CHAPTER 5

ROAD NETWORK

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5.1 EXISTING ROAD NETWORK CHARACTERISTICS

It is clear without a word that a road network is a basic infrastructure to support a transport system. Without an appropriate road system, many modes of transport including buses, passenger cars, trucks and motorcycles can not be operated properly. Consequently, a road system's role in a transport master plan is very significant.

5.1.1 Road Condition Survey

Field surveys were carried out to investigate the present road conditions in the Study Area. The Road and Bridge Division, DPWT had already compiled a road inventory for the urbanized area in the municipality. Using the data collected during the field survey, a considerable portion of this inventory was updated and supplemented with data of suburban areas. The outcome is finalized and summarized as the Road Inventory in Appendix 5-1.

5.1.2 Road Classification by Administrator

In general, roads are classified according to the governmental agency responsible for the administration of the road; *ie.* national road, provincial road, municipal (city, town, village) road, etc. In Cambodia, National Roads (NRs) are clearly designated as important arterial roads. Other roads are categorized into Provincial (Municipal) Road, District Roads and Commune Roads. In reality, however, there is no list of roads by such categories. Consequently, the total length and other data of roads by these categories are not available. In addition, actual maintenance/rehabilitation works of all of Municipal Roads, District Roads and below are implemented by DPWT. These facts lead to a rather limited sense of road classification by administrator among the concerned agencies/officials.

5.1.3 Road Hierarchy in the Study Area

The concept of road hierarchy is widely used by road planners in many countries. Under this concept, roads are classified into three types based on their functions; arterial road, collector road and local road. Arterial roads are main roads with the highest standard and cater for large volumes of traffic with longer trip length and higher travel speed. On the contrary, local roads are directly connected to houses, shops and other facilities and serve as the primary access to the road users. Collector roads connect the arterial roads and local roads. It is also widely accepted that a good road network should be well balanced from viewpoint of road hierarchy.

(1) Road Network in the Suburban Area

Figure 5.1-1 shows the present road network in the suburban area. The NRs are functioning as principal arterial roads mainly in the radial directions, and the proposed Outer Ring Road and the Inner Ring Road (existing: Sts. 70, 271 and 272) are serving as the principal arterial roads for the circular movement. Major Municipal roads are functioning as collector roads.

According to the road inventory prepared by DPWT, the total length of roads in the Municipality of Phnom Penh is 782.7 km. Out of 783 km; about 306 km are roads in the urban area. Thus the total length of suburban roads is 477 km. This indicates that the density of roads in the suburban area is considerably lower than that of the urban area. In addition, local roads, which connect communities and/or houses to the collector/distributor roads, are not sufficient.

National Road Network

All principal NRs, except NR 7, are connected to Phnom Penh. NR 7 is not directly connected to Phnom Penh, but joins NR 6 at Skun, Kampong Cham Province, a city located about 55 km northeast of Phnom Penh, and NR 6 enters Phnom Penh with about 100 km travel distance from Skun. Thus, practically, all the principal NRs are centered in Phnom Penh. Therefore, It may be said that traffic conditions in Phnom Penh influence the economy and other socioeconomic activities of the entire nation, and *vice versa*; the inbound and outbound traffic volume of the Study Area is expected to increase as the traffic volume on these NRs increases. More details are given in Appendix 5-2.

(2) Urban Streets

Figure 5.1-2 shows the road network in the urbanized area. (In this figure, arterial streets are subdivided into "principal arterial" and "minor arterial". Minor arterials cater for the traffic with shorter trip length.) The urban road network is well planned and developed. Table 5.1-1 shows a summary of the urban road inventory. The total length of the network is approximately 306 km. The typical distribution of a functional urban system as per the American Association of State Highway and Transport Officials (AASHTO) is shown in Table 5.1-2. A comparison of this distribution with that of the urban roads in Phnom Penh in Figure 5.1-3 shows that the urban road network has a well-balanced road hierarchy.

The total area of the streets in the urbanized area is estimated as about 5 km^2 accounting for 18.5% of the urban area, which compares favorably with other capital cities as shown in Table 5.1-3.

Table 5.1-1 Urban Road Network

Road Classification	Total Length (km)	Percentage	Total Area (Km^2)
Arterial Road	54	17.3	1,380
Collector street	26	8.4	536
Local Road	231	74.3	3,091
Total	311	100.0	5,007

Source: Road Inventory prepared by DPWT, MPP and revised after the joint field survey conducted by the Study Team and the Counterparts.

Table 5.1-2 Typical Urban Functional System

Systems	Length (%)
Principal Arterial Plus Minor Arterial System	15 –25
Collector Street System	5 – 10
Local Street System	65 - 80

Source: A Policy on Geometric Design of Highways and Streets, AASHTO, 1994

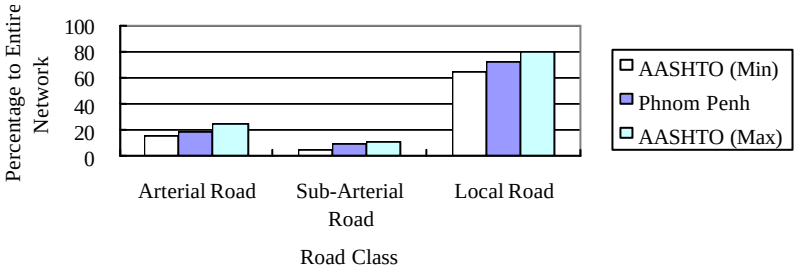


Figure 5.1-3 Composition of Road Hierarchy:

Table 5.1-3 Road Area Rate in Phnom Penh and Other Capital Cities

Name of City	Road Area Rate (%)
Washington DC	25.0
Paris	20.0
London	16.6
Tokyo (Urban)	15.2
Phnom Penh	**18.5**

