D. SOIL & TOPOGRAPHY

D-1. Drilling Logs

NORAK ENGINEERING Co, Ltd. — **WATER CONTENT & N-VALUE**

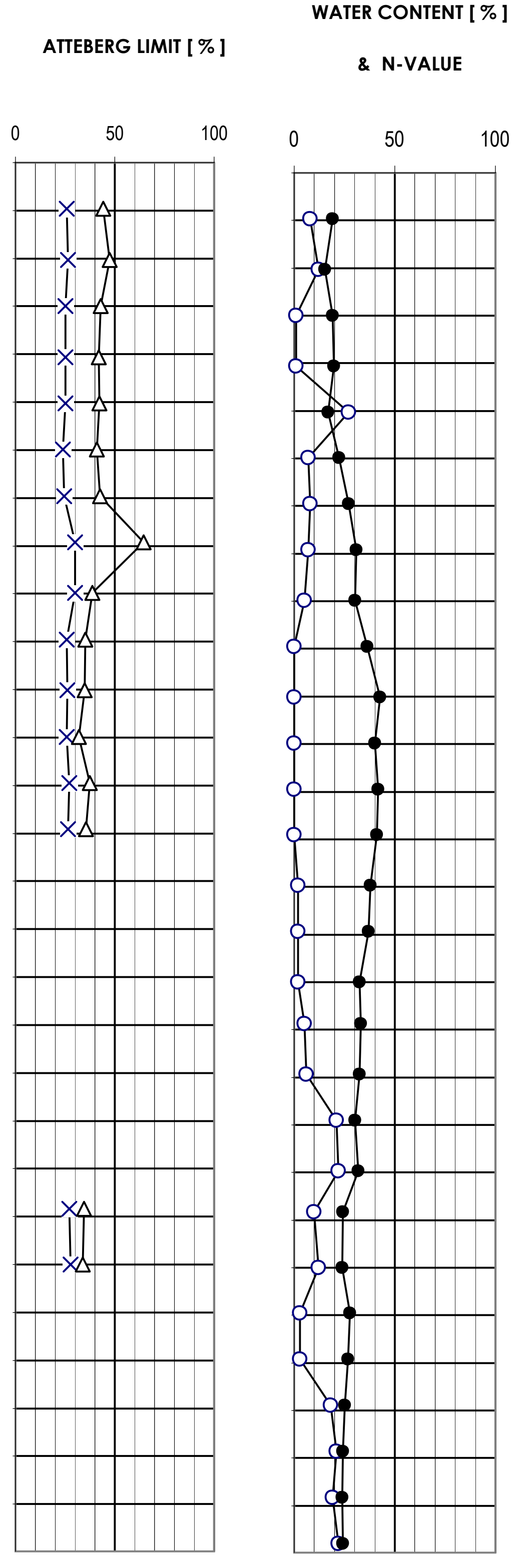
SOIL TESTING LABORATORY — *BOREHOLE No SPT 1*

SHEET	1
DATE	17'/06/02

WATER CONTENT, N-VALUE & ATTEBERGE LIMIT

Project: WATER GATE	Owner:	●	**Natural water Content %** ○ N- VALUE
	Contractor	Δ	**LIQUID LIMIT %**
Location: NATIONAL ROAD	**CH-** 41 + 026	×	**PLASTIC LIMIT %**
No 1, KIEN SVAY DISTRCT.			
	Elevation + 8.74		

DEPTH [m] 0.00	LEGEND OF SOIL	DEPTH OF SAMPLE	N-Value 30cm	SOIL DESCRIPTION OF STRATA
1.50		1.00 - 1.45	8	1/ Made ground
		2.00 - 2.45	12	2/ Stiff brown silty lean CLAY [CL]
3.00		3.00 - 3.45	1	3/ Very soft brown silty lean CLAY [CL]
		4.00 - 4.45	1	
5.00		5.00 - 5.45	27	4/ Very stiff brown silty lean CLAY [CL]
6.00		6.00 - 6.45	7	5/ Medium bronw silty lean CLAY [CL]
		7.00 - 7.45	8	
8.00		8.00 - 8.45	7	6/ Medium gray, yellow fat CLAY [CH]
9.00		9.00 - 9.45	5	7/ Medium brownish-gray lean SILT [ML]
10.00		10.00- 10.45	0	
		11.00 - 11.45	0	8/ Very soft brownish-gray and dark-gray
		12.00 - 12.45	0	
		13.00 - 13.45	0	fine sandy lean SILT [ML].
		14.00 - 14.45	0	
15.00		15.00 - 15.45	2	9/ Very loose dark-gray very silty fine
		16.00 - 16.45	2	
		17.00 - 17.45	2	SAND [MS]
18.00		18.00 - 18.45	5	10/ Loose dark-gray very silty fine
		19.00 - 19.45	6	SAND [MS]
20.00		20.00 - 20.45	21	11/ Medium dense dark-gray very silty
		21.00 - 21.45	22	fine to medium SAND [MS]
22.00		22.00 - 22.45	10	12/ Stiff brown fine sandy lean SILT [ML]
		23.00 - 23.45	12	
23.50		24.00 - 24.45	3	13/ Very loose gray, very silty fine to
		25.00 - 25.45	3	medium SAND [MS]
26.00		26.00 - 26.45	18	
		27.00 - 27.45	21	14/ Medium dense very silty fine to
		28.00 - 28.45	19	medium SAND [MS]
30.00		29.50 - 29.95	22	



NORAK ENGINEERING Co, Ltd.
SOIL TESTING LABORATORY

WATER CONTENT & N-VALUE

BOREHOLE No *SPT* 2

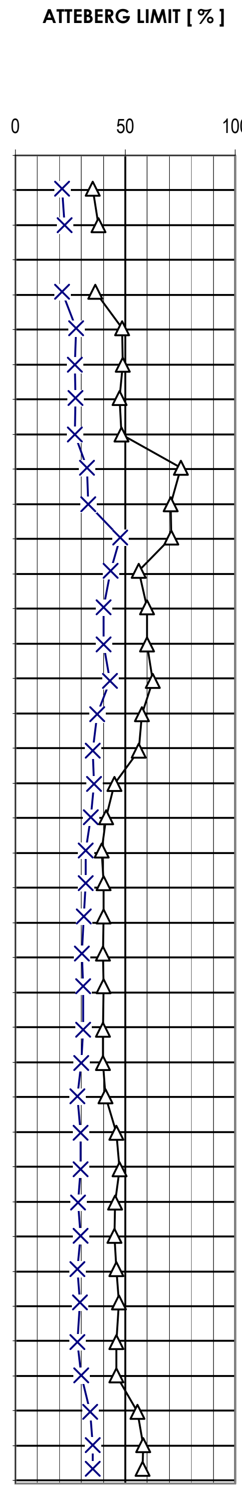
SHEET	2
DATE	17'06/02

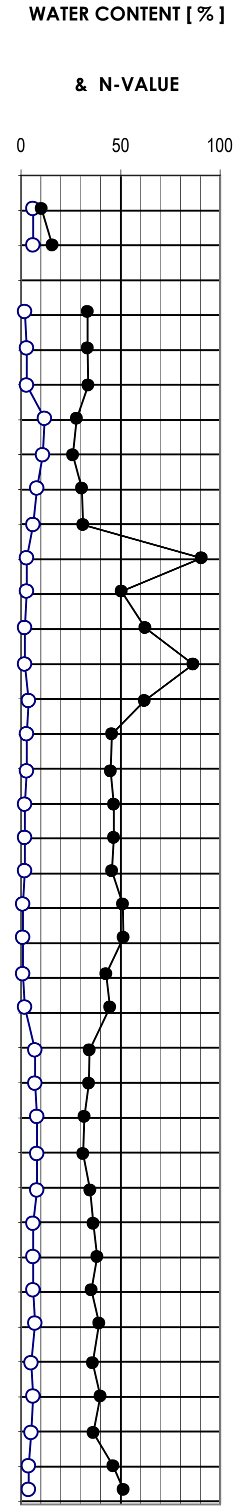
WATER CONTENT, N-VALUE & ATTEBERGE LIMIT

Project: WATER GATE	Owner:	●	**Natural water Content %**
	Contractor	Δ	**LIQUID LIMIT %**
Location: NATIONAL ROAD	**CH-** 50 +061	×	**PLASTIC LIMIT %**
No 1, KIEN SVAY DISTRCT.			
	Elevation + 8.15		

Legend: ○ N- VALUE

DEPTH [m]	LEGEND OF SOIL	DEPTH OF SAMPLE	N-Value 30cm	SOIL DESCRIPTION OF STRATA
0.00				
1.50		1.00 - 1.45	6	1/ Made ground
3.00		2.00 - 2.45	6	2/ Medium brown silty lean CLAY.
3.50		3.00 - 3.45	0	3/ Concrete slab of bridge.
		4.00 - 4.45	2	4/ Soft brown fine sandy, silt and lean
		5.00 - 5.45	3	
6.50		6.00 - 6.45	3	CLAY[CL]
		7.00 - 7.45	12	5/ Stiff brown and gray silty lean CLAY
8.50		8.00 - 8.45	11	[CL].
		9.00 - 9.45	8	6/ Medium gray and yellow fat CLAY
10.50		10.00- 10.45	6	(CH).
		11.00 - 11.45	3	
		12.00 - 12.45	3	7/ Soft dark-gray peaty fat SILT [MH]
		13.00 - 13.45	2	[organic soil].
15.00		14.00 - 14.45	2	
		15.00 - 15.45	4	8/ Very soft dark-grey and brownish-gray
		16.00 - 16.45	3	
17.50		17.00 - 17.45	3	peaty fat SILT [MH], [organic soil]
		18.00 - 18.45	2	
		19.00 - 19.45	2	
		20.00 - 20.45	2	
		21.00 - 21.45	1	9/ Very soft brownish-gray lean SILT[ML]
		22.00 - 22.45	1	
		23.00 - 23.45	1	
25.00		24.00 - 24.45	2	
		25.00 - 25.45	7	
		26.00 - 26.45	7	10/ Medium brownish-yellow clay,
		27.00 - 27.45	8	lean SILT [ML].
29.00		28.00 - 28.45	8	
		29.50 - 29.95	8	
		31.00-31.45	6	
		32.00-32.45	6	11/ Medium brownish-gray clay lean
		33.00-33.45	6	
		34.00-34.45	7	SILT [ML].
		35.00-35.45	5	
37.00		36.00-36.45	6	
		37.00-37.45	5	12/ Soft dark-gray peaty fat SILT [MH]
		38.00-38.45	4	
40.00		39.50-39.95	4	[organic soil].





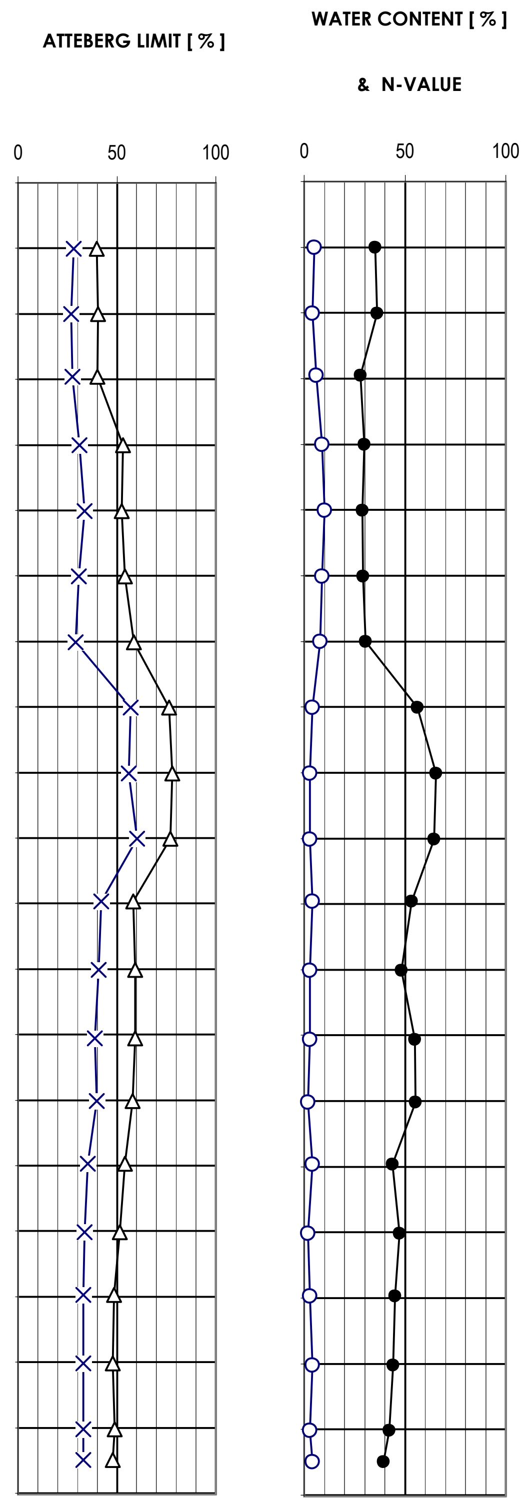
NORAK ENGINEERING Co, Ltd.	WATER CONTENT & N-VALUE	SHEET	3
SOIL TESTING LABORATORY	*BOREHOLE No SPT* 3	DATE	19'/06/02

WATER CONTENT, N-VALUE & ATTEBERGE LIMIT

Project: WATER GATE	Owner:	●	**Natural water Content %**
	Contractor	Δ	**LIQUID LIMIT %**
Location: NATIONAL ROAD	**CH-** 50+024	×	**PLASTIC LIMIT %**
No 1, KIEN SVAY DISTRCT.			
	Elevation + 6.26		

○ N- VALUE

DEPTH [m]	LEGEND OF SOIL	DEPTH OF SAMPLE	N-Value 30cm	SOIL DESCRIPTION OF STRATA
0.00		1.00 - 1.45	5	1/ Made ground
2.00		2.00 - 2.45	4	2/ Medium brown clay lean SILT [ML]
		3.00 - 3.45	6	
4.00		4.00 - 4.45	9	3/ Stiff yellow, gray and brown fat
		5.00 - 5.45	10	
		6.00 - 6.45	9	SILT [MH]
6.50		7.00 - 7.45	8	4/ Medium gray, yellow fat CLAY [CH]
8.00		8.00 - 8.45	4	
		9.00 - 9.45	3	
		10.00- 10.45	3	5/ Soft dark-gray peaty fat SILT [MH]
		11.00 - 11.45	4	
		12.00 - 12.45	3	[organic soil]
		13.00 - 13.45	3	
		14.00 - 14.45	2	
		15.00 - 15.45	4	
		16.00 - 16.45	2	
16.50		17.00 - 17.45	3	
		18.00 - 18.45	4	6/ Soft brownish-gray clay lean SILT[ML]
		19.00 - 19.45	3	
20.45		20.00-20.45	4	

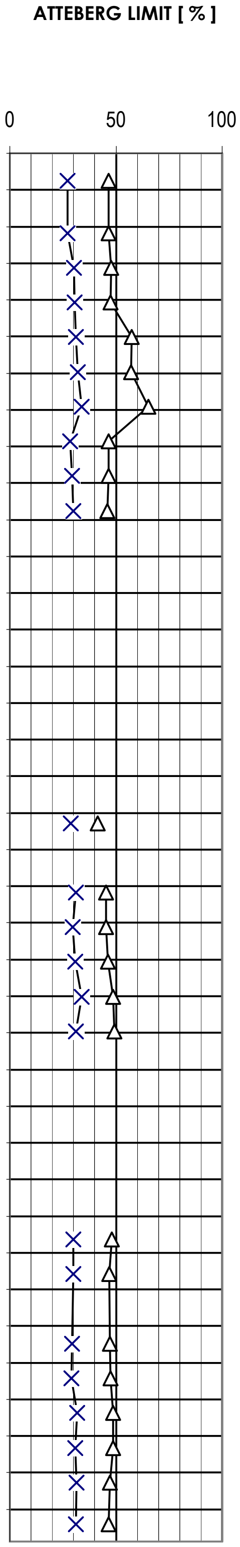


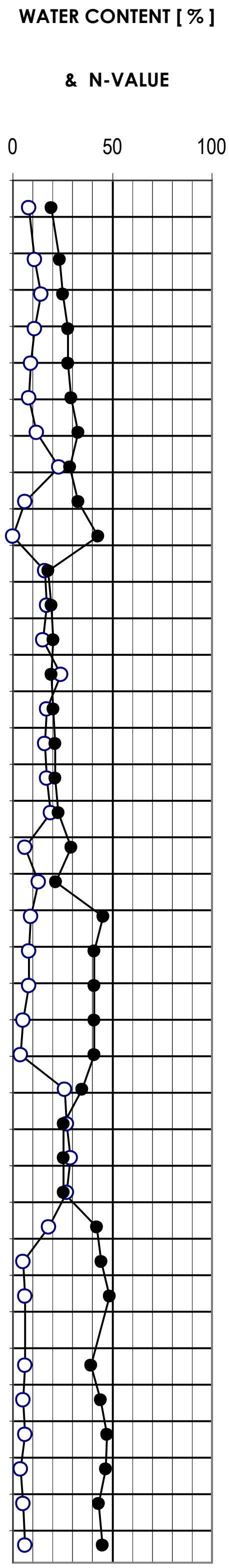
NORAK ENGINEERING Co, Ltd.	**WATER CONTENT & N-VALUE**	SHEET	4
SOIL TESTING LABORATORY	*BOREHOLE No SPT* 4	DATE	17'06/02

WATER CONTENT, N-VALUE & ATTEBERGE LIMIT

Project: WATER GATE	Owner:	● Natural water Content %	○ N- VALUE
	Contractor	Δ LIQUID LIMIT %	
Location: NATIONAL ROAD	**CH-** 42+100	× PLASTIC LIMIT %	
No 1, KIEN SVAY DISTRCT.			
	Elevation + 8.14		

DEPTH [m]	LEGEND OF SOIL	DEPTH OF SAMPLE	N-Value 30cm	SOIL DESCRIPTION OF STRATA
0.00		1.00 - 1.45	8	1/ Made ground [Stiff brown lean CLAY [CL] and lean SILT [ML]
		2.00 - 2.45	11	
		3.00 - 3.45	14	
		4.00 - 4.45	11	
5.00		5.00 - 5.45	9	2/ Stiff dark-gray clay fat SILT [MH]
		6.00 - 6.45	8	
		7.00 - 7.45	12	
8.00		8.00 - 8.45	23	3/ Very stiff gray fine sandy lean SILT[ML]
8.50		9.00 - 9.45	6	4/ Medium brown fine sandy lean SILT[ML]
9.50		10.00- 10.45	0	5/ Very soft gray fine sandy CLAY[CL]
10.50		11.00 - 11.45	16	6/ Medium dense gray very silty fine to medium SAND [MS]
		12.00 - 12.45	17	
		13.00 - 13.45	15	
		14.00 - 14.45	24	
		15.00 - 15.45	17	
		16.00 - 16.45	16	
		17.00 - 17.45	17	
18.50		18.00 - 18.45	19	
19.50		19.00 - 19.45	6	7/ Medium fine sandy clay, lean SILT[ML]
		20.00 - 20.45	13	8/ Medium dense silty fine SAND [MS]
21.00		21.00 - 21.45	9	9/ Medium dark-gray clay, fine sandy lean SILT [ML]
		22.00 - 22.45	8	
		23.00 - 23.45	8	
		24.00 - 24.45	5	
		25.00 - 25.45	4	
25.50		26.00 - 26.45	26	10/ Medium dense dark-gray very silty fine to medium SAND(MS).
		27.00 - 27.45	27	
		28.00 - 28.45	29	
		29.50 - 29.95	27	
		31.00-31.45	18	
31.50		32.00-32.45	5	11/ Medium brownish-gray, clay lean SILT [ML], with some fine sand.
		33.00-33.45	6	
		34.00-34.45	6	
		35.00-35.45	5	
		36.00-36.45	6	
		37.00-37.45	4	
		38.00-38.45	5	
40.00		39.50-39.95	6	





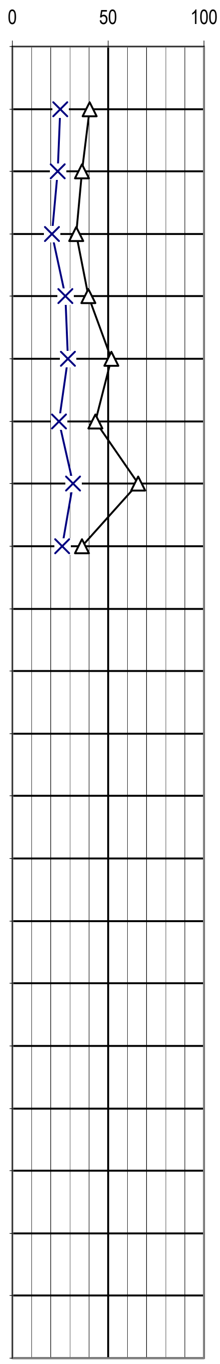
NORAK ENGINEERING Co, Ltd.	WATER CONTENT & N-VALUE	SHEET	5
SOIL TESTING LABORATORY	BOREHOLE No SPT 5	DATE	20'/06/02

