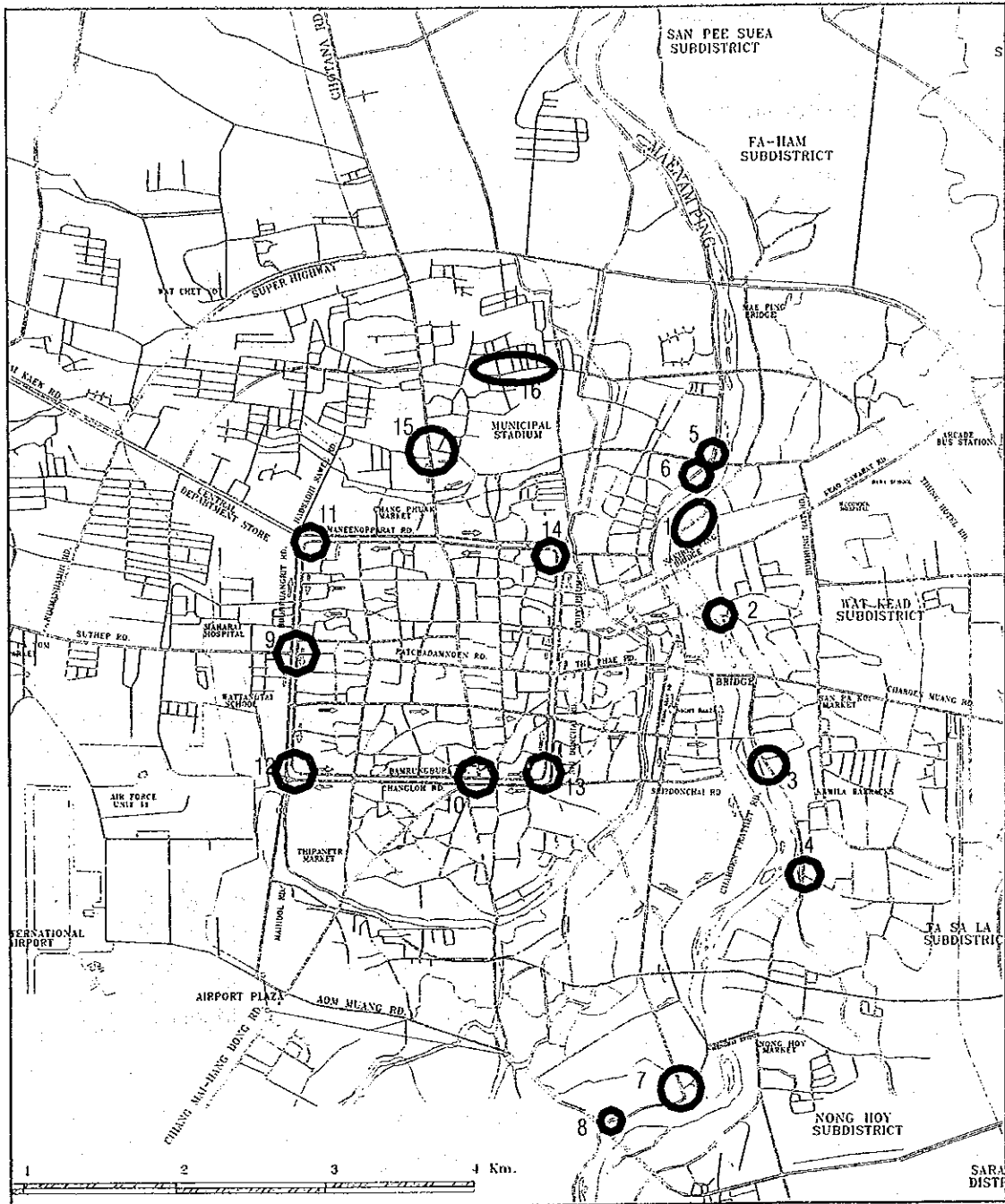


Figure 6-10 Traffic Hazardous Locations

(2) Applicable Guidelines for Hazardous Location Improvement

General

The improvements for hazardous locations may be classified as below.

- Poor road alignment and bad sight distance:
 - Install warning signs before the target section.
 - Install reflective indicators to ensure safe driving at night.
 - Install road mirrors at sections or locations with poor visibility.
- Unsignalized intersection with poor visibility
 - Install stop sign and stop line at approaches to all minor access roads of intersections.
 - Install road mirrors at sections or locations with poor visibility.
- Road section with sudden narrowing of width/lanes and sharp curves.
 - Install warning signs before such locations,
 - Install zebra markings to warn driver of such sudden geometric changes ahead, supplemented by road studs and reflective indicators.
 - Install road mirrors at mid-blocks or non-signalized junctions with poor visibility.