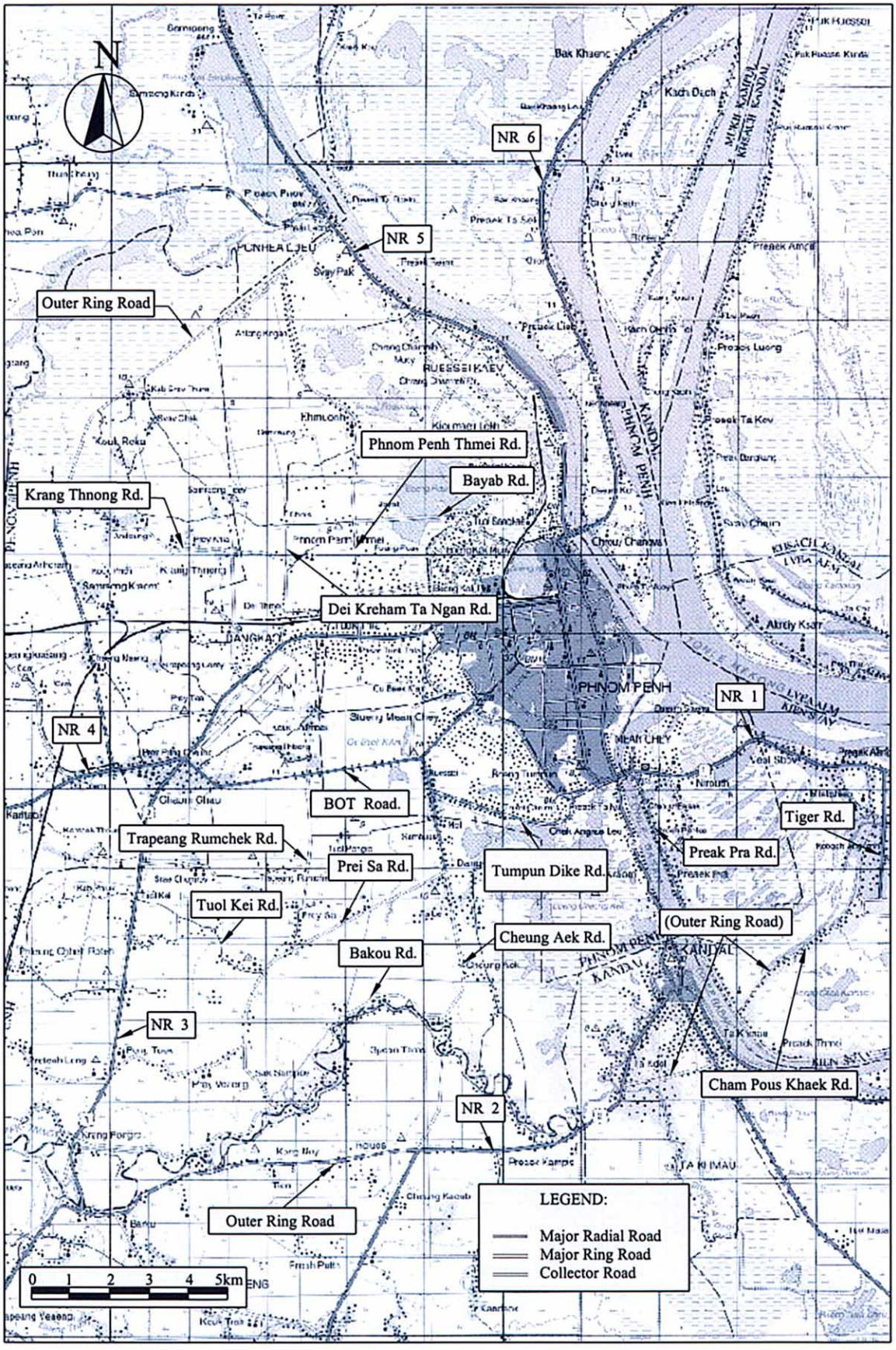


Figure 5.1-1 Road Network in Suburban Area

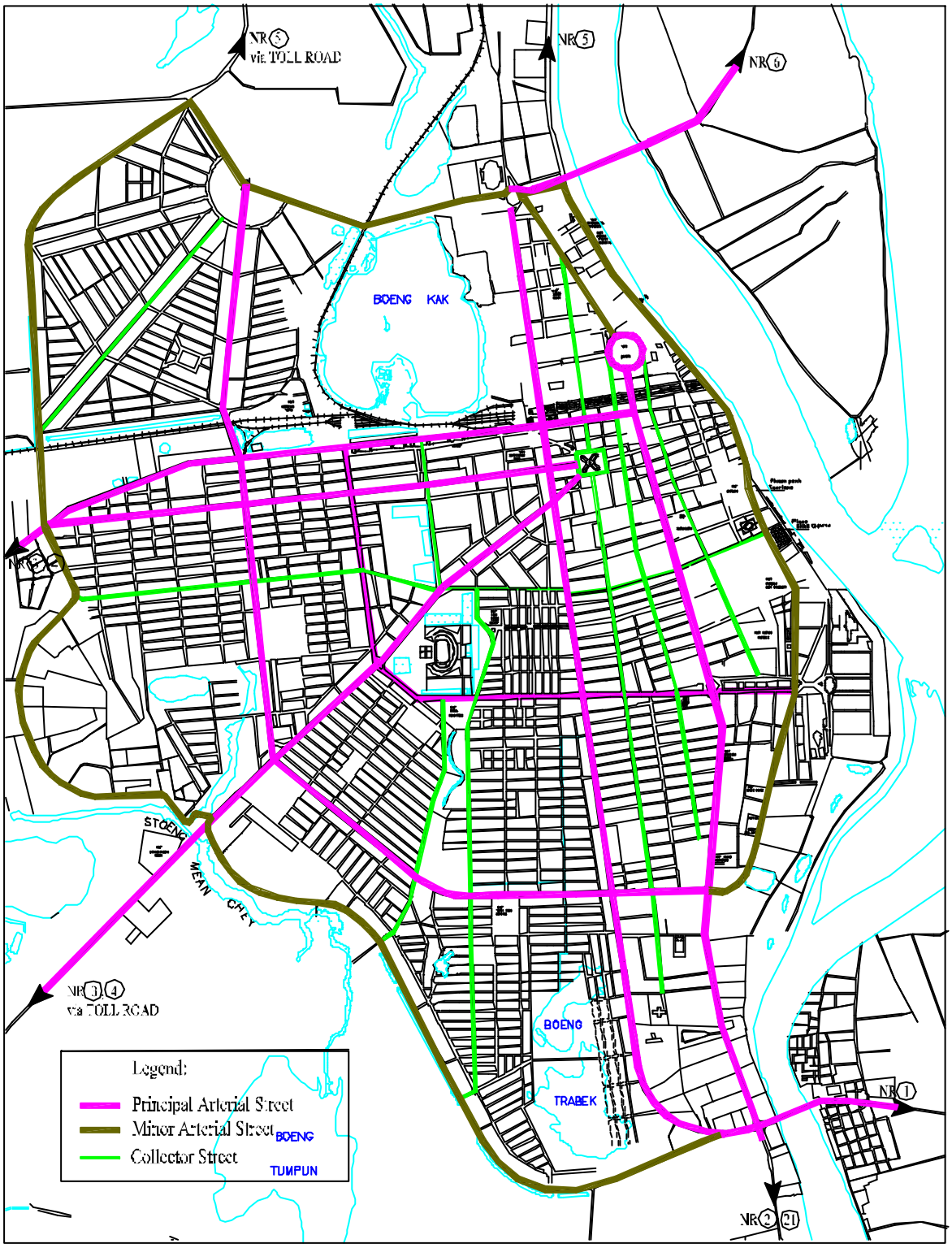


Figure 5.1-2 Road Network in Urbanized Area

5.2 ROAD GEOMETRY AND CONDITION

Unfavorable geometry of roads, such as insufficient width and sub-standard curve, often causes traffic congestion and/or traffic accidents. In this section the geometry of the roads in the Study Area is reviewed.

5.2.1 Cross Section

(1) Urban Streets

Many of the principal urban arterial streets in Phnom Penh have right-of-way width of 30 meters or more and carriageway width of 18 meters, as seen the road inventory in Appendix 5-1. Typical cross-sectional composition of these roads is as shown in Figure 5.2-1. Cars, trucks and buses use the center lanes while motorcycles and cyclos use mainly the right lane. The shoulders are used as parking space unless it is prohibited.

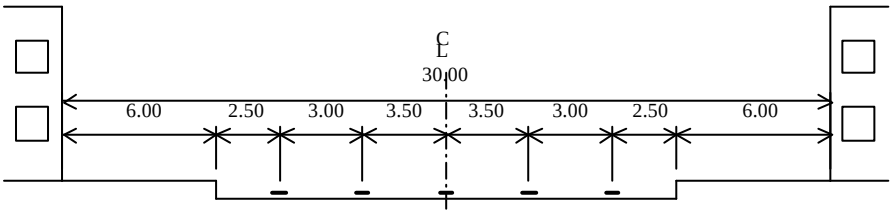


Figure 5.2-1 Typical Cross-section of Arterial Road

Usually, wide sidewalks are provided on both sides of the major arterial streets. These sidewalks are quite often used as parking space, creating obstructions for pedestrians.

The road markings at present are often worn out and practically non-existent or not visible, and division of lanes and shoulders are not clear. DPWT is currently improving the road marking. The newly laid road markings are of thermal-plastic type and seem to be of satisfactory quality.

Collector streets have less wide right-of-way and carriageway. Widths of carriageways of the majority of the collector streets are 8 to 12 meters. Quite often, sidewalks are occupied by various kinds of vendors/shops such as repair shops of motorcycles and on-street barbers, and part of carriageway is blocked by motodops and cyclos waiting for passengers and cars parked for some business with the road side shops. As a result, it is rare that the full width of the carriageway can be used by the traffic.