WATER CONTENT, N-VALUE & ATTEBERGE LIMIT

Project: WATER GATE	Owner:	●	Natural water Content %
	Contractor	Δ	LIQUID LIMIT %
Location: NATIONAL ROAD	**CH-** 32+780	×	PLASTIC LIMIT %
No 1, KIEN SVAY DISTRCT.		○	N- VALUE
	Elevation + 8.77		

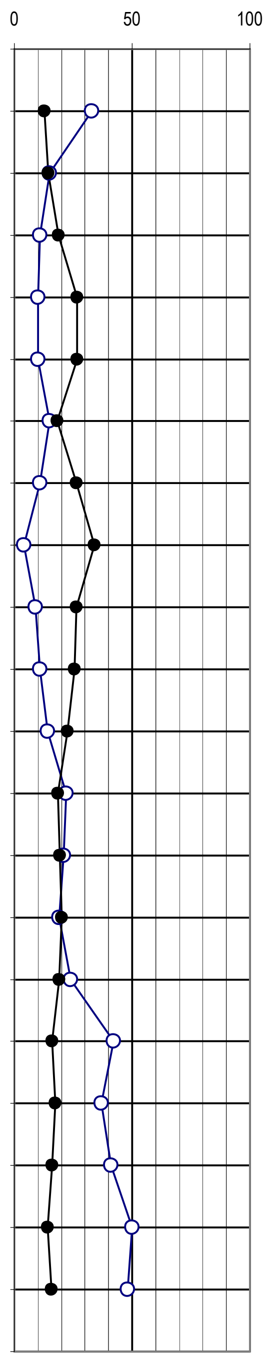
DEPTH [m]	LEGEND OF SOIL	DEPTH OF SAMPLE	N-Value 30cm	SOIL DESCRIPTION OF STRATA
0.00				
1.00				1/ Made ground
2.00		1.00 - 1.45	33	2/ Hard brown silty lean CLAY [CL]
		2.00 - 2.45	15	3/ Stiff brown silty lean CLAY [CL]
3.50		3.00 - 3.45	11	
4.50		4.00 - 4.45	10	4/ Stiff brown clay lean SILT [ML]
6.00		5.00 - 5.45	10	5/ Stiff gray, yellow clay fat SILT [MH]
6.50		6.00 - 6.45	15	6/ Stiff brown silty lean CLAY [CL]
8.00		7.00 - 7.45	11	7/ Stiff gray, yellow fat CLAY[CH], gravel.
8.50		8.00 - 8.45	4	8/ Soft dark-gray clay lean SILT[ML]
10.00		9.00 - 9.45	9	9/ Loose dark-gray silty fine SAND [MS]
		10.00- 10.45	11	10/ Medium dense gray very silty fine to medium SAND[MS]
		11.00 - 11.45	14	
		12.00 - 12.45	22	
		13.00 - 13.45	21	
		14.00 - 14.45	19	
16.00		15.00 - 15.45	24	
		16.00 - 16.45	42	11/ Dense gray very silty fine to medium SAND[MS]
		17.00 - 17.45	37	
		18.00 - 18.45	41	
		19.00 - 19.45	50	
20.45		20.00-20.45	48	

ATTEBERG LIMIT [%]



WATER CONTENT [%]

& N-VALUE

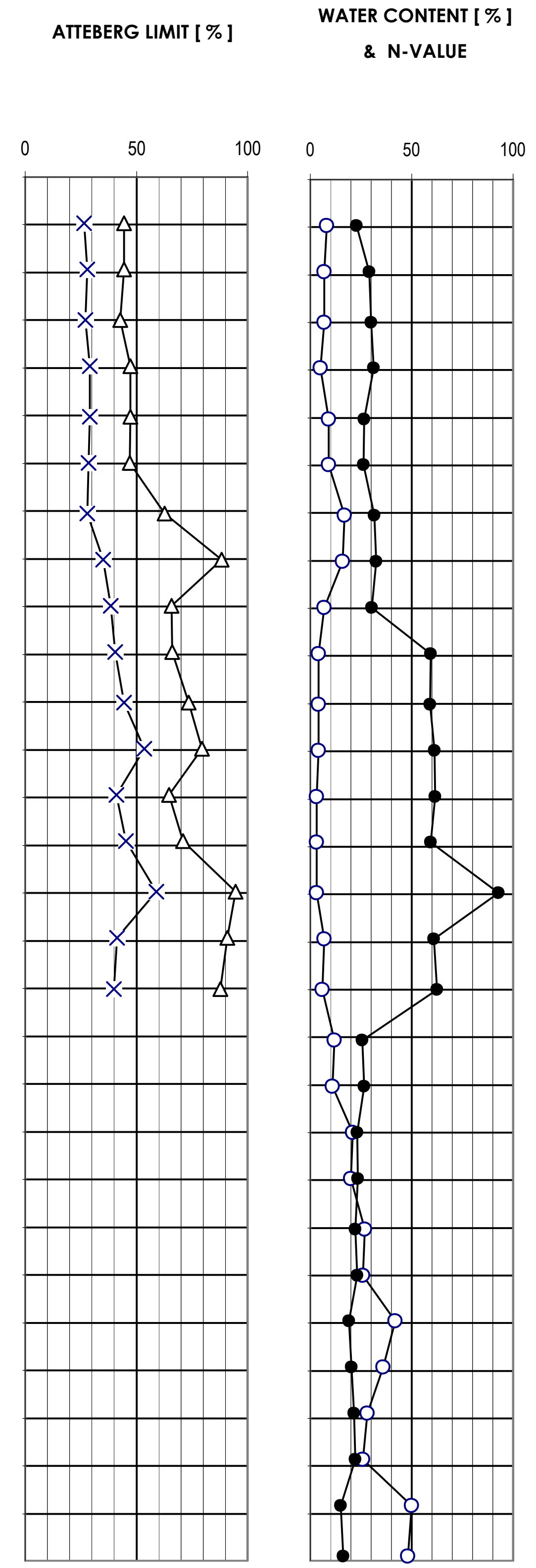


NORAK ENGINEERING Co, Ltd.	**WATER CONTENT & N-VALUE**	SHEET	6
SOIL TESTING LABORATORY	*BOREHOLE No SPT 6*	DATE	22'/06/02

WATER CONTENT, N-VALUE & ATTEBERGE LIMIT

Project: WATER GATE	Owner:	● Natural water Content %	○ N- VALUE
	Contractor	Δ LIQUID LIMIT %	
Location: NATIONAL ROAD	**CH-** 48 + 015	× PLASTIC LIMIT %	
No 1, KIEN SVAY DISTRCT.			
	Elevation + 7.98		

DEPTH [m]	LEGEND OF SOIL	DEPTH OF SAMPLE	N-Value 30cm	SOIL DESCRIPTION OF STRATA
0.00		1.00 - 1.45	8	1/ Made groud [Medium brown clay,
		2.00 - 2.45	7	lean SILT[ML]
3.50		3.00 - 3.45	7	
		4.00 - 4.45	5	2/ Medium trace sandy clay lean SILT [ML]
5.00		5.00 - 5.45	9	3/ Stiff brown clay lean SILT [ML]
6.50		6.00 - 6.45	9	
		7.00 - 7.45	17	4/ Very stiff gray and yellow fat CLAY
8.50		8.00 - 8.45	16	[CH]
9.50		9.00 - 9.45	7	5/ Medium peaty fat SITL [MH]
		10.00- 10.45	4	
		11.00 - 11.45	4	
		12.00 - 12.45	4	6/ Soft brownish-gray peaty fat SILT [MH]
		13.00 - 13.45	3	[organic soil]
		14.00 - 14.45	3	
16.00		15.00 - 15.45	3	
		16.00 - 16.45	7	7/ Medium dark-gray peaty fat SILT [MH]
18.00		17.00 - 17.45	6	[organic soil]
		18.00 - 18.45	12	
		19.00 - 19.45	11	
		20.00 - 20.45	21	8/ Medium dense gray very silty fine to
		21.00 - 21.45	20	
		22.00 - 22.45	27	medium SAND [MS]
24.00		23.00 - 23.45	26	
		24.00 - 24.45	42	9/ Dense gray very silty fine to medium
25.50		25.00 - 25.45	36	SAND[MS]
		26.00 - 26.45	28	10/ Medium dense gray very silty fine to
27.50		27.00 - 27.45	26	SAND[MS]
		28.00 - 28.45	50	11/ Dense gray very silty fine to medium
30.00		29.50 - 29.95	48	SAND[MS]



SOIL TESTING LABORATORY

FIELD BORING LOG

BOREHOLE No **1**

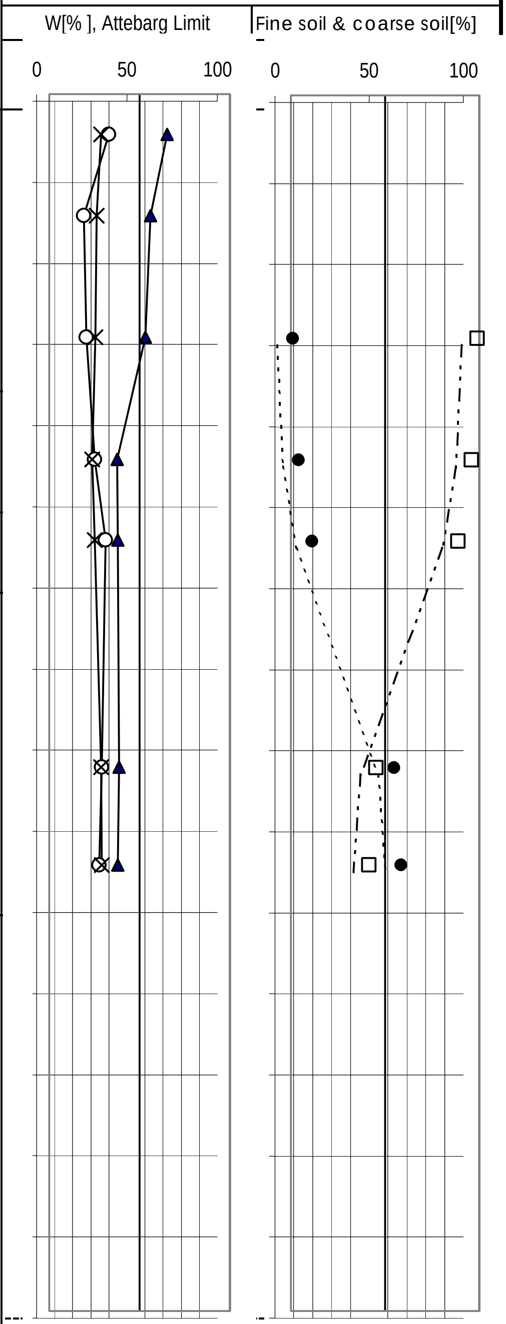
SHEET	**1**
DATE	01'07/02

METHOD: BORING BY ROTARY AUGER

Project: **National Road No 1, Kien Svay district, Kandal province, Kingdom of Cambodia.**	Owner:	○	Natural water Content %
	Contractor	Δ	LIQUID LIMIT %
Location: **National Road No 1. from Phnom Penh to Neak Loeung.**	Date started 2002/1/7	×	PLASTIC LIMIT %
	Date finished 2002/1/7	●	SAND & GRAVEL %
Elevation **+ 7.33**	CH- 2 + 480	□	CLAY & SILT %

DEPTH AND TYPE OF SAMPLES (M)	U	D	No	DESCRIPTION OF STRATA	DEPTH AND THICK.	LEGEND OF SOIL
0		D	1		0.00	
2		D	2	1/ Borwn trcae fine sandy silt fat CLAY. [CL]	[3.50]	
3		D	3		3.50	
4		D	4	2/ Yellow clay lean SILT [ML] , with some fine sand.	[1.50] 5.00	
6		D	5	3/ Dark-grey clay lean SILT[ML].	[1.00] 6.00	
8	U		6	4/ Grey silty fine SAND [MS].	[4.00]	
10		D	7		10.00	
11–15						

Natural and atteberg limit water content, fine & coarse soil[%]



Consistency and Relative Density

VS Very soft	VL-Very loose
S-Soft	L-Loose
M-Medium	Medium dense
ST-Stiff	Dense

Depth to water strike 4.00 M

Depth to water level after 20min. boring at 3.00 M Below on borehole.

G.W Ground Water Level

W.S Water strike

Figure

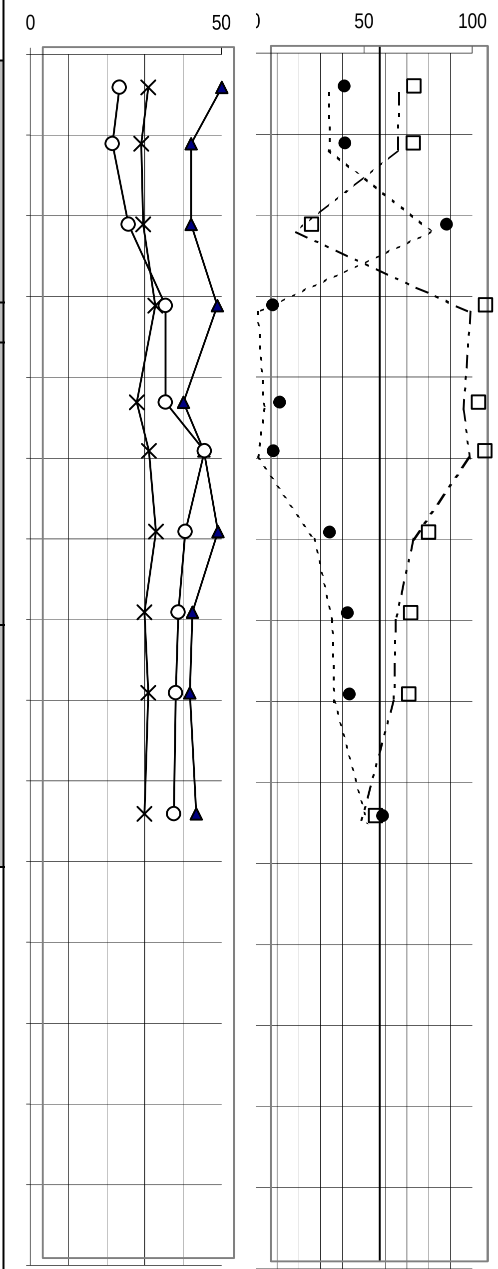
SOIL TESTING LABORATORY	FIELD BORING LOG	SHEET	1
	BOREHOLE No ***2***	DATE	2002/8/7

METHOD: BORING BY ROTARY AUGER

Project: **National Road No 1, Kien Svay**	Owner:	○	Natural water Content %
district, Kandal province, Kingdom of Cambodia.	Contractor	Δ	LIQUID LIMIT %
Location: **National Road No 1.**	Date started #####	×	PLASTIC LIMIT %
from Phnom Penh to Neak Loeung.	Date finished #####	●	SAND & GRAVEL %
Elevation **+ 6.65**	CH- 18 + 500	□	CLAY & SILT %

DEPTH AND TYPE OF SAMPLES (M)	U	D	No	DESCRIPTION OF STRATA	DEPTH AND THICK.
0 – 1		D	1		0.00
1 – 2		D	2	1/ Light yellow fine sandy silty lean CLAY.	[3.00]
2 – 3		D	3		3.00
3 – 4		D	4	2/ Brownisg-gray clayey trace fine sandy Lean SILT [ML]	3.50
4 – 5		D	5		
5 – 6	U		6	3/ Very soft brownish-gray and dark-gray clay lean SILT [ML], with some fine sand.	[3.50]
6 – 7	U		7		7.00
7 – 8		D	8		
8 – 9		D	9	4/ Dark-gray fine sandy clay lean SILT [ML]	[3.00]
9 – 10		D	10		10.00
10 – 15				END OF BOREHOLE 10.00M DEPTH.	

Natural and atteberg limit water content, fine & coarse soil[%]



Consistency and Relative Density

VS Very soft	VL-Very loose	Depth to water strike 7.00 M
S-Soft	L-Loose	Depth to water level after 20min. boring at 4.00 M Below on borehole.
M-Medium	Medium dense	**G.W** Ground Water Level
ST-Stiff	Dense	**W.S** Water strike

Figure

SOIL TESTING LABORATORY	FIELD BORING LOG	SHEET	1
	BOREHOLE No **3**	DATE	15/07/02

METHOD: BORING BY ROTARY AUGER

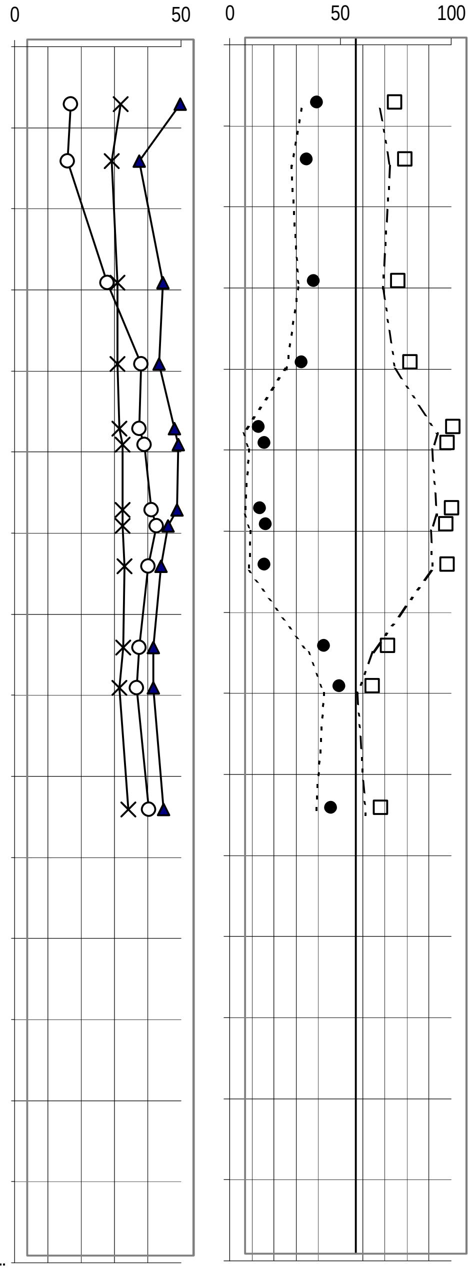
Project: **National Road No 1, Kien Svay district, Kandal province, Kingdom of Cambodia.**	Owner:	○	Natural water Content %
	Contractor	Δ	LIQUID LIMIT %
Location: **National Road No 1. from Phnom Penh to Neak Loeung.**	Date started 15/07/02	×	PLASTIC LIMIT %
	Date finished 15/07/02	●	SAND & GRAVEL %
Elevation **+ 6.47**	CH- 18 + 495	□	CLAY & SILT %

DEPTH AND TYPE OF SAMPLES (M)	U	D	No	DESCRIPTION OF STRATA	DEPTH AND THICK.
0					0.00
1		D	1		
				1/ Light yellow fine sandy clay lean SILT	[3.00]
2		D	2	[ML]	
3					3.00
		D	3	2/ Brownisg-gray clay trace fine sandy lean SILT[ML]	3.50
4	U		4		
5		D	5	3/ Soft brownish-gray and dark-gray	[3.00]
	U		6	clay lean SILT [ML], with some fine sand.	
6	U		7		
	U		8		6.50
7					
		D	9		
8					
		D	10	4/ Dark-gray fine sandy clay lean SILT	[3.50]
9		D	11	[ML]	
10		D	12		10.00
				End of SBH-2 at 10m. depth.	
11					
12					
13					
14					
15					

LEGEND OF SOIL

Natural and atteberg limit water content, fine & coarse soil[%]

W[%], Attebarg Limit | Fine soil & coarse soil[%]



Consistency and Relative Density

VS Very soft	VL-Very loose	Depth to water strike 7.00 M
S-Soft	L-Loose	Depth to water level after 20min. boring at 3.00 M Below on borehole.
M-Medium	Medium dense	**G.W** Ground Water Level
ST-Stiff	Dense	**W.S** Water strike

Figure

D-2. Additional Surveys in the Design Stage

The following geotechnical investigations and topographical surveys are recommended in the basic design stage.

1. Geotechnical Investigations

(1) Geotechnical investigations for bridges and culverts
Boring with standard penetration tests (STP) shall be conducted at the following locations

(i) Bridges
One bridge with 4 spans and two bridges with 3 spans are planned. Accordingly, the number of locations of boring/STP is as follows.