Guidelines for Road Mirror Installation in Mid-block

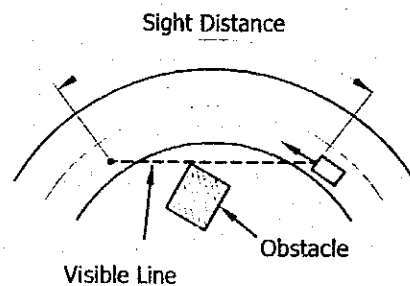
Road mirrors should be installed at mid-blocks when the roadway has two-way traffic with poor visibility and heavy traffic.

Guidelines for providing safe sight distances are given in the table below. Along road sections with sight distances below the recommended distance as shown, the risk of collision is much greater if any obstacles exist ahead.

Table 6-13 Minimum Safe Sight Distances at Mid Block

Type of Road Section	Vehicle Speed	Safe Sight Distance
Two-Way Road (less than two lanes)	30 km/h	More than 60 m
	20 km/h	More than 40 m
Two-Way Road (more than two lanes)	50 km/h	More than 55 m
	40 km/h	More than 40 m

Source: Japanese Road Mirror Installation Standards



Source: Japanese Road Mirror Installation Standards

Figure 6-11 Sight Distance of Two-Way Road

Guidelines for Road Mirror Installation in Intersection

Road mirrors should be installed in the intersection if the following characteristics exist:

- An unsignalized intersection of an access road with a major road, falling under either of the categories specified in the table below.
- Entrance and exit traffic volumes from the access road are heavy with numerous dangerous traffic conflicts.

To supplement the mirror, a yield sign and stop line markings should be implemented.

Target junctions shall be those that are along an arterial or main street and meet the above criteria (as verified by site investigations). Safe sight distances for traffic making left and right turns from the access road at such intersections are given below.

Table 6-14 Safe Sight Distances for Left and Right Turning Traffic from Junction

Sight Distance Required by Left Turning Traffic from the Access Road		Sight Distance Required by Right Turning Traffic from the Access Road	
Travel Speed on the Main Road	Running Distance on the Main Road	Travel Speed on the Main Road	Running Distance on the Main Road
40 km/h	62 m	40 km/h	44 m
50 km/h	78 m	50 km/h	56 m
60 km/h	93 m	60 km/h	67 m

Note: The running distance on the main road is computed by the following formula:

$$D(\text{or } D') = V(T + t(\text{or } t')) / 3.6$$

D (D'): Running distance of a vehicle on the main road (m)

V: Vehicle travel speed on the main road (km/h)

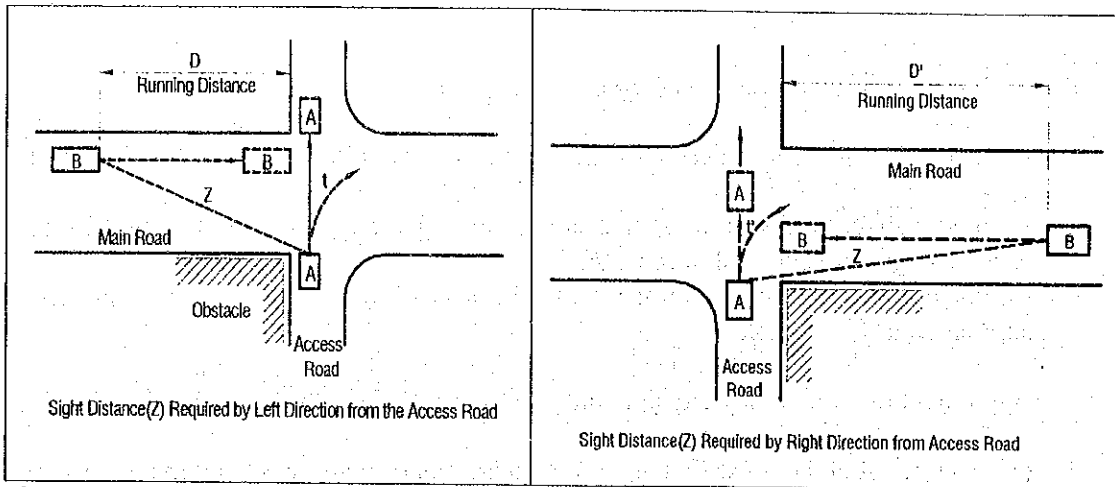
T: Reaction time (sec) for a vehicle from the access to take off after it sighted conditions on the main road (taken as 2 seconds for the above formula)

t: Time (sec) taken for a vehicle from the access road to cross the main road. (taken as 3.6 sec in the above formula)

t': Time (sec) taken by a vehicle from the access road to make a left turn onto the main road. (taken as 2 sec. in the above formula)

Source: Japanese Road Mirror Installation Standards

In unsignalized junction, it is necessary to install a road mirror when the sight distance (Z) from an access road is shorter than the running distance (D or D') on the main road.