(2) Suburban Roads

National Roads

National Roads (NRs) in the suburban area typically have 7.0 to 8.0 meter-wide paved carriageways plus 2 to 3 meter-wide unpaved shoulder on both sides. Figure 5.2-2 shows the typical cross-sectional composition of NRs in the suburban area.

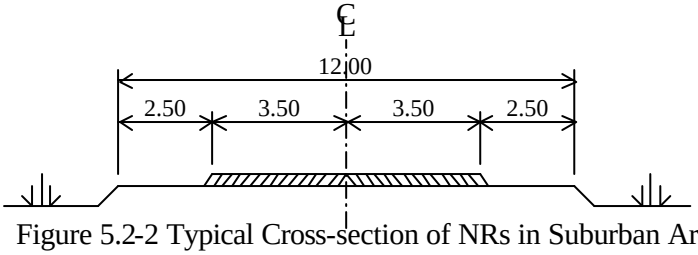


Figure 5.2-2 Typical Cross-section of NRs in Suburban Area

This cross-section is similar to the standard cross section used in many other countries. Owing

to the relatively low traffic volume on the NRs, vehicles can travel smoothly except when they overtake slow-going vehicles such as motorumok and cattle-driven carts. The slow-going vehicles, on the contrary, have to pull onto the unpaved shoulders when harrassed by the trucks frustrated by the slow-going vehicles.

Municipal Roads

According to the road inventory prepared by DPWT, Municipal roads in the Study Area have wide variation in width, ranging from 30 meters to less than 3 meters. Figure 5.2-3 shows the distribution of roads by width. This figure includes data of urban streets, as most of the roads with width of 10 meters or more are urban streets.

Most of the municipal road network has a width of 8 meters of less. A road width of 8 meters is considered to be the minimum width for an opposed two-lane road. Helped by the very low traffic volume on these roads, this narrow road width is not causing serious traffic congestion at present. It is easily foreseen that this width will become the cause of traffic congestion in the future as traffic volume increases.