Structure	Number
Abutment	6
Pier	7
Total	13

(ii) Culverts
Thirteen culverts in total are planned. Boring/STP for two of them was conducted in this Study. Therefore, boring/STP is needed at 11 locations.

As the total, boring/STP needs to be conducted at 23 locations. The boring should be accompanied by sampling of soil and laboratory tests for physical properties of soils.

(2) Geotechnical investigations for soft ground

As explained in Sub-Section 13.1.4 “Embankment on Soft Ground”, no serious soft ground was found in this Study. However, also as explained in Sub-Section 13.1.4 and Appendix G-5 “General Consideration on Soft Ground”, diligent observation/investigation is required as the precaution to prevent “avoidable” failure of embankment.

In case of NR-1 C-1, the type of soft grounds are supposed to consist of deposits of rivers and lakes, not marine deposits. Therefore, the properties of soils can be completely different at locations only 10 m away with each other. Accordingly, it is not practically feasible to investigate the possibility of existence soft grounds along whole 55 km-long section by means of STP. Usual practice in Japan in such case is to carry our preliminary geotechnical investigation using handy apparatus, such as Swedish sounding apparatus or Dutch cone-penetrometer at every 100 m or so where existence of soft ground is suspected. However, such handy sounding apparatus is currently not available in Cambodia. If any of these apparatuses is available, it is recommended to conduct such soundings at every 100 m where existence of soft ground is suspected. The depth of sounding should be approximately 10 m. The locations where the existence of soft ground was suspected at the time of this Study was conducted are as follows:

(i) St 2+000 – 4+000 (right side of the road)
(ii) St 2+800 – 3+700 (left side)
(iii) St 6+900 – 7+500 (left side)
(iv) St 10+100 – 11+200 (left side)
(v) St 15+600 – 16+800 (left side)
(vi) St 17+600 – 18+800 (light side)
(vii) St 18+000 – 19+300 (right side)
(viii) St 23+600 – 23+900 (left side)
(ix) St 32+600 – 32+900 (both side)

In addition to the above, at any location where existence of soft ground is suspected, such as small to medium size ponds exists within 30 m from the toe of the existing embankment slope, sounding should be conducted.

Also the data of the boring for bridges and culverts should be carefully interpreted to find any sign of existence of soft ground.

If serious soft layer is found as the result of the sounding, detailed geotechnical investigations and analysis of stability and/or settlement need to be carried out as shown in Appendix G. In the detailed geotechnical investigations, undisturbed samples shall be obtained and unconfined compression tests shall be conducted to know the strengths of the soils. At this stage, advice of expert of soft ground shall be obtained, as much as possible.

2. Topographic Survey

Topographic surveys are needed for designing of bridges and culverts.

(1) Topographic Survey for Bridge

Plane survey with a scale of 1:200 should be conducted to know the detailed topography around the bridges. The area to be surveyed is as follows:

Width: 30 m from the road center line on both sides (= 60 m)

Length: length of bridge + 20 on both ends
(100 m + 20 m x 2 = 140 m: 1 bridge; 66 m + 20 m x 2 = 106 m: 2 bridges
Total 352 m)

Area: 60 x 352 = 21,120 m^2

(2) Profile Survey and Cross Section Survey of Rivers

The following surveys are needed to know the topography of the rivers or channels flowing under the bridges and culverts. The scale shall be 1:100

(i) Bridges

Profile survey: 100 m from the road center line on both sides (= 200 m) for 3 bridges (Total 600 m)

Cross section survey: Along road center line and 3 cross sections each for both sides (= 7 sections per 1 bridge: total 21 sections)

(ii) Culverts

Profile survey: 50 m from the road center line on both sides (= 100 m) for 13 culverts: Total 1,300 m

Cross section survey: 3 sections each on both sides (= 6 sections per 1 culvert) for 13 culverts: Total 78 sections

E. TRAFFIC SURVEY

E-1. Form of Traffic Surveys and Interviews

Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002
(Roadside Traffic Volume Counts)

Roadside / at		of		Date		Key Map
Direction / from		to		Surveyed by		from ⇨ to
Category / (I / II / III / IV / V)				Supervised by		

Category of Vehicle	I: Motorcycles (MC)		II: Light Vehicles (LV)		III: Heavy Vehicles (HV)			IV: Pedal Cycles (PC)		V: Others (OT)	
	Motorbike / M.Tricycle	Motorbike Trailer	Sedan / Wagon / Light Van	Pick-up / Jeep / Light Truck	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck	Bicycle	Cyclo / P.Bike Trailer	Pedestrian / Cart	Ox / Horse Farm Trailer
Sub-Category	Motorbike Sedan 2-Axle Bus	Pick-up 3-Axle Bus	Bicycle Pedestrian	M.Tricycle Wagon 2-Axle Truck	Jeep 3-Axle Truck	Cyclo Parking Cart Ox/Horse Trlr.	M.Bike Trlr. Light Van S.Trlr. Truck	Light Truck F.Trlr. Truck	P.Bike Trlr. S.Farm Tractor L.Farm Tractor	Total Volume	
Hours	Cumulative or Manual Counts		15-Min Counts	Cumulative or Manual Counts		15-Min Counts	Cumulative or Manual Counts		15-Min Counts	Quarters	Hours
06:00 - 06:15											
06:15 - 06:30											
06:30 - 06:45											
06:45 - 07:00											

Fig. E-1 Field Form for Roadside Traffic Volume Counts

Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002
(Intersection Traffic Movement Counts)

Intersection / of		with		Date		Key Map
Location / (N / E / S / W)				Surveyed by		
Category / (I / II / III / IV / V)				Supervised by		

Category of Vehicle	I: Motorcycles		II: Light Vehicles		III: Heavy Vehicles			IV: Pedal Cycles		V: Others	
	Motorbike / Tricycle	Motorbike Trailer	Sedan / Wagon / Light Van	Pick-up / Jeep / Light Truck	Short & Long Body Bus	Short & Long Body Truck	Semi & Full Trailer Truck	Bicycle	Cyclo / Bicycle Trailer	Pedestrian / Cart	Ox / Horse Farm Trailer
Direction	Right Turn			Through Pass			Left Turn			Total Inbound	
Hours	12-Min Counts		Adjusted 15-Min Counts	12-Min Counts		Adjusted 15-Min Counts	12-Min Counts		Adjusted 15-Min Counts	Quarters	Hours
06:00 - 06:15											
06:15 - 06:30											
06:30 - 06:45											
06:45 - 07:00											

Fig. E-2 Field Form for Intersection Traffic Movement Counts

Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002
(Travel Speed Survey)

Route No.: ________ Date: ________ Travel Time / From: ________
To: ________

Supervised by: ________ Recorded by: ________ Direction / From: ________
To: ________

#	Check Point	Cumulative Distance (km)	Cumulative Time (hr:min:sec)	Stop Time (second)	Sectional Distance (km)	Sectional Time (second)	Average Speed (km/h)	Remarks

Fig. E-3 Field Form for Travel Speed Survey

Origin and Destination (OD) Interview for the Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002

Please Answer Following Questions and Return to Interviewer (For Driver)

Card No. ☐☐ Station ☐☐ Date ☐☐☐ Hour ☐☐ Vehicle Type ☐☐

1. Where Did This Trip Begin?
   ________ Commune / Districts
   ________ City / Province
   ☐☐

2. What Time Did You Leave Starting Point?
   ___ : ___
   ☐☐

3. Where Will This Trip End?
   ________ Commune / Districts
   ________ City / Province
   ☐☐

4. What Time Do You Expect To Arrive At Final Destination?
   ___ : ___
   ☐☐

5. What Route Did or Will You Take? ☐☐

6. What Is The Purpose Of This Trip?
   - To Work ☐
   - To School ☐
   - To Shop / Market ☐
   - To Business ☐
   - To Others ☐
   - To Home ☐
   ☐☐

7. How Often Do You Make This Trip Each Week?
   - 5 Times Or More ☐
   - 4 Times ☐
   - 3 Times ☐
   - 2 Times ☐
   - 1 Time ☐
   - Seldom ☐
   ☐☐

8. How Many People On Board? (Icluding Driver & Co-driver)
   ________ pax
   ☐☐

9. How Many The Seating Capacity?
   ________ seat
   ☐☐

10. What Kind Of Products Do You Carry?
   ____
   ☐☐
   (for Cargo Vehicle Only)

11. How Many Tons of Cargo Do You Carry Now?
   ________ ton
   ☐☐
   (for Cargo Vehicle Only)

12. How Much The Loading Capacity?
   ________ ton
   ☐☐
   (for Cargo Vehicle Only)

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Fig. E-4 Field Form for OD Interview (Driver)

Origin and Destination (OD) Interview for the Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002

Please Answer Following Questions and Return to Interviewer (For Passenger)

Card No. ☐☐ Station ☐☐ Date ☐☐☐ Hour ☐☐ Vehicle Type ☐☐

1. Where Did This Trip Begin?
   ______ Commune / Districts
   ______ City / Province ☐☐

2. What Time Did You Leave Starting Point?
   ___ : ___ ☐☐

3. Where Will This Trip End?
   ______ Commune / Districts
   ______ City / Province ☐☐

4. What Time Do You Expect To Arrive At Final Destination?
   ___ : ___ ☐☐

5. What Route Did or Will You Take Mainly? ☐☐

6. What Is The Purpose Of This Trip?
   - To Work ☐
   - To School ☐
   - To Shop / Market ☐
   - To Business ☐
   - To Others ☐
   - To Home ☐

   ☐☐

7. How Often Do You Make This Trip Each Week?
   - 5 Times Or More ☐
   - 4 Times ☐
   - 3 Times ☐
   - 2 Times ☐
   - 1 Time ☐
   - Seldom ☐

   ☐☐

8. How Many Adult (Over 18) Do You Travel With?
   ______ pax ☐☐

9. How Many Children (Under 18) Do You Travel With?
   ______ pax ☐☐

10. & 11. What Kind Of Other Mode Did and Will You Use to Reach This Mode and Destination?
   - Same as This Mode ☐ ☐
   - Private or Company Car ☐ ☐
   - Private or Company Bike ☐ ☐
   - Commercial Car/Van/Bus ☐ ☐
   - Commercial Bike/Cyclo ☐ ☐
   - Bicycle or Walk ☐ ☐

   ☐☐

12. How Much Do You Spend For This (One Way) Trip in Total?
   ______ Riel ☐☐
   (including Fuel and Other Expenses for Private Car and Bike)

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Fig. E-5 Field Form for OD Interview (Passenger)

Vehicle Type:

Left Box:
- MC: Motorcycles
- LV: Light Vehicles
- HV: Heavy Vehicles
- PC: Pedal Cycles
- OT: Other Land Modes
- IW: Inland Waterway

Right Box:
- Motorcycles (MC)
  - 1-Motorbike (including Motodop)
  - 2-Tricycle (Tuk-Tuk)
  - 3-Motorbike Trailer (Motoremork)
- Light Vehicles (LV)
  - 1-Sedan
  - 2-Station Wagon
  - 3-Light Van
  - 4-Pick Up
  - 5-Jeep
  - 6-Light Truck
- Heavy Vehicles (HV)
  - 1-Short Body Bus
  - 2-Long Body Bus
  - 3-Short Body Truck (2-Axles)
  - 4-Long Body Truck (3-Axles)
  - 5-Semi Trailer & Tractor (4-Axles or More)
  - 6-Full Trailer & Truck (4-Axles or More)
- Pedal Cycles (PC)
  - 1-Bicycle
  - 2-Tricycle (Cyclo)
  - 3-Bicycle Trailer (Bicycle-remork)
- Other Land Modes (OT)
  - 1-Pedestrian (Walker)
  - 2-Pushing Cart
  - 3-Ox/Horse Cart (Trailer)
  - 4-Small Farm Tractor & Trailer
  - 5-Large Farm Tractor & Trailer
- Inland Waterway (IW)
  - 1-Ferry
  - 2-River Boat

Origin & Destination:

Within Cambodia - Central
- Phnom Penh (PP)
  - 1-Central (4-Districts)
  - 2-Mean Chey/East (Chbar Ampov)
  - 3-Mean Chey/Middle (Chak Angrae)
  - 4-Mean Chey/West (Steung Mean Chey)
  - 5-Russei Keo/South (Tuol Tida Thanei)
  - 6-Russei Keo/Middle (Russei Keo)
  - 7-Russei Keo/North (Prek Leap)
  - 8-Dangkao/South (Prey Veaeng)
  - 9-Dangkao/Middle (Pochentong)
  - 10-Dangkao/North (Kouk Roka)
- Kandal (KD)
  - 11-Takh Khmau
  - 12-Kien Svay
  - 13-Leuk Daek
  - 14-S'ang
  - 15-Kach Thom
  - 16-Kandal Stueng
  - 17-Angk Snuol
  - 18-Ponhea Kraek
  - 19-Mukh Kampul
  - 20-Khsach Kandal
  - 21-Lvea Aem

Within Cambodia - Others
- National Road No.1 (NR1)
  - 22-Prey Veaeng/South
  - 23-Prey Veaeng/North
  - 24-Svay Rieng
- National Road No.2 (NR2)
  - 25-Takeo
- National Road No.3 (NR3)
  - 26-Kampot
- National Road No.4 (NR4)
  - 27-Krong Preah Sihanouk
  - 28-Kampong Speu
  - 29-Koh Kong
- National Road No.5 (NR5)
  - 30-Kampong Chhnang
  - 31-Pursat
  - 32-Bat Dambang & Pailin
- National Road No.6 (NR6)
  - 33-Kampong Cham/West
  - 34-Kampong Cham/East
  - 35-Kampong Thum
  - 36-Siem Reab
  - 37-Otdar Mean Chey
  - 38-Banteay Mean Chey
  - 39-Preah Vihear
- National Road No.7 (NR7)
  - 40-Kracheh
  - 41-Stueng Traeng
  - 42-Rotanak Kiri
  - 43-Mondol Kiri

Outside Cambodia
- Viet Nam (VN)
  - 101-Hanoi
  - 102-Ho Chi Minh
  - 103-Others
- Thai (TH)
  - 104-Thai
- Lao PDR (LP)
  - 105-Lao PDR

Cargo Description:

Company Categories
- 1-Retail
- 2-Wholesaler
- 3-Warehouse
- 4-Manufacture
- 5-Freight Industry
- 6-Construction
- 7-Government/UN/NGO's
- 8-Others

Item Categories
- 1-Agriculture (Rice, Corn, Vegetable, Fruit, etc.)
- 2-Forest (Log, Timber, Plywood, etc.)
- 3-Marine (Fish, Shell, Seaweed, etc.)
- 4-Mineral (Coal, Copper, Iron, Salt, etc.)
- 5-Metal & Machine (Steel, Generator, Car & Bike, etc.)
- 6-Chemical (Petroleum, Alcohol, Acid, etc.)
- 7-Light Industry / Electronics (Machine Parts, IC, Electronic Appliances, etc.)
- 8-Miscellaneous Industry (Garment, Shoes, etc.)
- 9-Construction (Sand, Gravel, Asphalt, Concrete, Re-Bar, Beam, etc.)
- 0-Others

Fare / Expense:

Payment Style
- 1-One Way Basis
- 2-Two Way Basis
- 3-Weekly Basis
- 4-Monthly Basis
- 5-Annual Basis
- 6-Other Special Discount Basis

Expense (from Origin to Destination)
- 1-upto 500 (-US$0.12)
- 2-500 upto 999 (US$0.13-0.24)
- 3-1000 upto 1999 (US$0.25-0.49)
- 4-2000 upto 3999 (US$0.50-0.99)
- 5-4000 upto 7999 (US$1.00-1.99)
- 6-8000 upto 11999 (US$2.00-2.99)
- 7-12000 upto 15999 (US$3.00-3.99)
- 8-16000 upto 19999 (US$4.00-4.99)
- 9-20000 or More (US$5.00-)

Fig. E-6 Coding Description Form

The Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002

Cargo Movement Interview Form

(First Sheet Only)

Date of Interview: ____________ Sheet No: ________ of ________

Name of Company / Organization: ____________ Category: ____________ Surveyed by: ____________

Location of Company / Organization: ____________ Zone Code: ____________ Supervised by: ____________

No. of Cargo Vehicles in Total: ________ vehicles No. of Administrative Staff in Total: ________ staff

No. of Driver in Total: ________ drivers No. of Assistant of Driver in Total: ________ assistants

Fuel Consumption: ________ liter (Gasoline) ________ liter (Diesel) per week/month/quarter/year

****

(By Each Sampled Vehicle)

Sampled Vehicle Registration No.: ____________ Loading Capacity of Sampled Vehicle: ________ tons

Data Covered From: ____________ To: ____________

Weekly Trips

No. of Trips	Day of Week	Origin & Mid Stop Point					Mid Stop Point & Final Destination					Route	Code of Cargo	Weight of Cargo (ton)
		Departure Time		City	District	Zoning	Arrival Time		City	District	Zoning			
		Hour	Minute	Province	Commune	Code	Hour	Minute	Province	Commune	Code			
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

(If Same Sampled Vehicle Made Several Dropping Off And/Or Picking Up Within The Same Or Different Traffic Zone, Please Assess Every Stopping Points As Origin And Destination With Their Times of Departure And Arrival Into The Following Raw Provided)

(If Same Sampled Vehicle Made More Than 20 Trips Within One (1) Week Or Different Vehicles Are Also Sampled, Please Use Other Sheets Provided, And Continue To Answer For Avoiding Bias And/Or Misinformation)

Categories: 1. Retail 2. Wholesales 3. Warehouse 4. Manufacture 5. Freight Industry 6. Construction 7. Government/UN/NGO's 8. Others

Cargo Items: 1. Agriculture 2. Forest 3. Marine 4. Mineral 5. Metal & Machine 6. Chemical 7. Light Industry / Electronics 8. Miscellaneous Industry 9. Construction 0. Others (including Empty)

Day of Week: 1. Monday 2. Tuesday 3. Wednesday 4. Thursday 5. Friday 6. Saturday 7. Sunday

Route: 1. NR1 2. NR2 3. NR3 4. NR4 5. NR5 6. NR6 7. NR7 8. Within Phnom Penh 9. Others

The Data Obtained From This Form Should Be Utilized For Present Traffic Analysis And Traffic Demand Forecast Purpose Only

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Fig. E-7 Field Form for Cargo Movement Interview

The Feasibility Study on the Improvement of National Road No.1, MPWT/JICA-2002

Public Transport Interview Form

(First Sheet Only)

Date of Interview: ________ Sheet No. ________ of ________

Name of Company / Organization: ________ Category: ________ Surveyed by: ________

Location of Company / Organization: ________ Zone Code: ________ Supervised by: ________

No. of Vehicles / Vessels in Total: ________ vehicles/vessels No. of Administrative Staff in Total: ________ staff

No. of Driver / Captain in Total: ________ drivers/captains No. of Conductor in Total: ________ conductors

No. of Average Passengers: ________ per day / week / month Main Operating Area / Route: ________

Fuel Consumption: ________ liter (Gasoline) ________ liter (Diesel) per week/month/quarter/year

****

(By Each Sampled Vehicle / Vessels)

Sampled Vehicle / Vessel Registration No.: ________ Seating Capacity of Sampled Vehicle / Vessel: ________ seats

Data Covered From: ________ To: ________

Weekly Trips

No. of Trips	Day of Week	Origin & Mid Stop Point					Mid Stop Point & Final Destination					Route	Amount of Fare Per Pax	Boarding No. of Passengers
		Departure Time		City	District	Zoning	Arrival Time		City	District	Zoning			
		Hour	Minute	Province	Commune	Code	Hour	Minute	Province	Commune	Code			
1														
2														
3														
4														
5														
6														
7														
8														
9														
10														
11														
12														
13														
14														
15														
16														
17														
18														
19														
20														

(If Same Sampled Vehicle/Vessel Made Several Dropping Off And/Or Picking Up Within The Same Or Different Traffic Zone, Please Assess Every Stopping Points As Origin And Destination With Their Times of Departure And Arrival Into The Following Raw Provided)

(If Same Sampled Vehicle/Vessel Made More Than 20 Trips Within One (1) Week Or Different Vehicles/Vessels Are Also Sampled, Please Use Other Sheets Provided, And Continue To Answer For Avoiding Disarrangement)

Category: 1. Large Scale Operator (No. of Fleets = 16 or More) 2. Middle Scale Operator (No. of Fleets = 5 to 15) 3. Small Scale Operator (No. of Fleets = 4 or Less)

Day of Week: 1. Monday 2. Tuesday 3. Wednesday 4. Thursday 5. Friday 6. Saturday 7. Sunday

Route: 1. NR1 2. NR2 3. NR3 4. NR4 5. NR5 6. NR6 7. NR7 8. Within Phnom Penh 9. Others

The Data Obtained From This Form Should Be Utilized For Present Traffic Analysis And Traffic Demand Forecast Purpose Only

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Fig. E-8 Field Form for Public Transport Interview