Source: Japanese Road Mirror Installation Standards

Figure 6-12 Sight Distance Required by Traffic from the Access Road

Guidelines on Selection of Road Mirror

Road mirrors generally come in two forms: angular and circular. In Japan, the circular type of road mirror is most common. However, angular road mirrors are more suitable if both right and left views are important, and where two images need to be joined together. The size of the mirrors and their radii of curvature are given in the table below. A minimum diameter of 600 mm is recommended for all road mirrors.

Table 6-15 Size and Radius of Curvature of Road Mirror

Shape of Mirror	Size of Mirror (mm)	Radius of Curvature of Mirror (mm)
Rounded (Diameter)	600; 800; 1,000 mm	$\geq 1,500; 2,200;$
Quadrate (Vertical x Horizontal)	450 x 600 mm; 600 x 800 mm	3,000; 3,600 mm

Source: Japanese Road Mirror Installation Standards

Road mirrors installed in Chiang Mai have smaller diameters (450 mm), with a limited view range. Road mirrors with such small diameters should only be used at places where vehicle speeds are low (i.e. in off-street parking lots, residential areas, etc.).

The radius of curvature of a road mirror is determined in relation to the required sight distance. The standard correlation between radius of curvature and sight distance is given below.

Table 6-16 Correlation between Radius of Curvature and Sight Distance

Required Sight Distance(D)	D < 40 m	40 m ≤ D ≤ 60 m	60 m < D
Radius of Curvature (mm)	1,500 mm; 2,200mm	3,000 mm	≥ 3,600 mm

Notes: 1) Road mirrors must possess sufficient structural strength.
 2) Due to common vandalism, materials with a good structural strength must be used.
 Source Japanese Road Mirror Installation Standards

Functions of Road Delineator

Delineators, also known as road studs, provide drivers with sight guidance, particularly during nighttime driving. In particular, reflections from vehicle headlights permit the driver to view the alignment and road width clearly, obviously improving traffic safety. As such, delineators or road studs are installed on both sides of a road.

During the day, drivers use the lane markings and guardrails as guidance for operating their vehicles. At night, the effectiveness of the markings and guardrails drops considerably as visible sight distances are cut drastically. These facilities are only visible within a constrained distance, which is limited by the power of the headlights and the presence of fog. For this reason, the installation of delineators particularly along road sections with potential hazardous sections is a necessity to ensure traffic safety at night.

Although it would be ideal and desirable to install delineators continuously along both flanks of a road, its function become even more effective if it is installed along road sections that posses sudden alignment or road width changes.

Table 6-17 Examples of Studies on the Effectiveness of Road Delineators

Examples	Two-way, 2 lanes road in Arizona, USA ^A	State boundary roads in Louisiana, USA ^B	Exit nose along Expressway ^C
Impacts	Travel speed along road section installed with delineators is faster by 5.4 km/h than state average. Vehicles also tend to run closer to the road center. However, there is not a clear effect on traffic accident reduction.	Although there are no significant effects on travel speed and travel location, most drivers however indicated that the delineators have given them considerable help in night driving.	Number of vehicles stopping or reversing near the nose has been reduced significantly, indicating that the delineators produced desirable effects in terms of promoting smoother and safer traffic flows.

Sources:

^A Highway Research Board Bull.255(1960)

^B Arizona Highway Dept. Research Report June 1963

^C NCHRP Report 145. Highway Research Board (1973)

There are very few delineators provided along roads in Chiang Mai city, a potential explanation for the frequent occurrence of nighttime traffic accidents. The Municipality of Chiang Mai has provided sight guidance facilities, in the form of alternate yellow and

black zebra-type stickers on telephone poles along a particular section of Suthep Road. (yellow stickers on painted black poles). The reflection from the yellow reflective sheets is obviously more effective than just normal painted surfaces.

In 2002 however, the Municipality began using 3M Scotchlite-type reflective sheets on sign poles. These did not stand out clearly at night since the reflective sheets were relatively small in size and the intervals poles was too far, thus making them ineffective for sight guidance.

It is important for the Municipality to prepare and adopt good installation standards on such sight guidance facilities in order to achieve the most effective results.