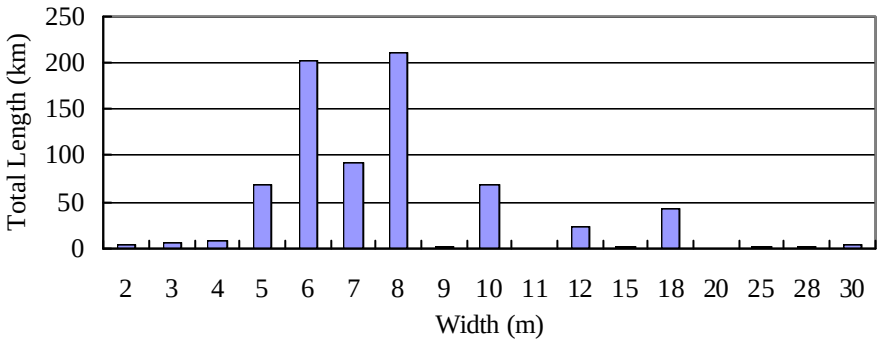


Figure5.2-3 Distribution of Road Length by Width

Regulation on Roadside Clearance

Combination of incomplete road network, poor surface condition and narrow road width makes the road condition very severe, and is hampering the sound development of the suburban area. Recently, the Government (MPWT) issued a new regulation prohibiting construction of buildings within the distances from the centerline of the roads as shown in Table 5.2-1.

Table 5.2-1 Minimum Distance from Centerline to Roadside Building

Road Category	Distance from Centerline to Roadside Building (m)
National Road No. 1, 4, 5	30
National Road No.2, 3, 6, 7,	25
National Road No 11, 22, 64, 78	25
Provincial Road	20
Commune Road	15

5.2.2 Alignment

(1) Vertical Alignment

Roads in the Study Area generally have flat vertical alignment owing to the flat topography of the area, and no serious problem is found in the vertical alignment. Several spots with steep gradient are seen adjacent to the small bridges in the suburban area. These sections are relatively short, and are not the primary factor of traffic hazard due to the relatively low travel speed of the vehicles due to poor surface condition.

(2) Horizontal Alignment

As for horizontal alignment also, roads in the Study Area have only few problems. Unfavorable horizontal curves are found (1) along NR No. 1, in front of Chbar Ampauv Market located on the east side of Monivong Bridge, and (2) along the Inner Ring Road, about 50 meters north of the intersection with Monireth Street near a pumping station. Explanations of these locations with sub-standard alignment are given in Appendix 5-3.

5.3 PAVEMENT CONDITION

(1) Urban Streets

Compared to the developed condition of the urban road network, pavement condition of the urban roads in Phnom Penh is very poor. Figure 5.3-1 shows the percentages of each class of surface condition of the arterial streets. About two-thirds are classified as "fair" or "good", while the rest (32 %) is "bad" or "very bad".

Figure 5.3-2 shows the surface condition of the collector streets. Contrary to the case of the arterial streets, the total of "good" and "fair" remains only 41 percent, while "bad" and "very bad" occupy the rest, 59 percent.

Figure 5.3-3 shows the pavement condition of the local streets. It is clearly seen that the percentage of "very bad" is very high compared with those in arterial streets and collector streets.

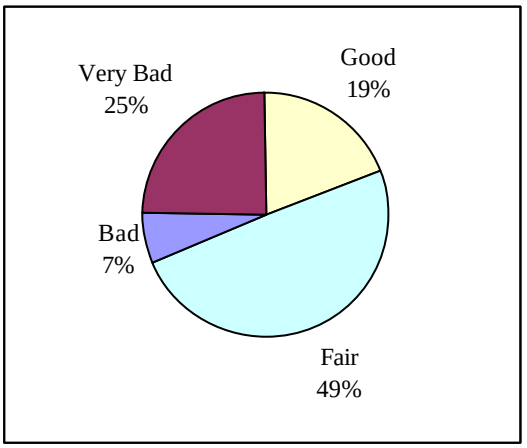
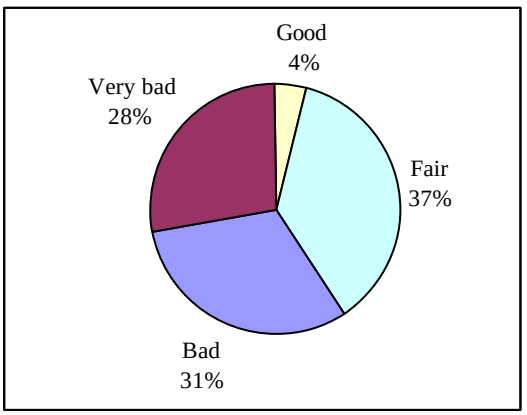


Figure 5.3-1 Pavement Condition of Arterial Streets



Good: Structurally intact with smooth surface
Fair: Structurally intact but rough surface; may need repair in near future
Bad: Many cracks with some pot holes; need careful drive to avoid pot holes
Very Bad: Many pot holes; substantial decrease in travel speed

Figure 5.3-2 Pavement Condition of Collector Streets

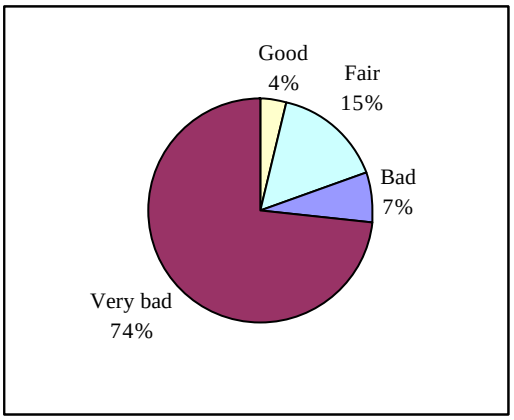


Figure 5.3-3 Pavement Condition of Local Streets in Central Districts

Because of the very poor condition of pavement on the local streets, drivers prefer to use the arterial streets, and traffic concentrates on these roads. Table 5.3-1 and Figure 5.3-4 show the comparison of the pavement conditions, surveyed on a random basis, of the four (4) Central Districts (Daun Penh, Prampi Makara, Chamkar Mon, Toul Kork). There is a substantial difference in pavement conditions among the Districts. Pavement conditions in Chamkar Mon and Toul Kork are very poor.