Direction	West Bound												
Classification No.	1	2	3	4	5	6	7	8	9	10	11	1~8	
Classification	Motorbike	Motorbike Trailer, Tricycles	Private Passenger Vehicle-S (Sedan, Wagon, Pick-up)	Commercial Passenger Vehicle-M (Light Van)	Commercial Cargo Vehicle-M (Light Truck)	Commercial Passenger Vehicle-L (Short & Long Body Bus)	Commercial Cargo Vehicle-L (Short & Long Body Truck)	Commercial Cargo Vehicle-LL (Semi & Full Trailer Truck)	Pedal Cycles (Bicycle)	Pedal Cycles (Cycle, Bicycle Trailer)	Others (Walker, Cart, Farm Tractor)	Motorized Vehicle Total	Directional (D) -Factor
Passenger Car Unit	0.50	0.75	1.00	1.50	1.50	3.00	3.00	4.50	-	-	-	PCU	
06:00 ~ 06:15	120	21	4	1	2	0	6	2	5	0	15	115	0.59
06:15 ~ 06:30	128	26	9	7	1	0	3	1	3	0	5	118	0.54
06:30 ~ 06:45	114	38	14	5	0	0	3	0	7	0	6	107	0.49
06:45 ~ 07:00	98	35	13	7	6	0	8	0	1	0	3	127	0.55
07:00 ~ 07:15	85	24	10	5	1	0	5	0	6	0	10	95	0.45
07:15 ~ 07:30	95	25	10	4	3	0	5	0	3	0	5	102	0.53
07:30 ~ 07:45	98	12	8	9	1	1	3	0	4	0	6	89	0.48
07:45 ~ 08:00	74	22	9	7	2	2	2	0	6	0	8	88	0.45
08:00 ~ 08:15	59	15	6	6	0	0	3	1	5	1	5	70	0.37
08:15 ~ 08:30	98	13	8	5	1	0	5	0	4	0	6	86	0.43
08:30 ~ 08:45	68	11	10	12	3	2	2	0	7	0	5	83	0.38
08:45 ~ 09:00	55	12	9	1	5	1	5	1	10	0	10	77	0.43
18:00 ~ 18:15	56	2	14	0	4	0	4	0	3	0	0	61	0.58
18:15 ~ 18:30	38	1	9	3	0	1	4	0	5	0	3	48	0.58
18:30 ~ 18:45	24	2	5	0	2	0	3	0	2	0	5	24	0.35
18:45 ~ 19:00	21	3	5	0	0	0	3	0	3	0	2	24	0.37
19:00 ~ 19:15	18	3	6	0	0	0	3	0	3	0	4	20	0.41
19:15 ~ 19:30	13	2	4	0	3	0	3	0	2	0	2	19	0.54
19:30 ~ 19:45	4	0	3	0	0	0	2	0	1	0	1	10	0.35
19:45 ~ 20:00	8	0	4	0	0	0	2	0	1	0	1	14	0.51
12-hr Traffic	3,814	691	492	285	123	16	215	7	179	2	240	3,853	0.48
14-hr Traffic	3,194	704	540	288	132	17	232	7	198	2	258	4,074	0.48
14/12-hr Ratio	1.06	1.02	1.10	1.01	1.07	1.06	1.08	1.08	1.11	1.00	1.08	1.06	
Peak Hour Traffic	461	128	59	48	16	4	28	3	28	1	33	467	
Peak Hour Ratio	0.15	0.17	0.12	0.17	0.13	0.25	0.13	0.43	0.16	0.50	0.14	0.12	
Peak Hour Start	06:00	06:15	17:00	09:30	15:45	07:45	16:30	06:00	16:45	13:30	08:15	06:00	
Peak Hour End	07:00	07:15	18:00	10:30	16:45	08:45	17:30	07:00	17:45	14:30	09:15	07:00	

Fig. E-9 Input Form for Roadside Traffic Volume Counts

Direction	West Bound						East Bound						Both Total					
Classification No.	1+2	3+4+5	6+7+8	9+10+11	1~11		1+2	3+4+5	6+7+8	9+10+11	1~11		1+2	3+4+5	6+7+8	9+10+11	1~11	
Classification	Motor Cycles (MC)	Light Vehicles (LV)	Heavy Vehicles (HV)	Pedal Cycles, Others (PC,OT)	Total	D-Factor	Motor Cycles (MC)	Light Vehicles (LV)	Heavy Vehicles (HV)	Pedal Cycles, Others (PC,OT)	Total	D-Factor	Motor Cycles (MC)	Light Vehicles (LV)	Heavy Vehicles (HV)	Pedal Cycles, Others (PC,OT)	Total	D-Factor
Passenger Car Unit	0.55	1.22	3.04	-	-		0.53	1.26	3.03	-	-		0.54	1.24	3.04	-	-	
06:00 ~ 06:15	149	7	8	28	183	0.59	110	12	2	5	128	0.41	258	18	10	25	311	-
06:15 ~ 06:30	155	17	4	8	184	0.56	114	23	2	5	144	0.44	269	40	6	13	328	-
06:30 ~ 06:45	149	19	1	13	182	0.51	136	27	2	8	172	0.49	284	46	3	21	354	-
06:45 ~ 07:00	125	28	8	4	163	0.48	141	23	0	9	173	0.52	266	48	8	13	335	-
07:00 ~ 07:15	109	16	5	16	146	0.48	127	24	6	4	161	0.52	236	40	11	20	307	-
07:15 ~ 07:30	128	17	5	8	158	0.53	108	16	5	4	133	0.47	228	33	10	12	283	-
07:30 ~ 07:45	102	18	4	18	134	0.48	113	15	7	9	144	0.52	215	33	11	19	278	-
07:45 ~ 08:00	96	18	4	14	132	0.43	139	19	5	13	176	0.57	235	37	9	27	308	-
08:00 ~ 08:15	74	12	4	11	101	0.34	164	23	1	10	199	0.66	238	36	5	21	300	-
08:15 ~ 08:30	103	14	5	18	132	0.43	145	21	4	8	178	0.57	248	34	9	18	309	-
08:30 ~ 08:45	71	25	4	12	112	0.36	156	30	5	9	200	0.64	227	55	9	21	312	-
08:45 ~ 09:00	67	15	7	28	109	0.43	108	26	5	5	144	0.57	175	41	12	25	253	-
18:00 ~ 18:15	58	18	4	3	83	0.44	94	6	2	5	107	0.56	152	24	6	8	190	-
18:15 ~ 18:30	39	12	5	8	63	0.47	56	11	3	1	71	0.53	94	23	8	9	134	-
18:30 ~ 18:45	28	7	1	7	41	0.36	62	8	1	0	71	0.64	88	15	2	7	112	-
18:45 ~ 19:00	24	5	2	4	35	0.37	49	12	0	0	61	0.63	73	17	2	4	96	-
19:00 ~ 19:15	21	6	1	7	35	0.52	22	7	2	1	32	0.48	43	13	3	8	67	-
19:15 ~ 19:30	15	7	1	4	28	0.49	19	4	0	5	28	0.51	33	11	1	9	54	-
19:30 ~ 19:45	4	3	2	2	10	0.32	12	8	1	1	22	0.68	16	10	3	3	32	-
19:45 ~ 20:00	8	4	2	2	15	0.50	7	2	2	4	15	0.50	15	6	4	6	31	-
12-hr Traffic	3,705	908	238	421	5,263	0.47	4,648	819	201	264	5,932	0.53	8,353	1,718	439	685	11,195	-
14-hr Traffic	3,898	968	256	458	5,572	0.47	4,949	877	212	281	6,339	0.53	8,866	1,837	468	739	11,910	-
14/12-hr Ratio	1.05	1.07	1.08	1.09	1.06		1.07	1.07	1.05	1.06	1.07		1.06	1.07	1.07	1.08	1.06	
Peak Hour Traffic	577	107	29	56	711		604	107	31	40	752		1,077	182	51	87	1,328	In-Out + In+Out
Peak Hour Ratio	0.16	0.12	0.12	0.13	0.14		0.13	0.13	0.15	0.15	0.13		0.13	0.11	0.12	0.13	0.12	
Peak Hour Start	06:00	10:45	16:30	16:45	06:00		07:45	08:30	14:15	07:45	07:45		06:00	08:30	15:00	08:15	06:00	
Peak Hour End	07:00	11:45	17:30	17:45	07:00		08:45	09:30	15:15	08:45	08:45		07:00	09:30	16:00	09:15	07:00	

Fig. E-10 Summary Sheet for Roadside Traffic Volume Counts

Time	West Bound																West Bound							
	I: Light Vehicles (in Veh Units)								II: Heavy Vehicles (in Veh Units)								III: Motorcycles (in Veh Units)							
	R. Turn		Through		L. Turn		Total		R. Turn		Through		L. Turn		Total		R. Turn		Through		L. Turn		Total	
Passenger Car Unit	1.00	1.50	1.00	1.50	1.00	1.50	1.00	1.50	1.00	1.25	1.00	1.25	1.00	1.25	1.00	1.25	1.00	1.50	1.00	1.50	1.00	1.50	1.00	1.50
06:00 – 06:15	2	1	3	5	0	0	5	6	0	0	0	2	0	0	0	2	38	0	23	0	16	1	77	1
06:15 – 06:30	0	1	0	2	1	0	1	3	0	0	0	3	0	0	0	3	32	0	13	0	3	0	48	0
06:30 – 06:45	0	2	2	5	2	3	4	10	0	0	0	0	0	0	0	0	31	1	28	0	17	1	76	2
06:45 – 07:00	1	2	3	5	1	4	5	11	0	0	0	4	0	0	0	4	52	0	62	0	14	1	128	1
07:00 – 07:15	3	3	2	2	3	5	8	10	0	0	0	1	0	1	0	2	23	0	48	1	13	0	84	1
07:15 – 07:30	1	2	0	4	1	0	2	6	1	2	0	1	0	0	1	3	30	0	61	0	7	0	98	0
07:30 – 07:45	2	4	1	7	2	6	5	17	0	1	0	0	0	0	0	1	45	0	65	0	8	0	118	0
07:45 – 08:00	1	1	2	4	0	0	3	5	0	0	0	0	0	0	0	0	32	0	51	0	10	0	93	0
08:00 – 08:15	1	1	5	4	1	0	7	5	0	0	0	0	0	0	0	0	27	3	62	0	9	0	98	3
08:15 – 08:30	0	3	1	5	0	7	1	15	0	0	0	0	0	0	0	0	33	0	48	0	9	0	90	0
08:30 – 08:45	0	4	5	6	0	0	5	10	0	0	0	3	0	0	0	3	23	0	86	0	8	0	117	0
08:45 – 09:00	0	1	0	4	1	9	1	14	0	0	0	1	0	0	0	1	21	0	53	0	5	0	79	0
09:00 – 09:15	0	0	5	7	0	9	5	16	0	0	1	2	0	0	1	2	19	0	58	0	6	0	83	0
09:15 – 09:30	0	2	3	6	3	1	6	9	0	1	0	0	0	0	0	1	24	0	30	0	5	0	59	0
09:30 – 09:45	0	4	4	12	0	0	4	16	0	0	0	0	0	0	0	0	16	1	46	0	4	0	66	1
09:45 – 10:00	1	1	2	9	1	0	4	10	0	0	0	0	0	0	0	0	10	0	36	0	1	0	47	0
16:00 – 16:15	1	1	2	9	0	1	3	11	0	0	0	0	0	0	0	0	9	0	62	0	4	0	75	0
16:15 – 16:30	1	0	1	3	0	0	2	3	0	0	0	0	0	0	0	0	10	0	23	0	9	0	42	0
16:30 – 16:45	0	1	1	4	1	0	2	5	0	0	1	1	0	0	1	1	23	0	50	0	8	0	81	0
16:45 – 17:00	0	0	1	3	0	0	1	3	0	0	0	1	0	0	0	1	11	0	15	0	6	0	32	0
17:00 – 17:15	0	0	2	1	1	0	3	1	0	0	0	0	0	0	0	0	16	1	18	0	3	0	37	1
17:15 – 17:30	0	1	4	1	0	1	4	3	0	0	0	0	0	0	0	0	12	0	17	0	4	0	33	0
17:30 – 17:45	1	0	1	2	3	0	5	2	0	0	0	0	0	0	0	0	13	0	19	0	5	0	37	0
17:45 – 18:00	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	8	0	16	0	2	0	26	0
18:00 – 18:15	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	13	0	32	0	8	0	53	0
18:15 – 18:30	2	1	1	2	0	1	3	4	0	0	0	1	0	0	0	1	3	0	5	0	5	0	13	0
18:30 – 18:45	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	0	17	0	4	0	23	0
18:45 – 19:00	0	0	0	1	0	1	0	2	0	0	0	1	0	0	0	1	4	0	52	0	3	0	59	0
19:00 – 19:15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	6	0	5	0	14	0
19:15 – 19:30	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	0	4	0	5	0	6	0	15	0
19:30 – 19:45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	8	0	3	0	13	0
19:45 – 20:00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	4	0	3	0	9	0
12-hr Traffic	30	54	105	187	40	56	175	297	2	12	6	37	0	2	8	51	840	13	1,526	2	305	3	2,679	18
14-hr Traffic	33	56	107	190	40	58	180	304	2	12	6	39	0	2	8	53	881	13	1,655	2	342	3	2,878	18
14/12-hr Ratio	1.10	1.04	1.02	1.02	1.00	1.04	1.03	1.02	1.00	1.00	1.00	1.05		1.00	1.00	1.04	1.04	1.00	1.08	1.00	1.12	1.00	1.07	1.00
Peak Hour Traffic	7	11	15	34	7	25	21	55	1	4	2	9	n/a	1	3	10	143	4	249	1	51	3	439	4
Peak Hour Ratio	0.23	0.20	0.14	0.18	0.18	0.45	0.12	0.19	0.50	0.33	0.33	0.24		0.50	0.38	0.20	0.17	0.31	0.16	0.50	0.17	1.00	0.16	0.22
Peak Hour Start	06:45	06:45	14:15	09:00	06:15	08:15	12:45	08:15	06:30	14:45	11:30	06:00	n/a	06:15	11:30	06:45	06:45	11:15	08:00	06:15	06:30	06:00	06:45	06:00
Peak Hour End	07:45	07:45	15:15	10:00	07:15	09:15	13:45	09:15	07:30	15:45	12:30	07:00	n/a	07:15	12:30	07:45	07:45	12:15	09:00	07:15	07:30	07:00	07:45	07:00

Fig. E-11 Input Form for Intersection Traffic Movement Counts

Time	West Bound								West Bound							
	I: Light Vehicles (in Veh Units)				II: Heavy Vehicles (in Veh Units)				III: Motorcycles (in Veh Units)				IV: Pedal-cycles (in Veh Units)			
	R. Turn	Through	L. Turn	Total	R. Turn	Through	L. Turn	Total	R. Turn	Through	L. Turn	Total	R. Turn	Through	L. Turn	Total
Passenger Car Unit	1.00	1.00	1.00	1.00	3.00	3.00	3.00	3.00	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
06:00 – 06:15	4	11	0	14	0	3	0	3	38	23	18	79	3	15	0	18
06:15 – 06:30	2	3	1	6	0	4	0	4	32	13	3	48	3	18	0	21
06:30 – 06:45	3	10	7	18	0	0	0	0	32	28	19	79	5	19	1	25
06:45 – 07:00	4	11	7	22	0	5	0	5	52	62	16	130	5	18	3	26
07:00 – 07:15	8	5	11	23	0	1	1	3	23	50	13	86	6	14	3	23
07:15 – 07:30	4	6	1	11	4	1	0	5	30	61	7	98	6	41	2	49
07:30 – 07:45	8	12	11	31	1	0	0	1	45	65	8	119	7	25	1	32
07:45 – 08:00	3	8	0	11	0	0	0	0	32	51	10	93	1	7	0	8
08:00 – 08:15	3	11	1	15	0	0	0	0	32	62	9	103	13	20	0	33
08:15 – 08:30	5	9	11	24	0	0	0	0	33	48	9	90	9	9	1	19
08:30 – 08:45	6	14	8	28	0	4	0	4	23	86	8	117	20	12	1	32
08:45 – 09:00	2	6	15	22	0	1	0	1	21	53	5	79	11	18	3	32
09:00 – 09:15	0	16	14	29	0	4	0	4	19	58	6	83	8	21	5	34
09:15 – 09:30	3	12	5	20	1	0	0	1	24	30	5	59	15	21	3	39
09:30 – 09:45	6	22	0	28	0	0	0	0	18	46	4	68	5	14	7	26
09:45 – 10:00	3	16	1	19	0	0	0	0	10	36	1	47	8	12	8	28
16:00 – 16:15	3	16	2	20	0	0	0	0	9	62	4	75	12	21	2	35
16:15 – 16:30	1	6	0	7	0	0	0	0	10	23	9	42	8	14	7	29
16:30 – 16:45	2	7	1	10	0	2	0	2	23	50	8	81	11	25	4	40
16:45 – 17:00	0	6	0	6	0	1	0	1	11	15	6	32	14	27	6	47
17:00 – 17:15	0	4	1	5	0	0	0	0	16	18	3	38	15	14	3	31
17:15 – 17:30	2	6	2	8	0	0	0	0	12	17	4	33	3	10	2	15
17:30 – 17:45	1	4	3	8	0	0	0	0	13	19	5	37	10	13	5	28
17:45 – 18:00	0	0	0	0	0	1	0	1	8	16	2	26	14	20	4	38
18:00 – 18:15	1	0	0	1	0	0	0	0	13	32	8	53	10	13	1	24
18:15 – 18:30	4	4	2	9	0	1	0	1	3	5	5	13	9	11	2	22
18:30 – 18:45	0	1	0	1	0	0	0	0	2	17	4	23	7	11	1	19
18:45 – 19:00	0	2	2	3	0	1	0	1	4	52	3	59	8	5	3	16
19:00 – 19:15	0	0	0	0	0	0	0	0	3	6	5	14	5	4	1	10
19:15 – 19:30	2	0	0	2	0	0	0	0	4	5	6	15	6	6	2	14
19:30 – 19:45	0	0	0	0	0	0	0	0	2	8	3	13	3	3	1	7
19:45 – 20:00	0	0	0	0	0	0	0	0	2	4	3	9	1	2	3	6
12-hr Traffic	111	386	124	621	17	52	3	72	860	1,529	310	2,700	500	833	206	1,542
14-hr Traffic	117	392	127	636	17	55	3	74	901	1,650	347	2,905	553	897	228	1,659
14/12-hr Ratio	1.05	1.02	1.02	1.02	1.00	1.05	1.00	1.03	1.04	1.08	1.12	1.07	1.10	1.07	1.07	1.08
Peak Hour Traffic	24	66	30	99	5	11	1	13	143	249	51	433	38	96	37	191
Peak Hour Ratio	0.22	0.17	0.31	0.16	0.29	0.21	0.48	0.18	0.17	0.16	0.18	0.16	0.17	0.12	0.18	0.12
Peak Hour Start	06:45	09:00	08:15	08:45	06:45	06:00	06:15	06:45	06:45	08:00	06:00	06:45	10:45	06:45	15:00	10:30
Peak Hour End	07:45	10:00	09:15	09:45	07:45	07:00	07:15	07:45	07:45	09:00	07:00	07:45	11:45	07:45	16:00	11:30