Standards for Delineator Intervals

The Japanese standard installation interval for delineators along road sections in relation to the road radii are shown in the table below.²

Table 6-18 Standard Installation Intervals of Delineators in Japan

Curve Radii (m)	Installation Interval (m)
50 < R	5.0
51 < R < 80	7.5
81 < R < 125	10.0
126 < R < 180	12.5
181 < R < 245	15.0

Note: 1) R = Curve Radii

2) Installation Interval (S) is given by the following formula: $S = 1.1\sqrt{R - 15}$

Source: Japanese Road Mirror Installation Standards

Furthermore, the installation interval should be precise and close enough to inform drivers of road changes. Lastly, the installation position on guardrails (or other safety devices) must be carefully chosen so that sight guidance and safety for the drivers will not be compromised.

Standards for Delineator Specification

Specifications for delineators including color, size, height, etc. are summarized below.

- Reflectors are differentiated by colors depending on where they are installed. Those installed on the left-hand side of a road should be colored white, whereas those on the right-hand side or along the median should be colored orange.
- Reflector diameter is normally determined by road and traffic conditions. In general, the diameter should be between 70 - 100 Mm.
- Installation height should be standardized, as despite the fact that those placed at low heights have been found to be effective, they pose maintenance problems. In general, the installation height shall be between 50-100 cm, with a standard of 90 cm being

² Delineators are installed along all road sections with sudden road width and alignment changes, unless nighttime illumination is considered to be sufficient and safe.

- commonly adopted.
- Road studs should be used when installation of delineators is difficult. These shall be installed along the curbside markings or along center line markings of road sections with sudden alignment changes.

6.8 Other Traffic Safety Devices

(1) Guard Fence

Guard fences such as guardrails for vehicles or guard cables along the roadway side of sidewalks are inadequate. Such facilities are limited to only specific areas, and are installed more for the intention of prohibiting the random crossing of pedestrians near to busy intersections in the shopping district. Where an overpass is present, guard rails along the median of the road are installed to prevent surface crossing to encourage the use of the overpass.

Guardrails should in fact be installed for the purpose of protecting pedestrians along narrow sidewalks or corners from the possibility of impact from vehicles. At intersections with sharp corners, for instance, vehicles losing control may sometimes mount the curb and injure pedestrians on the sidewalk.

6.9 Summary of Issues

(1) Traffic Safety Issues

- One of the main issues on traffic safety in Chiang Mai is the exceptionally high incidence of traffic accidents, where the injury ratio is 3 times, and fatality ratio 5 times more than that of Japan.
- High accident frequency locations are found on Super Highway in Chiang Mai. The main reason is that those junctions operate at-grade.
- Most of traffic accidents are due to unlicensed driving and drunken driving. Reckless driving habit is another major cause of traffic accidents.
- More than 70% of those persons injured or lost their lives due to accidents are motorcyclists. (refer to chapter 8.3 for motorcycle issues).
- About 50% of all motorcycle riders do not wear safety helmets. Motorcycles with 3 or more persons are common. Most pillion riders do not wear helmets, the rate of which is much lower than that for the riders. It is clear that the high injury and fatality rates among motorcyclists involved in traffic accidents are due to the reluctance of the users to wear the safety helmet required by law.
- A high proportion of persons involved in accidents are motorcyclists in the younger age groups. Mitigation measures must be implemented.
- Traffic accident rate is higher at night.
- Traffic safety measures for pedestrians are lagging behind those for the automobiles. Most motorists have little regard for the pedestrians on roads, such as when they are crossing the streets.

- Pedestrians, including tourists, have to contend with a general lack of safe and comfortable sidewalks, pedestrian crossing signals and signalized pedestrian crossings along busy streets.

(2) Sidewalk

- Results of investigations on the existing pedestrian sidewalk show that safe and comfortable sidewalks for pedestrians in the city are grossly inadequate even outside the old city. The average width is found to be only 1.5 m.
- Most sidewalks are interrupted by trees, telephone and light poles, sign posts and are at a substantially higher level than the roads, making them difficult for elderly citizens and people with handicaps.

(3) Road Signs

- A thorough review on the suitability and the exact installation location of road signs especially on the city streets is urgently needed.
- The size and figures of road signs generally require enlargement to improve legibility.
- Reflectivity of road signs is generally poor and requires improvement by the use of better reflective materials.

(4) Road Markings

- Center line, lane line, pedestrian crossing and stop lines are important markings which must be provided.
- No stopping or parking signs must be supplemented by prohibition markings.
- Visibility of markings requires improvement by increasing marking width, use of stronger materials for wear and tear, and with higher reflective quality.

(5) Other Traffic Safety Devices

- Guardrails are insufficient and should in fact be installed for the purpose of protecting pedestrians along narrow sidewalks or corners from the possibility of impact from vehicles.
- The reflective material for the chatter bar currently installed in the central belt of roads is hardly reflective.