Table 5.3-1 Pavement Conditions of Local Streets in Central Districts

No	Name of District	Good (Km)	Fair (Km)	Bad (Km)	Very bad (Km)	Total (Km)
1	Daun Penh	3.53	8.88	2.75	4.20	19.35
2	Chamkar Mon	0.10	2.40	1.50	32.50	36.50
3	Prampi Makara	0.50	3.85	2.40	6.85	13.60
4	Toul Kork	-	0.25	0.50	29.90	30.65
Total		4.13	15.38	7.15	73.45	100.10
Percentage		4%	15%	7%	73%	100%

(Based on the Sample Survey)

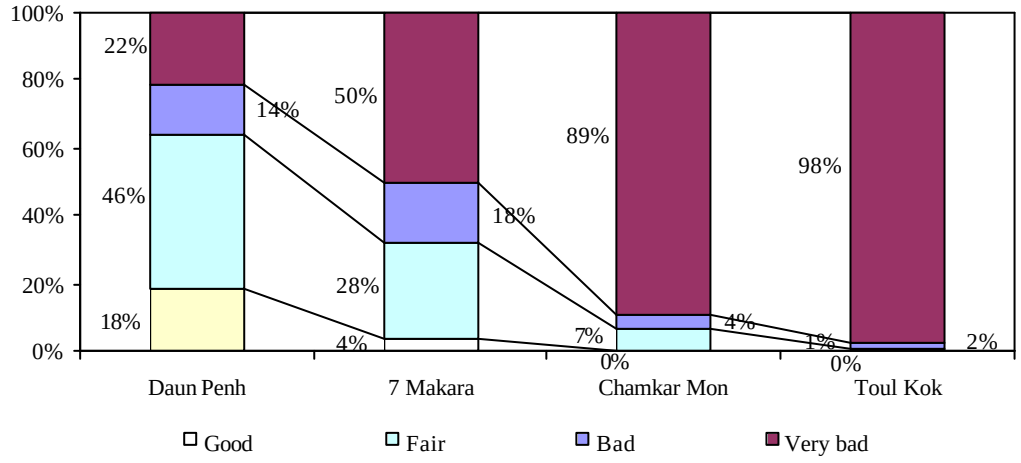


Figure 5.3-4 Pavement Conditions of Local Streets in Central Districts

5.4 INUNDATION

One of the major problems associated with roads in Phnom Penh is inundation. Due to malfunction of the drainage system and low elevation of the ground relative to the river water, many sections of the

urban roads are frequently inundated during the rainy season. The depth of inundation is as much as 50 cm, and the road sections become impassable, resulting in traffic jams. Fortunately, the inundation does not typically continue for more than one day. Figure 5.4-1 shows the road sections where inundation occurs frequently.

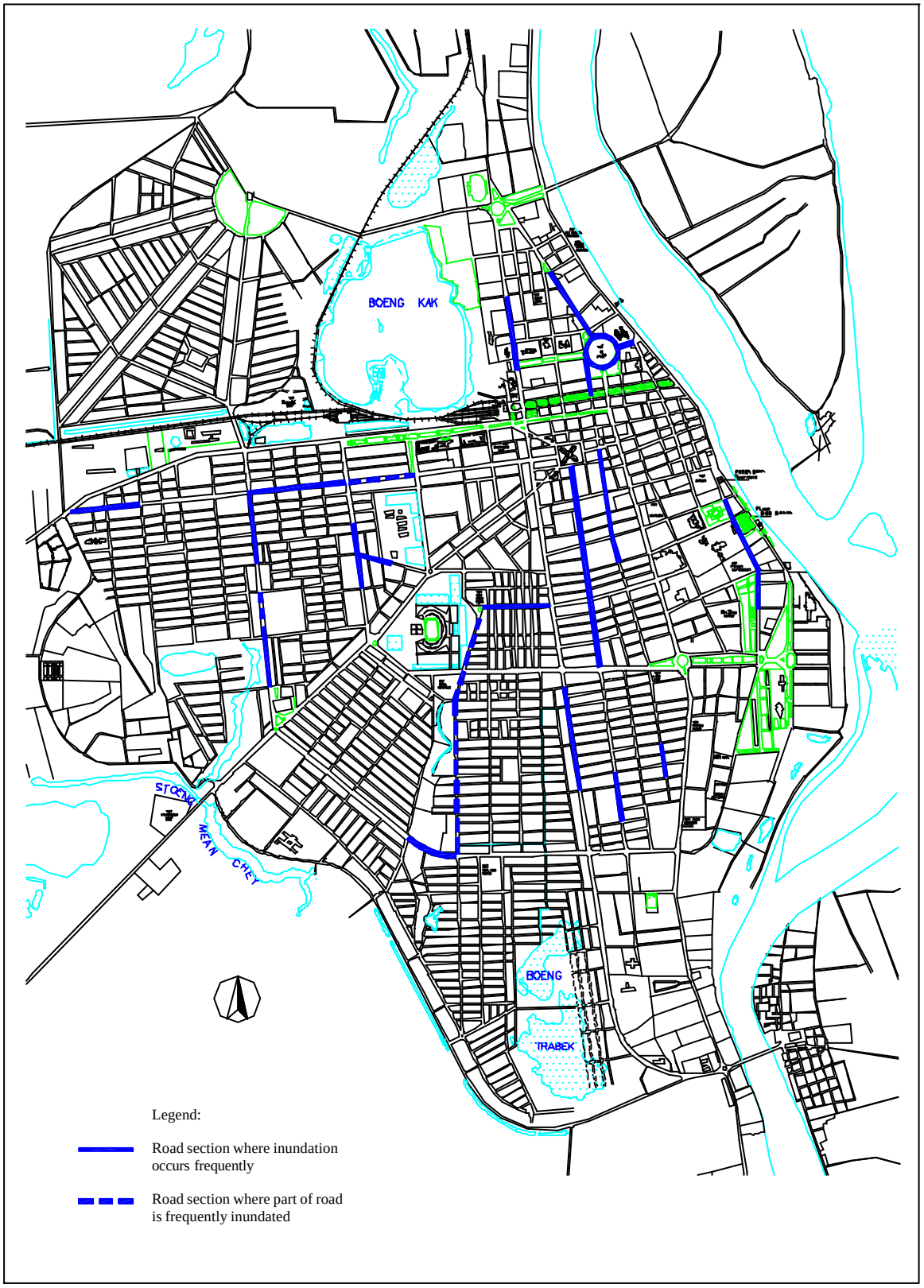


Figure 5.4-1 Road Sections with Frequent Inundation

5.5 BRIDGE STRUCTURE AND CONDITIONS

There are 30 bridges in the Study Area according to the list of DPWT, MPP and DPWT of Kandal Province. The locations of bridges in the Study Area are as shown in Figure 5.5-1. Many of these bridges are severely damaged and are not capable of supporting the required load. In particular, the bridges on the suburban roads other than NRs are in very poor and/or dangerous condition.