Fig. E-12 Summary Sheet for Intersection Traffic Movement Counts

No.	Time		Vehicle Type		1.Origin			2.Dept. Time		3.Destination			4.Arrvl. Time		5.Route	6.Purpo	7.Often	8.Passe	9. S.Ca	10.Item	11.Loa
	Hr.	Min.	Class	Type	Prov.	Dist.	Comm.	Hr.	Min.	Prov.	Dist.	Comm.	Hr.	Min.							
1	6	0	LV	6	8	13		5	10	1			6	30	1	4	6	3	2	6	2.50
2	6	10	MC	1																	
3	6	10	MC	3	8	12	6	5	0	1	2		6	50	1	4	1	25	4		
4	6	10	LV	1	8	13		5	18	1	4	9	7	0	1	4	1	5	4		
5	6	10	LV	3	8	13		6	0	1			6	30	1	3	1	2	2	10	0.80
6	6	12	HV	6	8	13		6	5	1			6	32	1	4	6	2	2	9	40.00
7	6	15	LV	3	8	13		6	10	1			6	35	1	1	1	2	2	10	0.50
8	6	15	MC	1																	
9	6	18	LV	6	8	12		6	10	1			6	43	1	4	1	8	2	9	5.00
10	6	20	MC	3	8	12	3	5	5	1	2		6	55	1	4	1	28	4		
11	6	20	MC	1																	
12	6	25	MC	1																	
13	6	25	MC	3	8	12	3	5	10	1	2		7	0	1	4	1	22	4		
14	6	25	LV	3	8	13		6	18	1			7	5	1	3	1	3	2	1	0.30
15	6	27	MC	1																	
16	6	30	HV	3	8	12		6	0	1			7	0	1	4	3	3	2	1	3.50
17	6	30	MC	3	8	12	3	5	20	1	2		7	0	1	4	1	15	4		
18	6	30	LV	6	8	12		6	20	8	12	9	6	40	1	4	6	3	2	2	2.50
19	6	35	LV	3	22			4	0	1			7	0	1	4	1	7	12		
20	6	35	MC	1																	
21	6	39	LV	3	24	1	3	3	0	1			7	0	1	4	6	4	2	10	1.50
22	6	40	LV	6	8	13		5	0	1			7	0	1	4	3	2	2	10	7.00
23	6	40	LV	3	8	13		6	0	8	12		7	0	1	4	1	3	2	1	2.00
24	6	44	LV	3	24	1		3	0	1			7	15	1	4	1	15	2		
25	6	45	LV	4	8	12		6	30	1			7	40	1	3	4	1	4	1	0.20
26	6	47	LV	3	23	12		4	30	1			7	20	1	4	1	15	2		
27	6	48	LV	3	23	12		5	30	1			7	15	1	4	1	18	14		
28	6	52	LV	3	8	13		6	10	1			7	15	1	4	1	5	2	1	1.50
29	7	0	MC	1																	
30	7	0	LV	3	8	12	3	6	5	1	10		7	45	1	1	1	14	12		
31	7	0	MC	3	8	12	6	6	30	1	2		7	40	1	4	1	18	4		
32	7	12	LV	6	8	12		6	50	1	4		8	20	1	3	3	2	2	9	5.00
33	7	18	LV	3	8	13		5	45	1			7	50	1	4	1	5	12		
34	7	20	MC	3	8	12	6	6	0	1	2		7	30	1	4	1	28	14		
35	7	25	LV	3	8	12	3	7	15	1			7	55	1	4	1	6	2	9	1.50
36	7	26	MC	1																	
37	7	30	LV	3	8	12		7	0	1	2		8	0	1	4	3	2	2	1	1.50
38	7	30	MC	1																	
39	7	30	MC	3	8	12	6	6	45	1	2		8	0	1	4	1	17	4		
40	7	32	HV	3	25	6	10	6	30	1			8	0	1	4	1	3	2	0	0.00

Fig. E-13 Input Form for Cordon Line OD Interview (Driver)

No.	Time		1.Origin			2.Time of Dept.		3.Destination			4.Time of Arriv		5.Route	6.Purpo	7.Often	8.Adult	9.Child	10.Mod	11.Mod	12.Expe
	Hr.	Min.	Prov.	Dist.	Comm.	Hr.	Min.	Prov.	Dist.	Comm.	Hr.	Min.						Before	After	
1	6	0																		
2	6	10	1	2	9	5	30	1	1		6	50	1	1	1	0	0	5	5	2500
3	6	10	8	12	6	5	30	1	2		6	40	1	2	1	0	0	6	6	1500
4	6	10	8	13		5	15	1	4	9	7	0	1	4	1	2	0	6	6	5000
5	6	10																		
6	6	12																		
7	6	15																		
8	6	15	8	12		6	10	1			6	35	1	1	1	0	0	3	3	3000
9	6	18																		
10	6	20	8	12	3	5	20	1	2		6	40	1	2	1	0	0	6	6	1500
11	6	20	8	12		6	15	8	12		6	30	1	1	1	0	1	3	3	3000
12	6	25	8	12		6	0	1			6	45	1	4	1	0	0	3	3	4000
13	6	25	1	2	3	5	30	1	3	1	6	35	1	2	1	0	0	6	6	1500
14	6	25																		
15	6	27	8	12		6	0	8	11		7	0	1	1	1	2	0	3	3	5000
16	6	30																		
17	6	30	8	12	6	5	25	1	2		7	0	1	4	1	2	2	6	6	3000
18	6	30																		
19	6	35	22			1	0	1			7	0	1	4	1	0	0	6	5	7000
20	6	35	8	12		6	10	1	1	9	7	0	1	3	1	0	0	5	5	2500
21	6	39																		
22	6	40																		
23	6	40																		
24	6	44	24	1		3	0	1			7	15	1	6	6	2	0	5	5	10000
25	6	45																		
26	6	47	23	12		2	27	1			7	25	1	6	6	0	0	5	5	10000
27	6	48	23	12		5	30	1			7	15	1	5	6	1	0	6	5	6000
28	6	52																		
29	7	0	8	12	9	6	40	1			7	25	1	4	1	1	0	5	5	4500
30	7	0	8	12	3	6	5	1	10		7	45	1	1	1	2	1	2	2	12000
31	7	0	8	12	6	6	30	1	2		7	40	1	3	1	1	0	6	6	2500
32	7	12																		
33	7	18	8	13		5	45	1			7	50	1	6	6	0	0	5	5	7000
34	7	20	8	12	6	6	10	8	12	9	7	40	1	3	1	1	0	6	6	2500
35	7	25																		
36	7	26	8	12		7	0	1	5		7	30	1	3	4	1	0	5	5	4000
37	7	30																		
38	7	30	8	12		7	0	1	2		8	10	1	4	1	1	0	5	5	3500
39	7	30	8	12	6	6	40	1	2		8	0	1	3	1	1	0	6	6	2500
40	7	32																		

Fig. E-14 Input Form for Cordon Line OD Interview (Passenger)

Compar No.	Date Month	Date	Day	Company Name	Categor	Location Prov.	Dist.	Comm.	Number Vehicle	Number of Vehicle by Capacity <4	<8	<16	<24	<32	32<	Admin.	Driver	Assist.	Capacit	Fuel Gasoline	Diesel	Unit
1	6	4	2	K.C HESIN	2	1	3		10				5	5		65	10	10	25		300	2
																			25		305	2
2	6	4	2	BEER COMPUCHE	2	1	1		60		50	10				189	60	60	8		1,080	3
																			8		880	3
																			8		880	3
																			8		1,080	3
																			8		880	3
																			8		1,080	2
																			8		1,080	2
																			8		880	2
																			18		780	2
																			18		780	3
																			18		380	2
																			18		380	2
3	6	4	2	SHELL	4	1	1		20		5	6	7	2		152	20		18		1,658	2
					4														18		1,658	2
					2														8		780	2
					2														8		780	2
4	6	6	4	VENG SRENG	2	1	4		7		5	2				21	7	5	18			
5	6	7	5	CA CA	1	1	8		4	4						20	4	4	2		250	2
6	6	6	4	TELA	1	1	1		40		20	12	6	2		450	40	40	5			
					1														5			
					1														5			
					3														12			
					4														16			
					4														16			
					3														12			
					3														12			
7	6	6	4	N.R.GROUP	6	1	1		10						10	20	10	10	48			
8	6	6	4	MENG SRENG	3	1	1		27			10	17			180	27	27	15			
					3														15			
					4														17			
					3														15			
					4														17			
9	6	7	5	CALTEX	4	1	1		34		12	6	4	2		45	42		18			
					4														23			
					4														16			
					2														8			
					6														32			
10	6	8	6	KHEN SOPHEA	3	1	1		39			9	28			50	39	39	15		680	2
					3														15		680	2
					4														17		880	2
					4														17		880	2

Fig. E-15 Input Form for Cargo Movement Interview (Campany)

Compar No.	Regist. No.	Loading Capacit	Covering Date From	To	Trip No.	Day of Week	Dept. Time Hr.	Min.	Origin Prov.	Dist.	Comm.	Arriv. Time Hr.	Min.	Destination Prov.	Dist.	Comm.	Route	Cargo Item	Weight
1	6036-3	25.0	04/07/02	04/14/02	1	1	7	15	1	7	3	7	55	8	11		2	9	20.0
					2	1	9	0	8	11		9	20	1	7	3	2	0	0.0
					3	2	8	0	1	7	3	9	0	1	4	1	0	9	20.0
					4	2	11	0	1	4	1	12	0	1	7	3	0	0	0.0
					5	3	8	0	1	7	3	9	0	1	6		0	9	20.0
					6	3	13	0	1	6		14	0	1	7	3	0	9	20.0
					7	4	7	0	1	7	3	7	40	1	1		0	0	0.0
					8	4	8	30	1	1		10	0	1	4		0	9	15.0
					9	4	13	0	1	4		14	0	1	7	3	0	0	0.0
1	5871-3	25.0	05/04/02	05/11/02	1	1	8	10	1	7	3	10	0	1	6		0	9	15.0
					2	1	13	0	1	6		13	50	1	7	3	0	0	0.0
					3	3	9	0	1	7	3	10	30	1	9		0	9	20.0
					4	3	14	0	1	9		14	50	1	7	3	0	0	0.0
					5	4	13	0	1	7	3	14	0	1	4		0	9	25.0
					6	4	16	30	1	4		17	30	1	7	3	0	0	0.0
2	2102-3	8.0	05/29/02	06/04/02	1	1	6	30	1			11	30	29	6		4	4	8.0
					2	1	14	0	29	6		17	0	1			4	0	0.0
					3	2	6	30	1			8	30	33	6		6	4	8.0
					4	2	13	0	33	6		14	30	1			6	0	0.0
					5	3	6	30	1			9	30	30			5	4	8.0
					6	3	14	0	30			16	30	1			5	0	0.0
					7	4	6	30	1			7	30	8	11		1	4	8.0
					8	4	10	30	8	11		11	0	1			1	0	0.0
					9	5	6	30	1			11	30	26			3	4	8.0
					10	6	6	30	26			11	0	1			3	0	0.0
					11	7	6	30	1			10	0	26	2	12	3	4	8.0
					12	7	13	30	26	2	12	16	0	1			3	0	0.0
2	8036-3	8.0	04/22/02	04/27/02	1	1	7	30	1			11	30	22	7	3	1	4	8.0
					2	1	11	50	22	7	3	15	0	34			1	4	8.0
					3	2	6	30	34			9	0	22	7	3	1	0	0.0
					4	2	9	20	22	7	3	13	30	1			1	0	0.0
					5	3	7	0	1			11	30	22	7	3	1	4	8.0
					6	3	11	30	22	7	3	13	0	23			1	4	8.0
					7	4	6	0	23			8	30	22	7	3	1	0	0.0
					8	4	9	0	22	7	3	12	30	1			1	0	0.0
					9	5	7	0	1			9	0	28			4	4	8.0
					10	5	13	0	28			15	30	1			4	0	0.0
2	5812-3	8.0	04/06/02	04/12/02	1	1	7	30	1			9	40	28			4	4	8.0
					2	1	13	0	28			15	0	1			4	0	0.0

Fig. E-16 Input Form for Cargo Movement Interview (Vehicle OD)

#	Date			Campany		Location			Number	Number of Vehicle by Capacity										Fuel		
Campar	Month	Date	Day	Name	Categor	Prov.	Dist.	Comm.	Vehicle	<4	<8	<16	<24	<32	32<	Admin.	Dr./Cap	Conduc	Capacity	Gasolin	Diesel	Unit
1	6	13	6	CAPITOL	4	1			20			3	16	1		30	20	2	30			
					4														25			
					3														25			
					3														25			
2	6	13	6	HO WAH	4	1	1		46					31	15	130	46	5	45		300	2
					4														45		450	2
					4														45		100	2
					4														45		150	2
					4														45		100	2
					4														35		250	2
					4														35		100	2
					4														35		200	2
					3														30		900	2
3	6	13	6	G S T	4	1			11						11	24	11	2	50		400	2
																			50		760	2
4	6	12	3	CHANNA	6	1			3		1				2	10	3	2	150			
																			150			
5	6	12	3	KHAMARA	6	1			5		2				3	15	5	2	200			
																			200			
6	6	12	3	NEAK LEONG FE	7	22	7	3	2						2	140	7	36				

Fig. E-17 Input Form for Public Transport Interview (Campany)

Campar	Regist.	Seating	Covering Date		Trip	Day of	Dept. Time		Origin			Arriv. Time		Destination			Route	Fare	No. of
No.	No.	Capacity	From	To	No.	Week	Hr.	Min.	Prov.	Dist.	Comm.	Hr.	Min.	Prov.	Dist.	Comm.		Amount	Passeng
1	3741-3	45	05/20/02	05/26/02	1	1	6	30	1			11	30	24	1		1	60000	28
					2	1	14	30	24	1		19	30	1			1	60000	28
					3	3	6	30	1			11	30	24	1		1	60000	30
					4	3	14	30	24	1		19	30	1			1	60000	40
					5	5	6	30	1			11	30	24	1		1	60000	30
					6	5	14	30	24	1		19	30	1			1	60000	42
1	3740-3	45	05/20/02	05/26/02	1	1	6	30	1			13	30	35	8		6	39000	30
					2	1	14	0	35	8		16	30	36			6	39000	30
					3	3	6	30	36			12	0	35			6	39000	30
					4	3	12	30	35			16	0	1			6	39000	30
					5	5	6	30	1			13	30	35	8		6	39000	30
					6	5	14	0	35	8		16	30	36			6	39000	30
					7	7	6	30	36			11	30	35	8		6	39000	30
					8	7	14	30	35	8		16	30	1			6	39000	30
1	6490-3	25	05/20/02	05/26/02	1	1	8	0	1			9	30	1	5		0	12000	15
					2	1	12	0	1	5		13	30	1			0	12000	15
					3	2	8	0	1			9	30	1	5		0	12000	10
					4	2	12	0	1	5		13	30	1			0	12000	10
					5	3	8	0	1			9	30	1	5		0	12000	20
					6	3	12	0	1	5		13	30	1			0	12000	20
					7	5	8	0	1			9	30	1	5		0	12000	15
					8	5	12	0	1	5		13	30	1			0	12000	15
					9	7	8	0	1			9	30	1	5		0	12000	15
					10	7	12	0	1	5		13	30	1			0	12000	15
1	6986-3	25	05/20/02	05/26/02	1	2	6	30	1			11	30	24	1		1	60000	15
					2	2	14	30	24	1		19	30	1			1	60000	15
					3	4	6	30	1			11	30	24	1		1	60000	15
					4	4	14	30	24	1		19	30	1			1	60000	15
					5	6	6	30	1			11	30	24	1		1	60000	15
					6	6	14	30	24	1		19	30	1			1	60000	15
2	4241-3	45	05/13/02	05/19/02	1	1	7	0	1	1		9	30	33	5		6	7000	40
					2	1	11	0	33	5		13	30	1	1		6	7000	35
					3	3	7	0	1	1		9	30	33	5		6	7000	38
					4	3	11	0	33	5		13	30	1	1		6	7000	30
					5	5	7	0	1	1		9	30	33	5		6	7000	35
					6	5	11	0	33	5		13	30	1	1		6	7000	35
2	4256-3	45	05/13/02	05/19/02	1	1	7	15	1	1		10	30	27			4	10000	45
					2	1	12	30	27			15	15	1	1		4	10000	40
					3	3	7	15	1	1		10	30	27			4	10000	30
					4	3	12	30	27			15	15	1	1		4	10000	25
					5	5	7	15	1	1		10	30	27			4	10000	20
					6	5	12	30	27			15	15	1	1		4	10000	20
2	4249-3	45	05/13/02	05/19/02	1	2	7	15	1			9	30	25			2	6000	40
					2	2	11	0	25			13	30	1			2	6000	45
					3	3	7	15	1			9	30	25			2	6000	25
					4	3	11	0	25			13	30	1			2	6000	30
					5	6	7	15	1			9	30	25			2	6000	20
					6	6	11	0	25			13	30	1			2	6000	20
2		45	05/13/02	05/19/02	1	2	7	15	1	1		9	30	8	20		1	6000	35
					2	2	11	15	8	20		13	30	1	1		1	6000	30
					3	3	7	15	1	1		9	30	8	20		1	6000	30
					4	3	11	15	8	20		13	30	1	1		1	6000	25
					5	6	7	15	1	1		9	30	8	20		1	6000	35
					6	6	11	15	8	20		13	30	1	1		1	6000	25
2	4247-3	45	05/13/02	05/19/02	1	2	7	15	1			9	30	30			5	6000	40
					2	2	11	15	30			13	30	1			5	6000	35

Fig. E-18 Input Form for Public Transport Interview (Vehicle OD)

Table 2-2-18 (a) Intersection Traffic Volume and Movement (Monivong Roundabout)

14-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	6	1,218	1,300	1,188	3,711
	East	1,883	6	1,724	1,576	5,190
	South	2,153	1,847	8	1,802	5,810
	West	2,054	1,762	1,880	7	5,703
Total		6,096	4,833	4,912	4,573	20,414

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	49	55	101	205
	East	44	0	109	202	356
	South	58	130	1	266	455
	West	110	245	272	2	629
Total		213	424	436	571	1,645

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	27	14,129	7,998	9,271	31,425
	East	14,803	117	16,925	19,620	51,465
	South	10,092	20,382	45	13,376	43,894
	West	9,255	18,692	10,581	48	38,576
Total		34,177	53,320	35,549	42,315	165,361

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	176	179	200	555
	East	236	2	404	453	1,095
	South	214	361	1	411	987
	West	275	465	472	2	1,214
Total		725	1,003	1,056	1,066	3,851

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	33	15,572	9,531	10,761	35,897
	East	16,967	125	19,162	21,851	58,106
	South	12,517	22,720	55	15,854	51,145
	West	11,694	21,164	13,205	59	46,122
Total		41,212	59,580	41,953	48,524	191,270

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	14	5,283	3,874	4,232	13,403
	East	6,280	39	6,897	7,745	20,961
	South	5,487	7,981	23	6,696	20,187
	West	5,364	7,910	6,133	28	19,436
Total		17,145	21,213	16,927	18,701	73,987

12-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	5	1,081	1,127	1,010	3,223
	East	1,685	6	1,497	1,341	4,528
	South	1,900	1,619	7	1,513	5,038
	West	1,782	1,518	1,583	6	4,890
Total		5,372	4,223	4,214	3,870	17,679

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	43	49	87	179
	East	40	0	104	184	328
	South	50	116	1	231	397
	West	92	213	240	2	546
Total		181	373	393	503	1,450

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	23	12,099	6,641	7,952	26,715
	East	13,432	106	14,853	17,787	46,178
	South	8,953	18,037	39	11,856	38,886
	West	8,095	16,308	8,951	42	33,396
Total		30,504	46,550	30,484	37,637	145,174

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	148	155	179	483
	East	213	1	357	410	981
	South	198	318	1	383	901
	West	240	385	403	2	1,029
Total		651	853	917	974	3,394

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	29	13,371	7,972	9,227	30,599
	East	15,369	113	16,810	19,722	52,015
	South	11,102	20,090	47	13,983	45,222
	West	10,209	18,424	11,177	51	39,861
Total		36,708	51,999	36,007	42,984	167,697

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	12	4,575	3,291	3,620	11,498
	East	5,666	35	6,062	6,916	18,679
	South	4,850	7,046	20	5,818	17,734
	West	4,655	6,870	5,217	24	16,767
Total		15,183	18,527	14,590	16,378	64,678

Peak Hour Traffic

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	1	247	137	121	507
	East	267	1	184	163	615
	South	219	273	1	134	625
	West	190	237	131	0	559
Total		676	758	454	418	2,306

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	11	8	12	32
	East	5	0	15	21	42
	South	6	23	0	24	53
	West	8	32	24	0	63
Total		19	67	48	57	190

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	5	1,574	963	1,085	3,626
	East	2,359	13	1,968	2,217	6,556
	South	2,216	3,020	7	2,082	7,325
	West	1,326	1,808	1,106	5	4,244
Total		5,905	6,414	4,044	5,388	21,751

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	42	44	64	151
	East	71	0	96	139	306
	South	75	97	0	147	320
	West	78	100	104	1	282
Total		224	240	245	350	1,059

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	5	1,875	1,153	1,282	4,316
	East	2,702	14	2,263	2,540	7,519
	South	2,515	3,413	8	2,386	8,323
	West	1,601	2,176	1,365	6	5,148
Total		6,824	7,479	4,790	6,214	25,306

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	2	756	455	483	1,697
	East	960	5	804	873	2,643
	South	868	1,207	3	813	2,891
	West	618	892	555	2	2,067
Total		2,448	2,861	1,817	2,171	9,297

Table 2-2-18 (b) Intersection Traffic Volume and Movement (Chbar Ampav Intersection)

14-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	474	78	628	1,180
	East	512	12	526	4,223	5,274
	South	13	80	0	106	198
	West	612	3,816	630	20	5,078
Total		1,137	4,382	1,235	4,976	11,730

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	29	5	36	70
	East	32	1	45	354	432
	South	1	5	0	7	13
	West	37	323	50	2	412
Total		70	359	100	398	926

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	32	6,537	3,037	24,459	34,065
	East	7,622	24	2,856	23,000	33,502
	South	1,328	1,071	2	4,006	6,408
	West	24,120	19,451	9,032	284	52,888
Total		33,103	27,084	14,927	51,748	126,862

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	3	628	678	421	1,731
	East	875	2	687	427	1,992
	South	475	346	1	232	1,054
	West	425	309	333	1	1,068
Total		1,779	1,285	1,699	1,081	5,844

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	35	7,669	3,798	25,545	37,046
	East	9,042	40	4,113	28,003	41,199
	South	1,817	1,502	3	4,350	7,673
	West	25,194	23,899	10,046	306	59,445
Total		36,089	33,110	17,960	58,204	145,362

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	9	2,494	1,044	7,141	10,688
	East	2,886	26	1,711	12,462	17,084
	South	469	474	1	1,217	2,161
	West	7,039	10,920	3,318	102	21,379
Total		10,403	13,915	6,073	20,921	51,313

12-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	442	68	565	1,075
	East	471	11	449	3,756	4,688
	South	10	65	0	83	159
	West	533	3,320	508	17	4,377
Total		1,015	3,839	1,025	4,421	10,300

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	25	3	32	60
	East	28	1	35	328	392
	South	1	5	0	7	13
	West	32	288	41	1	362
Total		60	319	80	368	826

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	28	5,384	2,671	22,120	30,203
	East	6,881	20	2,533	20,979	30,412
	South	1,080	802	2	3,291	5,175
	West	21,720	16,119	7,992	258	46,089
Total		29,709	22,325	13,197	46,648	111,880

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	3	550	627	388	1,568
	East	746	2	584	361	1,693
	South	426	293	1	206	927
	West	357	245	280	1	883
Total		1,532	1,091	1,492	956	5,070

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	32	6,401	3,369	23,105	32,906
	East	8,125	34	3,602	25,424	37,186
	South	1,517	1,165	3	3,588	6,273
	West	22,641	19,972	8,821	277	51,711
Total		32,316	27,573	15,794	52,394	128,076

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	8	2,128	922	6,454	9,513
	East	2,599	24	1,474	11,259	15,356
	South	392	375	1	1,004	1,772
	West	6,304	9,320	2,855	91	18,571
Total		9,303	11,847	5,252	18,809	45,211

Peak Hour Traffic

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	39	12	63	114
	East	57	1	72	367	497
	South	29	116	0	190	336
	West	73	288	92	2	454
Total		159	443	177	623	1,402

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	9	2	11	21
	East	15	0	10	61	85
	South	1	4	0	4	9
	West	12	44	8	0	64
Total		28	57	19	76	180

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	3	628	258	2,511	3,399
	East	1,075	4	393	3,829	5,300
	South	219	195	0	780	1,194
	West	2,340	2,087	855	33	5,315
Total		3,636	2,914	1,506	7,152	15,208

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	1	122	124	135	382
	East	136	0	74	81	291
	South	90	48	0	53	191
	West	92	49	50	0	191
Total		318	219	249	269	1,055

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	4	798	396	2,719	3,917
	East	1,283	5	549	4,337	6,174
	South	339	363	1	1,028	1,730
	West	2,517	2,467	1,005	35	6,024
Total		4,142	3,633	1,951	8,119	17,845

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	1	270	117	780	1,169
	East	430	3	243	1,663	2,339
	South	118	220	0	462	801
	West	746	1,057	371	11	2,185
Total		1,294	1,550	731	2,917	6,493

Table 2-2-18 (c) Intersection Traffic Volume and Movement (Tiger Road Intersection)

14-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		3	4	88	95
	East	13		34	1,370	1,417
	South	5	52		176	233
	West	63	1,429	203		1,695
Total		81	1,484	241	1,634	3,440

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		0	1	0	1
	East	3		0	242	245
	South	0	4		53	57
	West	2	239	48		289
Total		5	242	49	295	592

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		49	56	420	524
	East	222		342	5,223	5,786
	South	69	256		501	826
	West	418	4,347	564		5,328
Total		708	4,651	961	6,144	12,463

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		30	16	90	136
	East	27		299	195	521
	South	46	209		59	313
	West	98	203	157		458
Total		171	442	472	343	1,427

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	82	77	598	756
	East	265	0	675	7,030	7,969
	South	120	520	0	789	1,428
	West	580	6,217	972	0	7,769
Total		965	6,818	1,723	8,416	17,921

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	0	23	27	237	287
	East	91	0	203	3,974	4,268
	South	35	194	0	559	788
	West	215	3,819	615	0	4,649
Total		341	4,036	844	4,770	9,991

12-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		3	3	80	86
	East	11		31	1,230	1,272
	South	4	49		157	210
	West	56	1,316	183		1,555
Total		71	1,367	217	1,467	3,122

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		0	1	0	1
	East	1		0	225	226
	South	0	4		49	52
	West	2	212	47		261
Total		3	215	48	274	540

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		47	50	378	474
	East	197		307	4,962	5,465
	South	63	235		463	761
	West	364	3,925	516		4,804
Total		623	4,207	872	5,802	11,503

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		29	16	86	131
	East	23		296	186	505
	South	41	203		52	295
	West	84	183	139		406
Total		148	415	451	323	1,336

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	79	70	544	692
	East	232	0	633	6,602	7,467
	South	108	490	0	720	1,317
	West	505	5,635	885	0	7,025
Total		845	6,203	1,587	7,866	16,500

Total (in PCU's)		Out-Bound North	East	South	West	Total
In-Bound	North	0	23	24	216	262
	East	72	0	189	3,669	3,930
	South	31	183	0	508	722
	West	189	3,465	570	0	4,223
Total		293	3,670	782	4,392	9,137

Peak Hour Traffic

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		1	2	15	18
	East	7		7	130	144
	South	3	12		28	43
	West	13	194	25		232
Total		23	207	34	173	437

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		0	1	0	1
	East	2		0	31	33
	South	0	1		12	13
	West	2	37	17		56
Total		4	38	18	43	103

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		12	11	58	81
	East	55		52	1,072	1,179
	South	11	39		80	130
	West	57	459	70		586
Total		123	510	133	1,210	1,976

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		9	7	34	50
	East	7		148	65	220
	South	14	91		15	120
	West	26	48	22		96
Total		47	148	177	114	486

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	22	21	107	150
	East	71	0	207	1,298	1,576
	South	28	143	0	135	306
	West	98	738	134	0	970
Total		197	903	362	1,540	3,002

Total (in PCU's)		Out-Bound North	East	South	West	Total
In-Bound	North	0	7	11	42	59
	East	32	0	59	563	654
	South	10	51	0	104	165
	West	45	508	118	0	671
Total		86	566	188	709	1,548

Table 2-2-18 (d) Intersection Traffic Volume and Movement (Neak Loueng East Intersection)

14-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		165	56	117	338
	East	99		36	392	527
	South	26	39		127	191
	West	127	386	13		526
Total		251	590	105	636	1,582

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		100	13	17	129
	East	99		6	55	160
	South	2	9		3	14
	West	38	75	8		120
Total		140	184	26	74	423

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		338	426	901	1,664
	East	1,411		563	1,658	3,632
	South	313	280		347	939
	West	970	1,687	278		2,935
Total		2,693	2,305	1,267	2,905	9,169

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		95	326	552	973
	East	521		351	887	1,759
	South	211	246		220	677
	West	654	933	215		1,801
Total		1,386	1,273	892	1,659	5,209

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	697	820	1,587	3,104
	East	2,130	0	956	2,992	6,078
	South	551	573	0	696	1,820
	West	1,788	3,080	514	0	5,381
Total		4,469	4,350	2,290	5,274	16,382

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	0	688	305	573	1,566
	East	979	0	296	1,332	2,606
	South	171	214	0	310	695
	West	706	1,417	168	0	2,291
Total		1,856	2,319	768	2,214	7,158

12-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		145	46	111	301
	East	93		26	386	505
	South	25	30		124	179
	West	117	372	13		502
Total		235	547	85	621	1,486

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		85	11	17	113
	East	87		5	52	144
	South	2	9		3	14
	West	34	70	8		111
Total		123	164	24	72	382

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		310	408	868	1,585
	East	1,347		532	1,529	3,408
	South	287	271		310	867
	West	935	1,593	273		2,801
Total		2,568	2,173	1,213	2,706	8,659

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		83	299	503	885
	East	491		316	833	1,639
	South	201	220		206	627
	West	631	895	207		1,733
Total		1,323	1,197	822	1,542	4,883

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	621	763	1,499	2,883
	East	2,017	0	878	2,799	5,695
	South	514	530	0	642	1,686
	West	1,717	2,929	501	0	5,146
Total		4,248	4,080	2,142	4,940	15,410

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	0	596	276	545	1,417
	East	901	0	262	1,268	2,431
	South	161	195	0	293	649
	West	666	1,348	164	0	2,178
Total		1,728	2,139	702	2,107	6,676

Peak Hour Traffic

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		21	14	24	59
	East	17		8	66	91
	South	5	10		38	53
	West	21	55	4		80
Total		43	86	26	128	283

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		21	3	5	29
	East	14		2	11	27
	South	1	3		1	5
	West	12	14	3		29
Total		27	38	8	17	90

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		44	68	148	260
	East	186		92	249	527
	South	81	55		55	191
	West	120	245	49		414
Total		387	344	209	452	1,392

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North		19	57	86	162
	East	84		63	96	243
	South	37	52		37	126
	West	100	130	42		272
Total		221	201	162	219	803

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	105	142	263	510
	East	301	0	165	422	888
	South	124	120	0	131	375
	West	253	444	98	0	795
Total		678	669	405	816	2,568

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	0	121	60	107	288
	East	141	0	56	210	408
	South	40	51	0	74	164
	West	126	215	39	0	380
Total		307	386	155	392	1,240

Table 2-2-18 (e) Intersection Traffic Volume and Movement (Skun Roundabout)

14-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	151	0	472	623
	East	146	1	0	796	943
	South	0	0	0	0	0
	West	423	735	0	9	1,167
Total		569	887	0	1,276	2,732

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	45	0	70	115
	East	34	0	0	141	176
	South	0	0	0	0	0
	West	52	137	0	1	190
Total		87	181	0	212	480

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	4	1,158	0	837	1,999
	East	1,119	5	0	1,013	2,137
	South	0	0	0	0	0
	West	914	1,144	0	3	2,061
Total		2,036	2,308	0	1,854	6,198

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	6	662	0	1,126	1,793
	East	596	1	0	439	1,037
	South	0	0	0	0	0
	West	897	389	0	3	1,288
Total		1,500	1,052	0	1,568	4,119

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	10	2,015	0	2,505	4,530
	East	1,896	8	0	2,389	4,293
	South	0	0	0	0	0
	West	2,286	2,405	0	16	4,706
Total		4,192	4,428	0	4,910	13,530

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	3	810	0	1,344	2,157
	East	740	4	0	1,888	2,632
	South	0	0	0	0	0
	West	1,177	1,814	0	16	3,007
Total		1,921	2,629	0	3,247	7,797

12-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	129	0	456	585
	East	131	1	0	766	898
	South	0	0	0	0	0
	West	413	689	0	9	1,112
Total		544	819	0	1,232	2,595

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	35	0	68	104
	East	25	0	0	131	157
	South	0	0	0	0	0
	West	48	128	0	1	176
Total		73	163	0	201	437

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	3	1,104	0	773	1,880
	East	1,047	5	0	946	1,999
	South	0	0	0	0	0
	West	840	1,084	0	3	1,927
Total		1,890	2,193	0	1,722	5,805

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	5	600	0	1,090	1,695
	East	527	1	0	439	967
	South	0	0	0	0	0
	West	806	370	0	3	1,178
Total		1,338	971	0	1,532	3,840

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	9	1,868	0	2,387	4,264
	East	1,730	7	0	2,283	4,021
	South	0	0	0	0	0
	West	2,107	2,271	0	16	4,393
Total		3,845	4,146	0	4,686	12,678

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	3	720	0	1,291	2,014
	East	652	4	0	1,797	2,453
	South	0	0	0	0	0
	West	1,107	1,704	0	17	2,827
Total		1,761	2,427	0	3,106	7,294

Peak Hour Traffic

Light Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	12	0	62	75
	East	18	0	0	101	119
	South	0	0	0	0	0
	West	66	73	0	1	140
Total		84	86	0	164	334

Heavy Vehicles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	7	0	11	18
	East	7	0	0	19	26
	South	0	0	0	0	0
	West	10	17	0	0	27
Total		17	24	0	29	71

Motorcycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	179	0	114	293
	East	173	2	0	258	432
	South	0	0	0	0	0
	West	96	226	0	1	322
Total		269	407	0	372	1,048

Pedal-cycles (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	0	83	0	339	422
	East	78	0	0	327	405
	South	0	0	0	0	0
	West	118	122	0	2	242
Total		196	205	0	667	1,069

Total (in Veh.Units)		Out-Bound North	East	South	West	Total
In-Bound	North	1	282	0	525	808
	East	276	2	0	704	981
	South	0	0	0	0	0
	West	289	438	0	4	731
Total		565	723	0	1,233	2,521

Total (in PCU)		Out-Bound North	East	South	West	Total
In-Bound	North	0	108	0	232	340
	East	111	1	0	341	453
	South	0	0	0	0	0
	West	172	243	0	3	418
Total		283	352	0	576	1,211

Table 2-2-18 (f) Intersection Traffic Volume and Movement (NR7 with NR11 Intersection)

14-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		9	2	0	11
	East	8		81	434	522
	South	2	78		92	171
	West	6	411	86		503
Total		16	498	168	525	1,206

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		5	0	0	5
	East	2		43	266	311
	South	5	49		33	86
	West	0	236	50		286
Total		7	290	93	299	689

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		65	65	198	328
	East	118		365	973	1,456
	South	64	524		258	846
	West	143	1,016	414		1,573
Total		325	1,605	844	1,429	4,203

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		61	104	112	277
	East	84		261	234	579
	South	64	274		102	440
	West	106	241	125		471
Total		254	576	490	447	1,766

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	140	171	310	620
	East	212	0	749	1,906	2,867
	South	135	925	0	484	1,543
	West	255	1,904	675	0	2,833
Total		601	2,968	1,594	2,699	7,863

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	61	44	78	183
	East	69	0	417	1,842	2,327
	South	53	480	0	326	859
	West	70	1,713	430	0	2,213
Total		191	2,255	890	2,245	5,581

12-hr Traffic Total

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		9	2	0	11
	East	6		69	399	473
	South	2	74		82	158
	West	6	386	76		468
Total		14	469	146	481	1,109

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		5	0	0	5
	East	1		36	239	276
	South	5	44		28	76
	West	0	211	44		255
Total		6	260	80	266	613

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		58	59	178	295
	East	110		327	945	1,381
	South	56	471		246	773
	West	125	942	351		1,418
Total		291	1,471	737	1,369	3,867

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		60	86	101	247
	East	79		228	219	526
	South	60	252		98	409
	West	94	224	103		420
Total		233	535	417	417	1,601

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	132	147	279	557
	East	196	0	659	1,800	2,656
	South	123	840	0	453	1,416
	West	225	1,763	573	0	2,561
Total		544	2,735	1,379	2,532	7,189

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	59	38	70	167
	East	59	0	360	1,684	2,104
	South	50	437	0	292	778
	West	62	1,566	372	0	2,000
Total		171	2,063	770	2,045	5,050

Peak Hour Traffic

Light Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		5	2	0	7
	East	2		14	64	80
	South	2	11		16	29
	West	6	61	18		85
Total		10	77	34	80	201

Heavy Vehicles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		2	0	0	2
	East	1		7	35	43
	South	3	10		11	24
	West	0	34	8		42
Total		4	46	15	46	111

Motorcycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		10	9	22	41
	East	16		51	157	224
	South	9	87		47	143
	West	19	129	54		202
Total		44	226	114	226	610

Pedal-cycles (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North		12	19	18	49
	East	16		33	34	83
	South	22	85		32	139
	West	22	60	14		96
Total		60	157	66	84	367

Total (in Veh.Units)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	29	30	40	99
	East	35	0	105	290	430
	South	36	193	0	106	335
	West	47	284	94	0	425
Total		118	506	229	436	1,289

Total (in PCU)		Out-Bound				Total
		North	East	South	West	
In-Bound	North	0	19	10	10	39
	East	14	0	65	259	338
	South	22	94	0	81	197
	West	18	251	70	0	338
Total		54	365	144	350	912

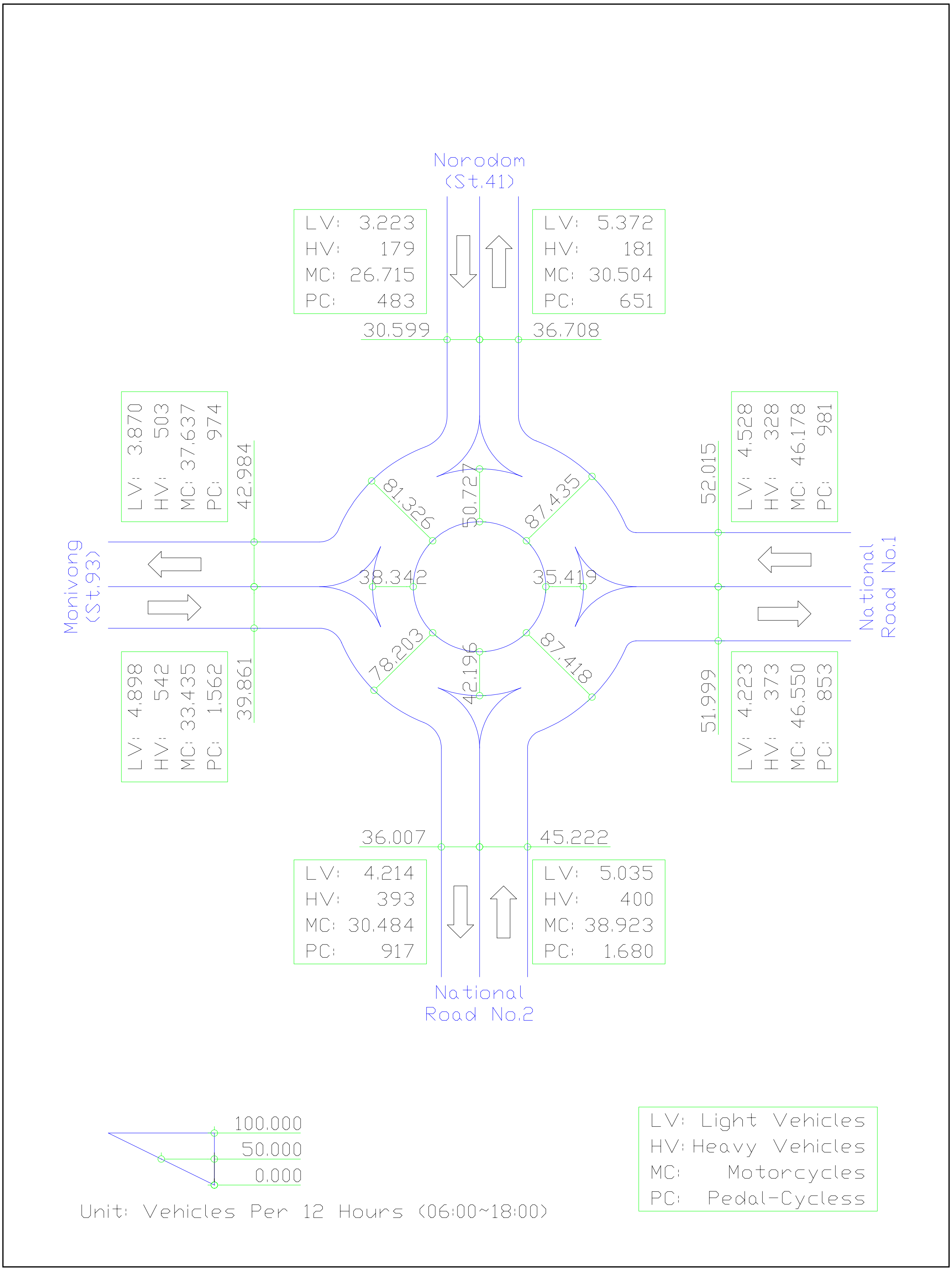


Fig. 2-2-19 (a) Intersection Traffic Volume and Movement (Monivong Roundabout)