(1) Bridges in Urbanized Area

There are three (3) major bridges on the fringe of the urban area of Phnom Penh; Japan Bridge (Chruoy Changvar Br.), Monivong Bridge and Steung Mean Chey Bridge. While all of these bridges are judged to be structurally in good condition, the traffic volumes on Monivong Bridge and Steung Mean Chey Bridge are approaching the capacities of these bridges.

(2) Bridges in the Suburban Area

Bridges on National Roads

There are six (6) bridges along NR No. 6 in the Study Area. All of these bridges appear to have been designed and constructed in the same period because they have the same structure. The basic structure of these bridges is reinforced concrete simple beam of 12-meter span with 9.1-meter width carriageway. The number of span varies from one (1) to five (5) depending on the necessary length of the bridge. According to the memory of the local people, these bridges were constructed in 1962. Despite their age these bridges are structurally in good condition. The deficiencies of bridges on other NRs in the Study Area are described in Appendix 5-4.

Bridges on Municipal and Provincial Roads

The majority of the bridges on the Municipal roads are temporary structures and are in very bad condition. A number of these bridges can support only pedestrians and motorcycles. Almost all of the rest can carry only light motored-vehicles (passenger cars and light trucks with light or no cargo). These bridges are hampering the smooth transportation of people and goods. The rehabilitation/upgrading of these bridges is urgently required to improve the daily life of the citizens. A list and brief explanations of these bridges are given in Appendix 5-4.

5.6 INTERSECTION GEOMETRY AND CONDITIONS

Intersections often become traffic bottlenecks because the traffic of two or more roads meets at one place. When the geometry of an intersection is not favorable, traffic congestion becomes more severe. In general, intersections in the Study Area, in both urban and suburban areas, have good geometry owing to flat topography and enough side clearance. However, the following problems can be pointed out.

- Roundabout intersection with the central island of small diameter
- Intersection with skewed intersecting angle
- Intersection with more than four (4) legs

These types of intersections tend to have less traffic capacity than those with regular geometry. Presently, many of such intersections in Phnom Penh do not constitute bottlenecks owing to the mutual adjustment of the drivers. In the future, however, these intersections may become bottlenecks, as the traffic volume will increase. Problems are described in Appendix 5-5.

5.7 LEVEL OF SERVICE ON MAIN URBAN ARTERIALS

The concept of "level of service (LOS)" is widely used to describe the quality of traffic flow on a road. LOS is usually classified into six (6) categories of A to F. LOS A denotes the most favorable condition, and LOS F denotes traffic jam. A detailed explanation of Level of Service is given in Appendix 5-6. LOS D is usually adopted as the lowest allowable level in road planning.

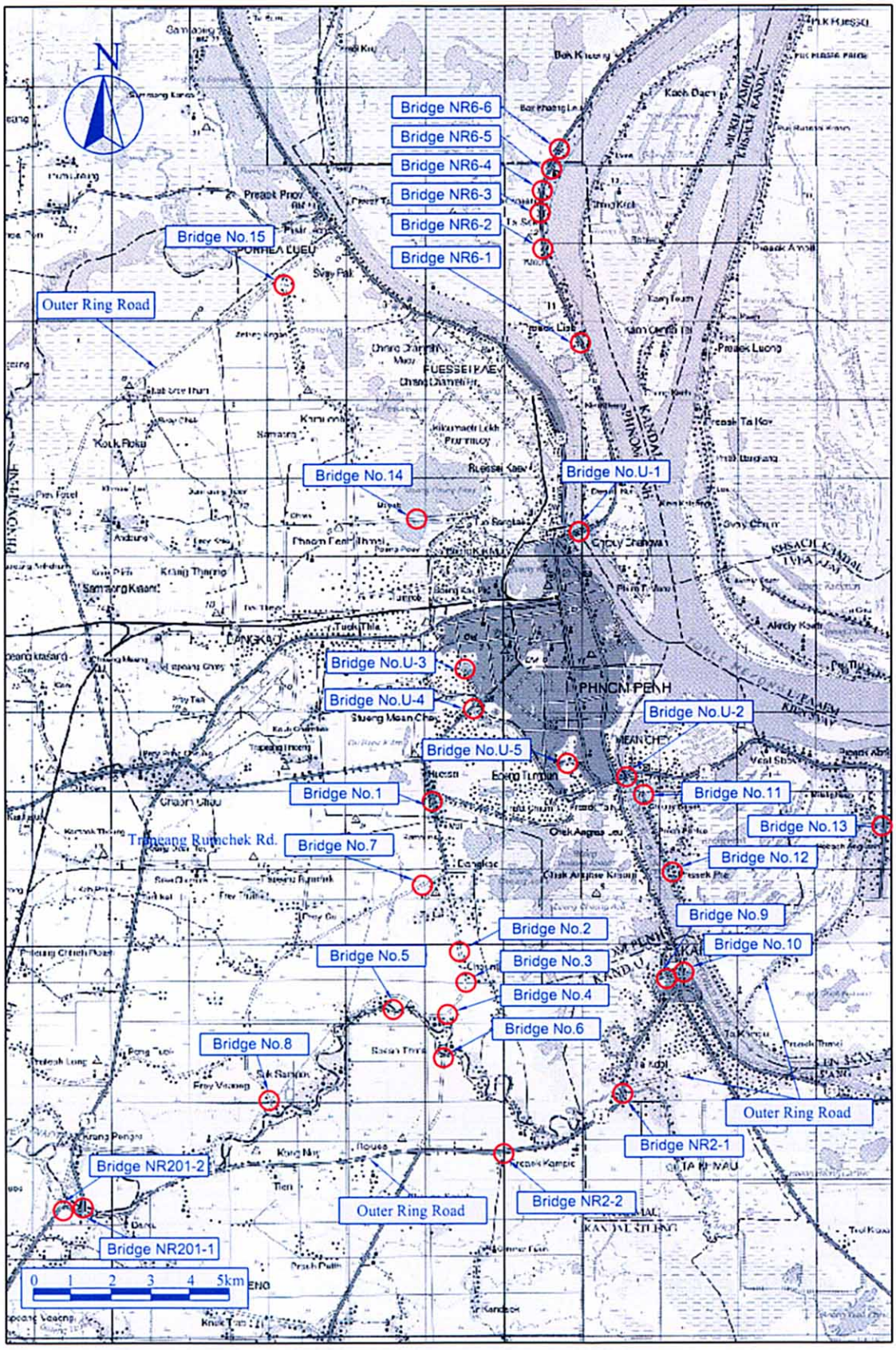


Figure 5.5-1 Location of Bridges in Study Area

5.7.1 LOS by Travel Speed

Table 5.7-1 shows the average travel speeds over the entire sections of major roads in Phnom Penh. As can be seen in the table, average travel speeds of the major arterial roads are still within the lowest acceptable range (LOS D). However, HCM defines that "LOS D" is the situation where "small increase in flow may cause substantial increase in delay and hence decrease in (arterial) speed." Therefore, even a small increase in traffic volume on these roads will lead to severe traffic congestion. In addition, travel speeds of those sections with LOS C are close to that of LOS D. Based on these facts, it can be said that **the traffic condition on the urban arterial roads is approaching an unacceptable level.**

Table 5.7-1 Travel Speed and Level of Service on Arterial Streets

Street Name		Direction	AM Peak Hr.		Noon		PM Peak Hr.		Average	
			km/hr	LOS	km/hr	LOS	km/hr	LOS	km/hr	LOS
Radial Roads	France / Norodom	N-bound	21.3	C	28.2	C	24.8	C	26.3	C
		S-bound	22.3	C	29.0	C	20.7	D	25.4	C
	Monivong	N-bound	19.9	D	26.2	C	20.6	D	23.3	C
		S-bound	22.4	C	26.3	C	20.7	D	23.8	C
	Charles de Gaulle / Monireth	NE-bound	14.1	D	20.4	C	16.4	D	17.4	D
		SW-bound	18.9	D	17.5	D	17.2	D	18.0	D
	Confederation de la Russie	E-bound	27.6	C	39.1	B	26.7	C	31.9	B
		W-bound	27.8	C	37.2	B	25.8	C	32.0	B
Ring Roads	Inner Ring Road	S/E-bound	18.7	D	21.9	C	20.4	D	20.5	C
		W/N-bound	18.7	D	21.1	C	19.4	D	20.1	C
	Kim Il Sung / Mao Tse Toung / Sisowath	S/E/N-bound	20.6	D	29.8	C	21.9	C	24.9	C
		S/W/N-bound	21.5	C	27.4	C	20.0	D	24.3	C
	Jawaharal Nehru / Sihanouk	S/E-bound	14.6	D	24.2	C	18.3	D	21.0	C
		W/N-bound	18.5	D	24.0	C	16.6	D	20.6	C

Travel speeds on Charles de Gaulle, Inner Ring Road (St. 271) and Sihanouk/Jawharal Nehru Blvd are lower than those of other major arterial roads. Suspected reasons for these lower travel speeds are as follows:

- Charles de Gaulle: Traffic congestion at three roundabout intersections on the route and very bad pavement condition.
- Inner Ring Road: Very bad pavement condition
- Sihanouk/Jawaharal Nehru: Severe traffic congestion

5.7.2 LOS by V/C Ratio

The ratio of traffic volume, v, to the capacity of the road, c, is also commonly used as an index for LOS for uniform road segments. Table 5.7-2 shows the LOS of the sections of Urban Arterial Roads in Phnom Penh based on the v/c ratios (VCR). In the calculation of this table, the assumptions shown in Table 5.7-3 were adopted. Figure 5.7-1 shows the road sections with VCR larger than 0.8. The surveyed traffic volume, VCR and travel speed on the arterial roads in the urbanized area are summarized comprehensively in Appendix 5-7. In these figures, it is seen that the travel speed becomes lower in the sections with higher VCR.

5.8 PROBLEM IDENTIFICATION

Given the factors described in the previous sections of this Chapter, the problems of the present road system in the Study Area can be briefly summarized as:

- Well balanced urban road network, but poor pavement condition of collector streets and local streets in the urbanized area

Table 5.7-2 Road Sections with VCR Larger than 0.8

Name of Road	Section (From→ To)	VCR	LOS
(a) Morning Peak Hour			
Tep Phan	Mao Tse Toung→J. Nerhu	1.08	E – F
	IRR→Mao Tse Toung	1.16	E – F
	Mao Tse Toung→IRR	1.29	E – F
Sihanouk	St 163→Monivong	1.05	E – F
	Monireth→St 163	0.90	E
	St 163→Monireth	1.25	E – F
Mao Tse Toung	St 163→Monivong	1.22	E – F
Monivong	Tep Phan→Sihnouk	0.82	E
	Sihonouk→Tep Phan	0.91	E
Confederation de la Russie	Tchecoslovaquie→J. Nerhu	0.86	E
	J. Nerhu→ Tchecoslovaquie	0.86	E
Kim Il Song	St 608→Conf. De la Russie	0.80	E
(b)Evening Peak Hour			
Name of Road	Section (From→ To)	v/c	LOS
Tep Phan	IRR→Mao Tse Toung	1.36	E – F
	Mao Tse Toung→IRR	1.18	E – F
Sihanouk	St 163→Monivong	1.07	E – F
	Sothearos→Norodom	0.85	E
Mao Tse Toung	Monireth→St 163	1.06	E – F
	St 163→Monireth	0.83	E
Conf. De Russie	Tchecoslovaquie→J. Nerhu	0.94	E