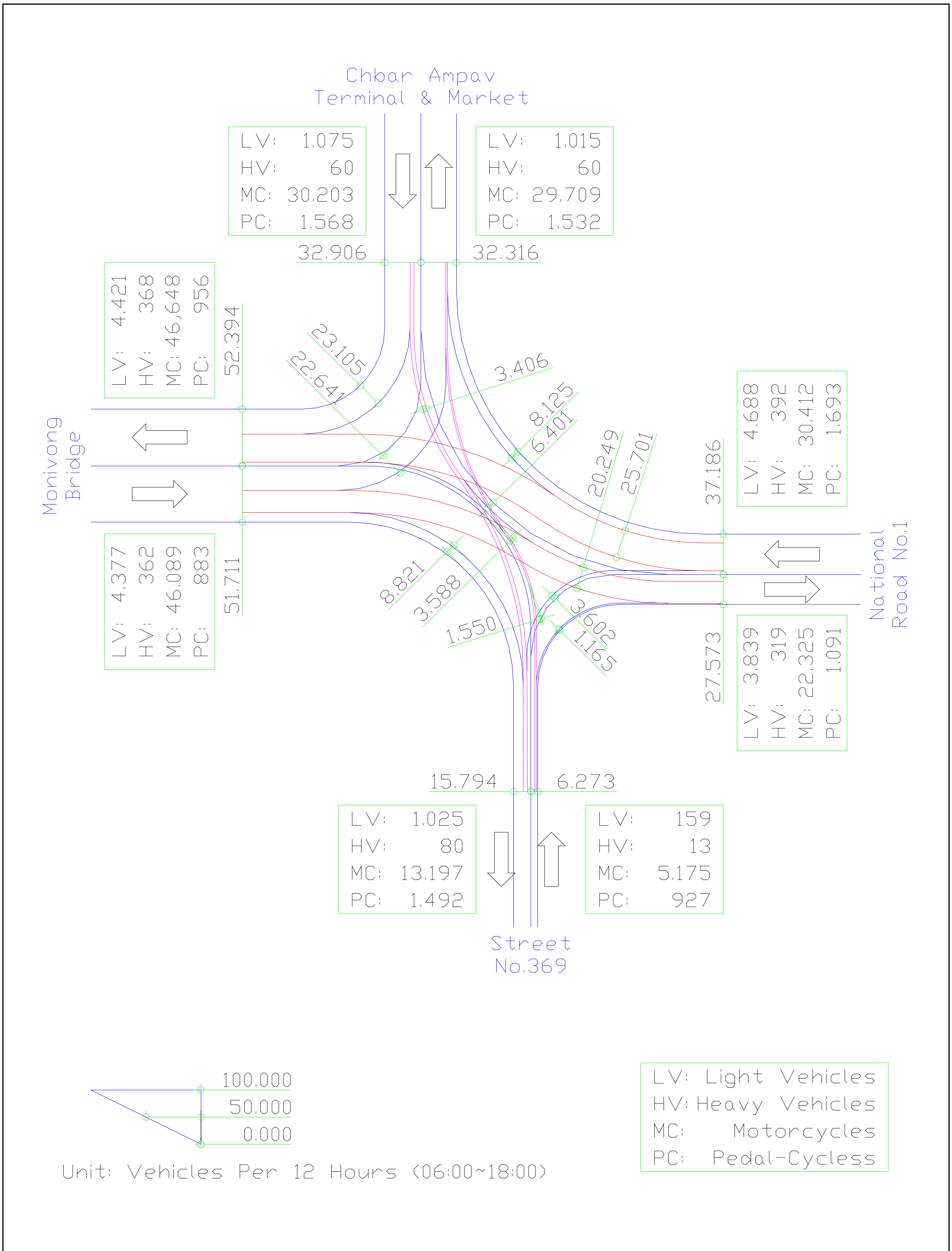


Fig. 2-2-19 (b) Intersection Traffic Volume and Movement (Chbar Ampav Intersection)

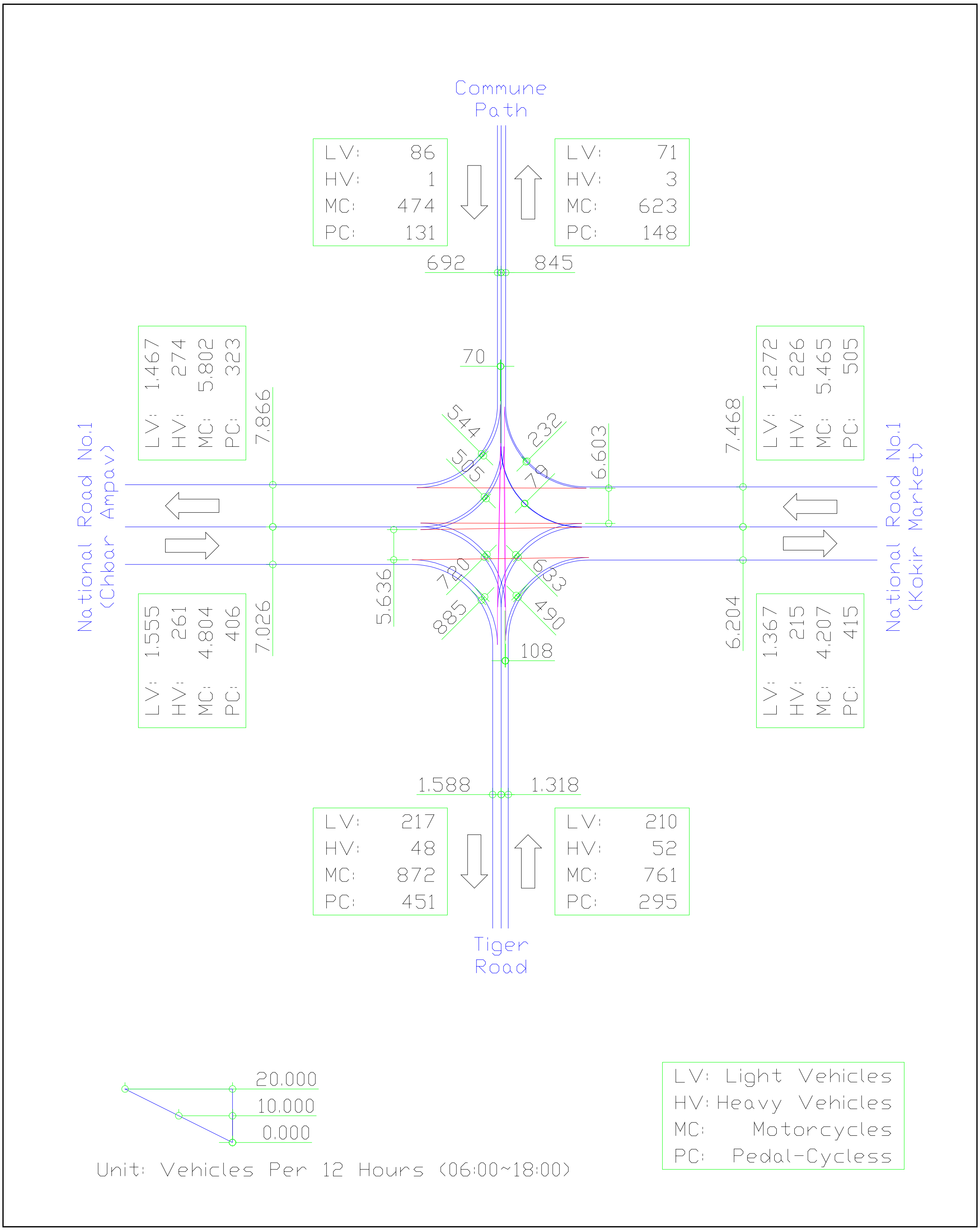


Fig. 2-2-19 (c) Intersection Traffic Volume and Movement (Tiger Road Intersection)

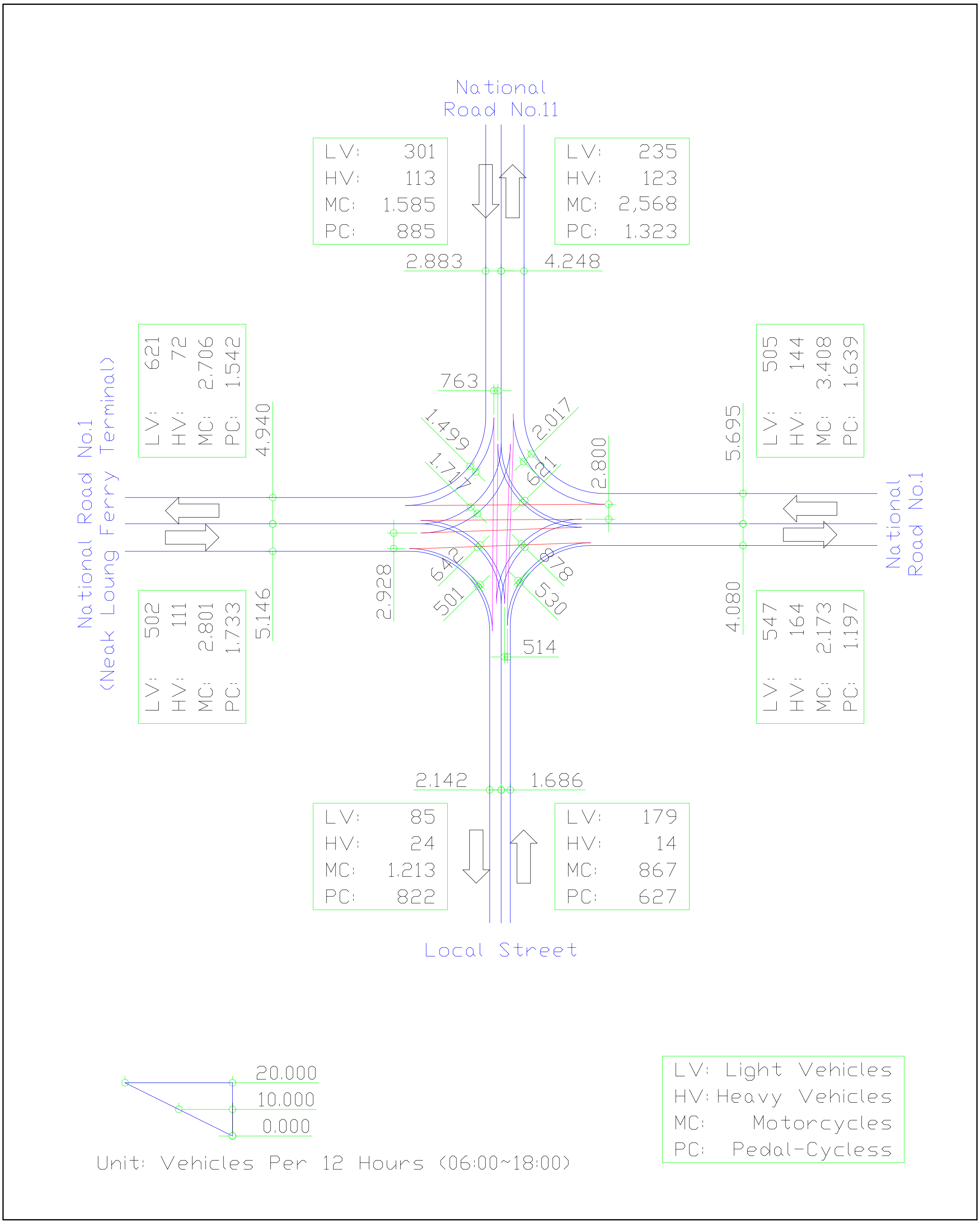


Fig. 2-2-19 (d) Intersection Traffic Volume and Movement (Neak Loueng East Intersection)

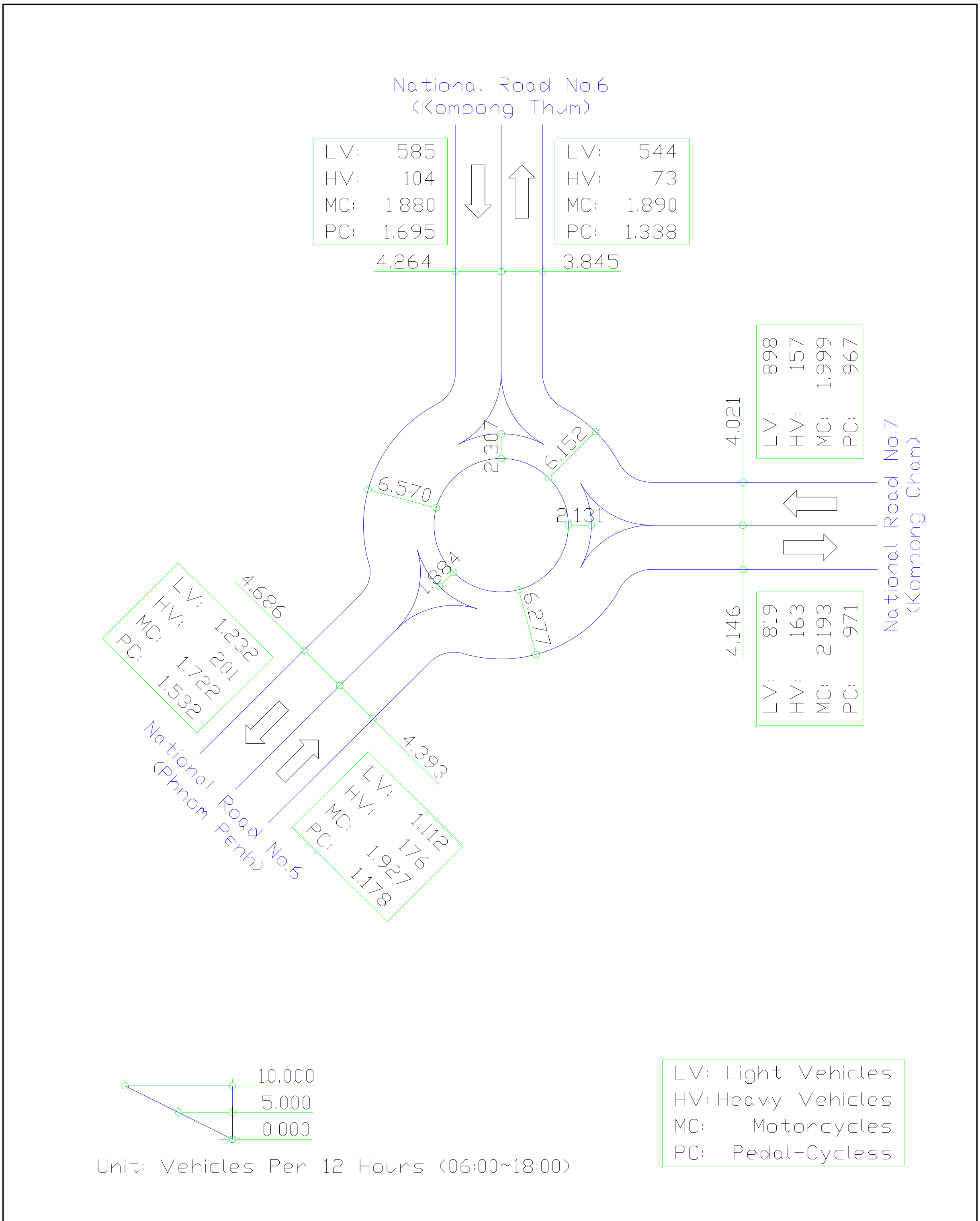


Fig. 2-2-19 (e) Intersection Traffic Volume and Movement (Skun Roundabout)

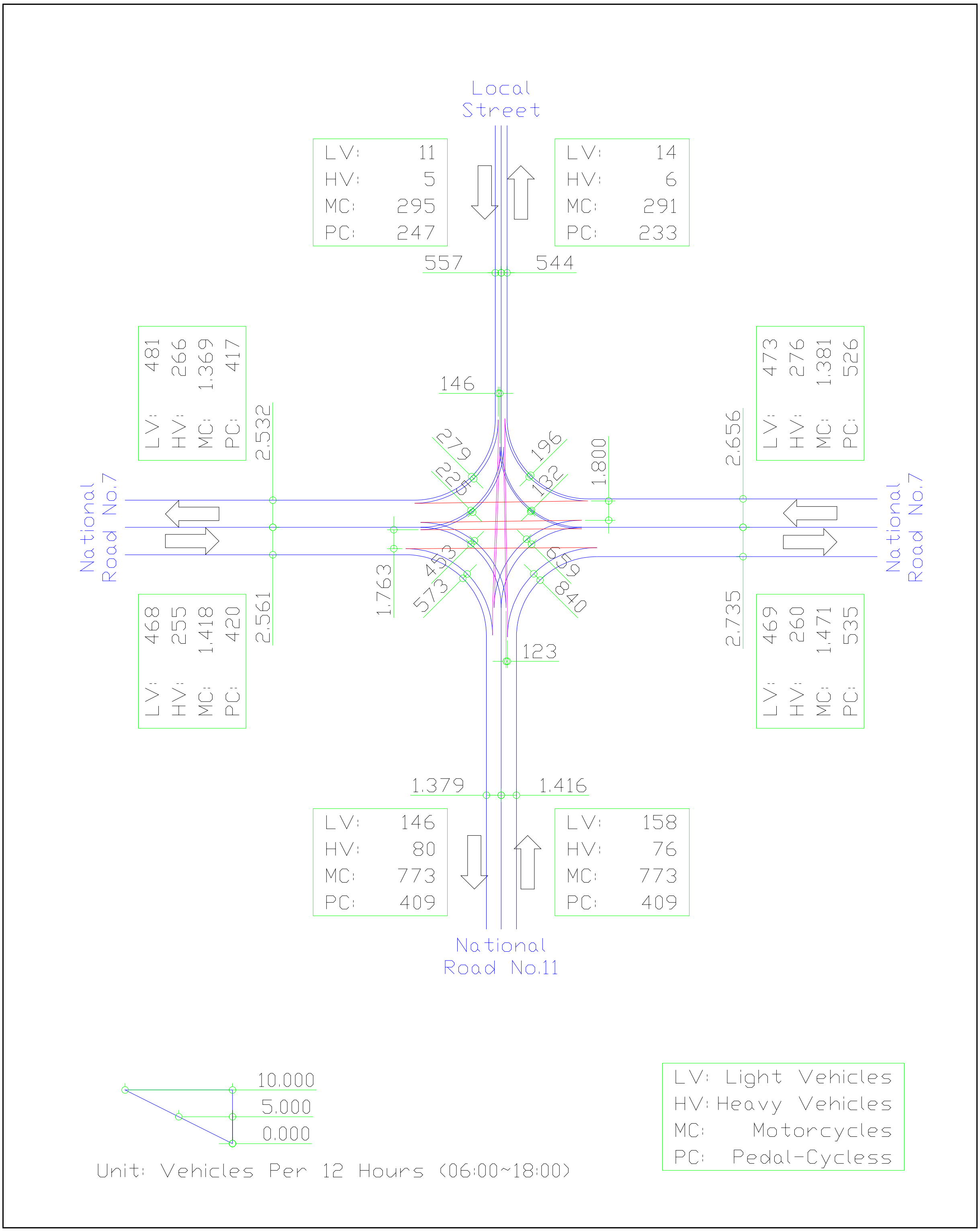


Fig. 2-2-19 (f) Intersection Traffic Volume and Movement (NR7 with NR11 Roundabout)

Table 2-2-19 (a) Classified Traffic Volume and its Compositions (NR-1 to NR-7)

Stations	Kilo Post	MC	LV	HV	CY	Total
CL-1.1	13	9,597 (0.72)	2,291 (0.17)	332 (0.02)	1,085 (0.08)	13,304 (1.00)
CL-1.2	123	1,871 (0.52)	450 (0.13)	247 (0.07)	1,024 (0.29)	3,592 (1.00)
CL-2		4,383 (0.73)	1,121 (0.19)	238 (0.04)	233 (0.04)	5,975 (1.00)
CL-3		3,408 (0.65)	1,533 (0.29)	134 (0.03)	157 (0.03)	5,232 (1.00)
CL-4		15,527 (0.70)	4,421 (0.20)	1,642 (0.07)	475 (0.02)	22,065 (1.00)
CL-5		2,150 (0.50)	1,428 (0.33)	304 (0.07)	421 (0.10)	4,303 (1.00)
CL-6		1,702 (0.20)	966 (0.11)	231 (0.03)	5,611 (0.66)	8,510 (1.00)
CL-7		2,065 (0.50)	446 (0.11)	297 (0.07)	1,331 (0.32)	4,139 (1.00)
Average		5,088 (0.61)	1,582 (0.19)	428 (0.05)	1,292 (0.15)	8,390 (1.00)

Note: MC: Motorcycles, LV: Light Vehicles, HV: Heavy Vehicles, CY: Pedal-cycles
Units: 12-hr Traffic Volume, figures in the bracket indicate compositions

Table 2-2-19 (b) Classified Traffic Volume and its Compositions (NR-1)

Stations	Kilo Post	MC	LV	HV	CY	Total
RS-1.1	18	8,353 (0.75)	1,718 (0.15)	439 (0.04)	685 (0.06)	11,195 (1.00)
RS-1.2	40	2,497 (0.45)	1,187 (0.21)	241 (0.04)	1,638 (0.29)	5,560 (1.00)
RS-1.3	60	3,453 (0.50)	1,109 (0.16)	233 (0.03)	2,047 (0.30)	6,842 (1.00)
RS-1.4	95	1,104 (0.47)	503 (0.22)	190 (0.08)	527 (0.23)	2,324 (1.00)