Table 5.7-3 Basic Assumption for Evaluating LOS

Basic Capacity	2,500 pcu/hour/lane
Pcu Conversion Factor	Motorcycle: 0.5 Cyclo/bicycle: 0.5 Heavy vehicle: 3.0

- Collector streets and local streets occupied by street vendors:
  Street vendors occupy not only sidewalks but also part of carriageway. Also the owners of shops along the road use sidewalks and part of carriageway as the extension of their shops. Customers coming to these shops and vendors park their vehicles (motorcycles and 4-wheel vehicles) on the street or sidewalks. All of these causes undesired road condition as follows:
  (i) Sidewalks are impassable for the pedestrians.
  (ii) Carriageway becomes narrow and side friction to the traffic increases, and the traffic capacity of the road is reduced.
- Inadequate suburban road network, together with narrow road width and poor pavement condition in suburban road areas:
  Present poor conditions of the municipal roads in the suburban area are hampering these roads from fully functioning as part of the road network. In addition, there are some areas with potential for future development that are not served by the present road network. Improvement of the existing municipal roads is required and construction of several new roads may be necessary.
- Damaged or deteriorated bridges:
  Many of the bridges in the suburban area are destroyed or severely deteriorated and cannot support the traffic. Reconstruction/replacement of these bridges are necessary.
- Inundation of roads:
  Many road sections, especially in the urban area, are often inundated during the rainy season. Malfunctioning of drainage/sewage system is the major cause of the inundation. The vehicles cannot pass the inundated sections and have to detour to passable arterial roads causing excess concentration and resultant traffic jam on the passable major roads. In addition flood water tends to seep in to the ground and reduces the bearing capacity of the sub-grade of road, substantially reducing the pavement life span. Therefore, rehabilitation of drainage/sewage system is needed before road improvement measures are implemented.

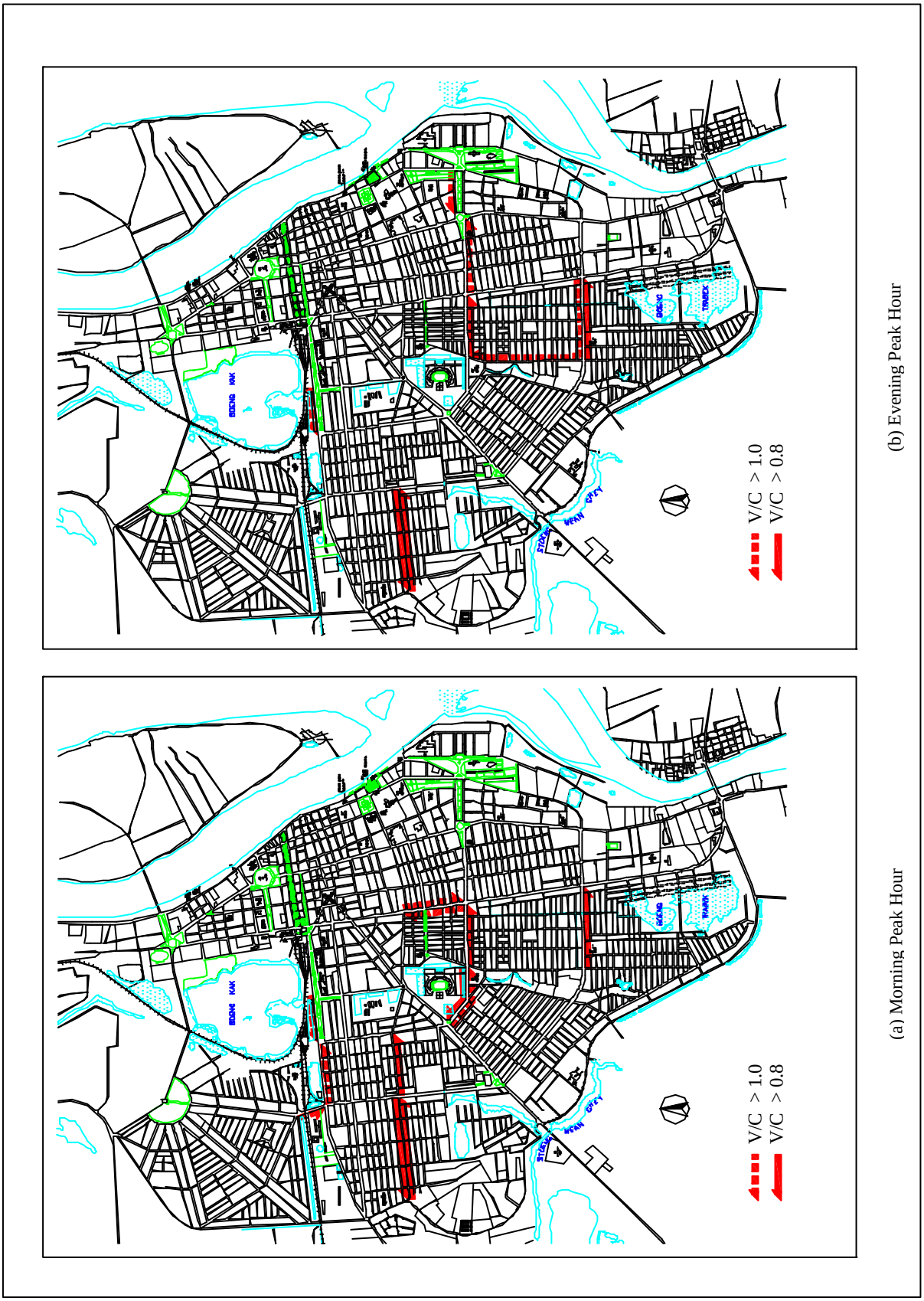


Figure 5.7-1 Road Sections with V/C > 0.8