Note: MC: Motorcycles, LV: Light Vehicles, HV: Heavy Vehicles, CY: Pedal-cycles
Units: 12-hr Traffic Volume, figures in the bracket indicate compositions

Table 2-2-19 (c) Classified Traffic Volume and its Compositions (NR-6, 7 and 11)

Stations	Kilo Post	MC	LV	HV	CY	Total
RS-6.1		8,319 (0.62)	4,090 (0.31)	517 (0.04)	385 (0.03)	13,311 (1.00)
RS-6.2		1,706 (0.35)	2,364 (0.48)	344 (0.07)	512 (0.10)	4,926 (1.00)
RS-7		4,253 (0.62)	1,119 (0.16)	214 (0.03)	1,230 (0.18)	6,816 (1.00)
RS-11.1		3,134 (0.59)	499 (0.09)	149 (0.03)	1,540 (0.29)	5,322 (1.00)
RS-11.2		3,275 (0.47)	249 (0.04)	312 (0.04)	3,138 (0.45)	6,974 (1.00)

Note: MC: Motorcycles, LV: Light Vehicles, HV: Heavy Vehicles, CY: Pedal-cycles
Units: 12-hr Traffic Volume, figures in the bracket indicate compositions

Table 2-2-19 (d) Classified Traffic Volume and its Compositions (Phnom Penh Area)

Stations	MC	LV	HV	CY	Total
RS-271.1	22,394 (0.67)	5,026 (0.15)	952 (0.03)	4,893 (0.15)	33,265 (1.00)
RS-271.2	8,237 (0.74)	1,694 (0.15)	351 (0.03)	854 (0.08)	11,137 (1.00)
RS-271.3	13,199 (0.86)	464 (0.03)	41 (0.00)	1,722 (0.11)	15,426 (1.00)
RS-TD	1,675 (0.68)	128 (0.05)	175 (0.07)	497 (0.20)	2,475 (1.00)
RS-BOT	17,002 (0.72)	3,253 (0.14)	943 (0.04)	2,500 (0.11)	23,698 (1.00)
RS-RK	19,697 (0.76)	3,698 (0.14)	664 (0.03)	1,872 (0.07)	25,931 (1.00)
RS-MV	63,461 (0.82)	9,432 (0.12)	946 (0.01)	3,373 (0.04)	77,212 (1.00)

MC: Motorcycles, LV: Light Vehicles, HV: Heavy Vehicles, CY: Pedal-cycles
Units: 12-hr Traffic Volume, figures in the bracket indicate compositions

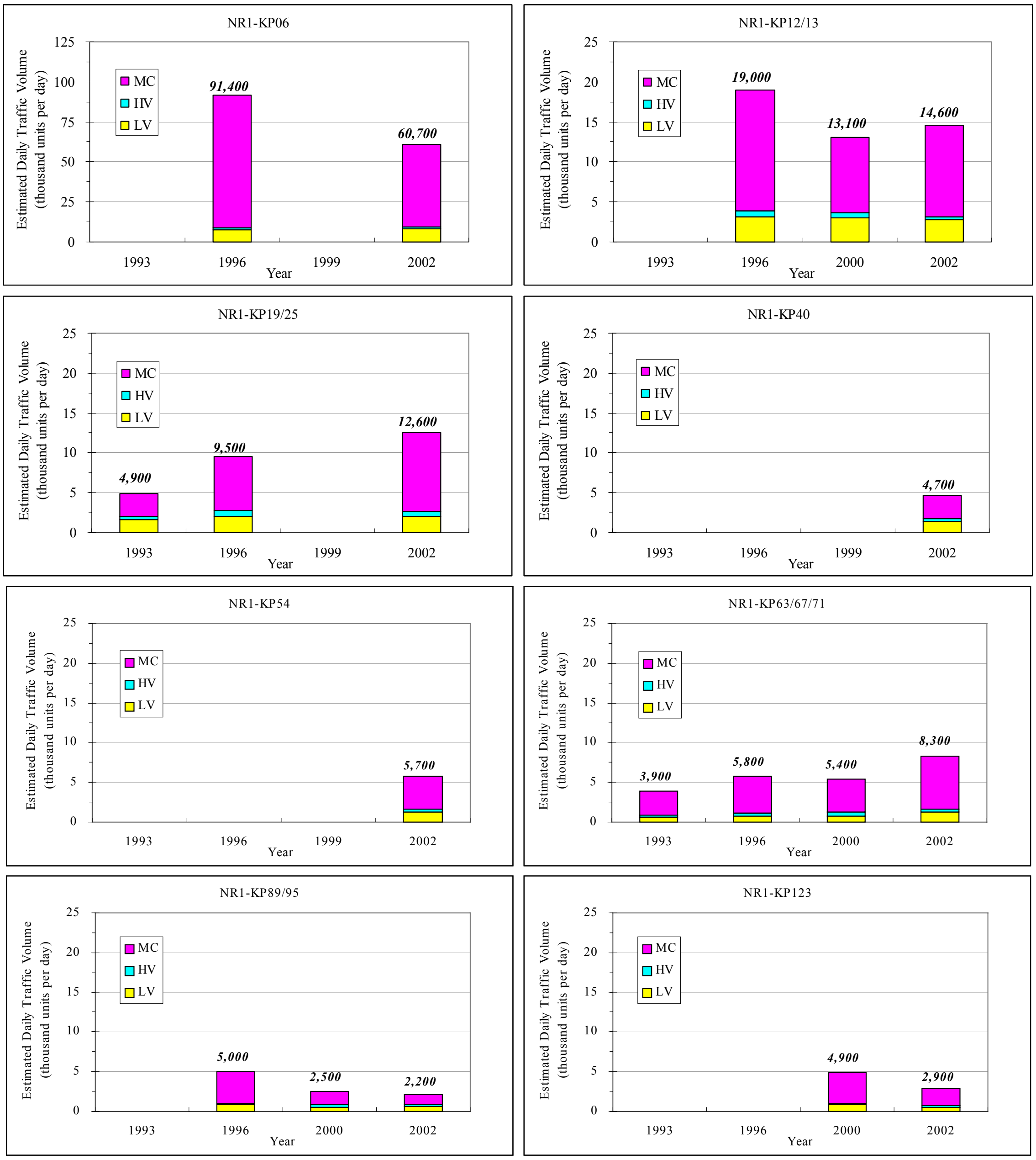


Fig. 2-2-20 (a) Past & Present Daily Traffic Volume along National Road No.1

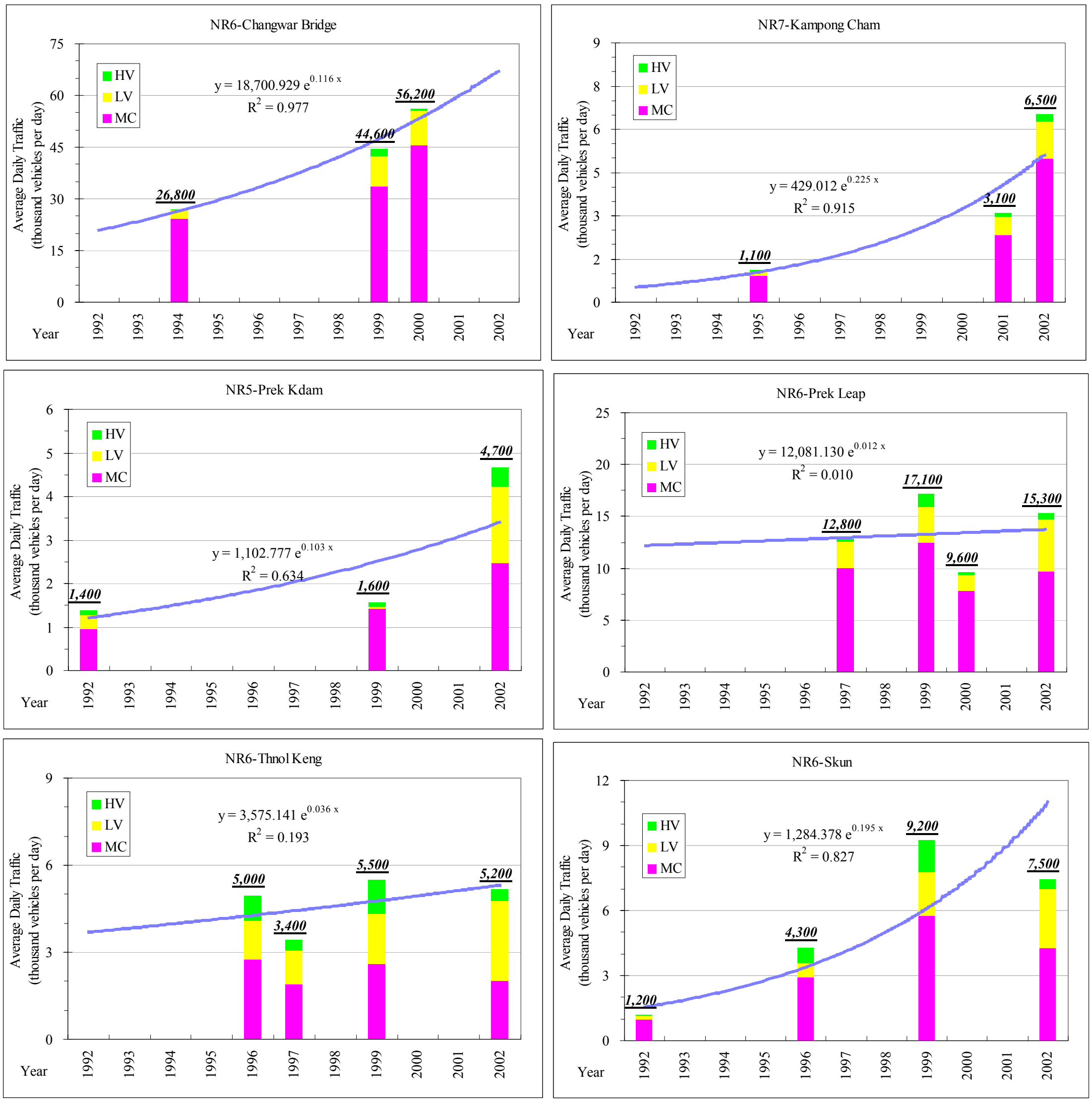


Fig. 2-2-20 (b) Past & Present Daily Traffic Volume along National Road No.5, No.6, & No.7

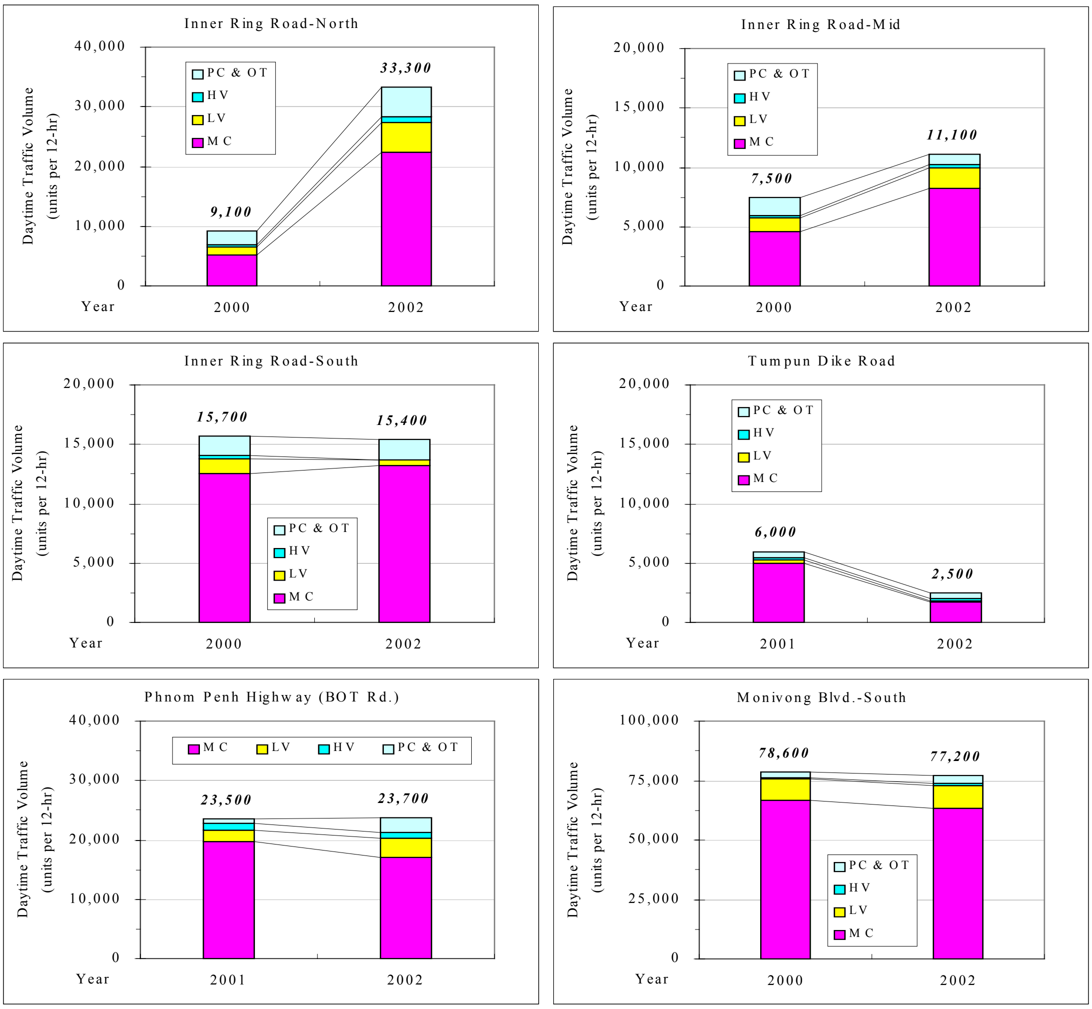


Fig. 2-2-20 (c) Past & Present Daytime Traffic Volume at Selected Station in Phnom Penh

F. TRAFFIC DEMAND FORECAST

Table F-1 (a) Trip Distribution by Large Zone (Vehicle OD - 2002)

Motorcycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	120,154	45,283	743	268	531	1,292	992	3,954	427	523	192	0	174,359
KD	45,282	8,424	1,069	194	669	489	144	597	268	374	93	0	57,603
PV	743	1,069	1,254	194	536	44	21	60	43	75	78	0	4,117
SR	268	194	194	0	701	19	9	26	19	23	222	0	1,675
KCM	531	669	536	701	394	46	25	71	125	59	265	0	3,422
NR2	1,291	489	44	19	46	0	0	188	39	55	23	0	2,194
NR3	991	144	21	9	25	0	0	0	0	33	15	0	1,238
NR4	3,954	597	60	26	71	188	0	0	0	75	30	0	5,001
NR5	427	268	43	19	125	39	0	0	0	195	49	0	1,165
NR6	523	373	75	23	59	55	33	75	195	0	42	0	1,453
NR7	192	93	78	222	265	23	15	30	49	42	0	0	1,009
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	174,356	57,603	4,117	1,675	3,422	2,195	1,239	5,001	1,165	1,454	1,009	0	253,236

Light Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	17,274	7,489	207	94	464	417	478	1,113	417	354	99	16	28,422
KD	7,489	1,018	151	68	252	134	56	139	98	130	21	0	9,556
PV	207	151	96	73	69	15	4	13	12	22	12	0	674
SR	94	68	73	0	139	7	3	6	9	9	39	0	447
KCM	464	253	69	139	70	27	23	57	30	44	53	0	1,229
NR2	417	134	15	7	27	0	0	71	20	29	9	0	729
NR3	478	56	4	3	23	0	0	0	0	23	7	0	594
NR4	1,112	139	13	6	57	71	0	0	0	47	15	0	1,460
NR5	417	98	12	9	29	20	0	0	0	27	8	0	620
NR6	353	130	22	9	44	29	23	47	26	0	13	0	696
NR7	99	21	12	39	53	9	7	15	8	13	0	0	276
EX	16	0	0	0	0	0	0	0	0	0	0	0	16
Total	28,420	9,557	674	447	1,227	729	594	1,461	620	698	276	16	44,719

Heavy Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	2,864	1,010	55	37	84	90	28	574	121	73	39	16	4,991
KD	1,011	82	15	0	43	24	0	50	7	0	0	0	1,232
PV	55	15	50	73	94	4	2	5	4	6	0	0	308
SR	37	0	73	0	185	3	1	2	3	0	0	0	304
KCM	84	41	94	186	90	6	3	15	6	62	9	0	596
NR2	90	24	4	3	6	0	0	8	6	6	0	0	147
NR3	28	0	2	1	3	0	0	0	0	3	0	0	37
NR4	574	50	5	2	15	8	0	0	0	15	4	0	673
NR5	121	7	4	3	6	6	0	0	0	8	0	0	155
NR6	73	0	6	0	62	6	3	15	8	0	0	0	173
NR7	39	0	0	0	9	0	0	4	0	0	0	0	52
EX	16	0	0	0	0	0	0	0	0	0	0	0	16
Total	4,992	1,229	308	305	597	147	37	673	155	173	52	16	8,684

Pedal Cycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	6,932	2,052	15	7	8	55	32	77	55	0	0	0	9,233
KD	2,053	612	1,018	19	44	7	2	9	4	4	0	0	3,772
PV	15	1,018	400	103	238	9	4	9	10	1	0	0	1,807
SR	7	19	103	0	460	5	2	5	5	8	2	0	616
KCM	8	44	238	461	24	4	2	7	314	1,748	142	0	2,992
NR2	55	7	9	5	4	0	0	6	1	13	2	0	102
NR3	31	2	4	2	2	0	0	0	0	11	1	0	53
NR4	77	9	9	5	7	6	0	0	0	25	3	0	141
NR5	55	4	10	5	314	1	0	0	0	499	24	0	912
NR6	0	4	1	8	1,746	12	11	25	499	0	40	0	2,346
NR7	0	0	0	2	142	2	1	3	24	40	0	0	214
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	9,233	3,771	1,807	617	2,989	101	54	141	912	2,349	214	0	22,188

Inland Waterway

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	0	0	0	0	2	0	0	0	0	2	0	0	4
KD	0	0	0	0	0	0	0	0	0	0	0	0	0
PV	0	0	0	0	0	0	0	0	0	0	0	1	1
SR	0	0	0	0	0	0	0	0	0	0	0	0	0
KCM	2	0	0	0	0	0	0	0	0	0	1	0	3
NR2	0	0	0	0	0	0	0	0	0	0	0	0	0
NR3	0	0	0	0	0	0	0	0	0	0	0	0	0
NR4	0	0	0	0	0	0	0	0	0	0	0	0	0
NR5	0	0	0	0	0	0	0	0	0	0	0	0	0
NR6	2	0	0	0	0	0	0	0	0	0	0	0	2
NR7	0	0	0	0	1	0	0	0	0	0	0	0	1
EX	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	4	0	1	0	3	0	0	0	0	2	1	1	12

Note: figures in the tables are not including the movements within the same traffic zone

Table F-1 (b) Trip Distribution by Large Zone (Vehicle OD - 2005)

Motorcycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	164,280	61,873	1,015	365	654	1,769	1,221	4,886	510	622	224	0	237,419
KD	61,872	11,390	1,465	261	832	663	175	730	314	440	98	0	78,240
PV	1,015	1,465	1,716	264	663	58	28	76	53	90	92	0	5,520
SR	365	261	264	0	866	25	12	33	23	27	265	0	2,141
KCM	655	829	664	865	438	56	28	80	137	65	285	0	4,102
NR2	1,768	663	58	25	56	0	0	234	46	64	25	0	2,939
NR3	1,220	175	28	12	28	0	0	0	0	37	18	0	1,518
NR4	4,882	732	76	33	80	233	0	0	0	86	35	0	6,157
NR5	509	318	53	23	135	46	0	0	0	204	53	0	1,341
NR6	625	444	88	27	65	66	37	86	204	0	47	0	1,689
NR7	226	98	94	265	285	27	18	35	53	46	0	0	1,147
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	237,417	78,248	5,521	2,140	4,102	2,943	1,519	6,160	1,340	1,681	1,142	0	342,213

Light Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	24,984	10,809	294	137	607	601	624	1,462	530	453	126	22	40,649
KD	10,809	1,372	202	95	338	186	72	176	118	164	21	0	13,553
PV	294	202	138	106	88	22	6	17	14	27	16	0	930
SR	137	95	106	0	180	9	4	8	12	11	50	0	612
KCM	609	334	88	182	84	35	27	69	37	55	63	0	1,583
NR2	601	186	22	9	35	0	0	94	25	37	13	0	1,022
NR3	624	70	6	4	27	0	0	0	0	29	10	0	770
NR4	1,461	177	17	8	69	93	0	0	0	60	19	0	1,904
NR5	529	119	14	12	35	25	0	0	0	32	8	0	774
NR6	453	164	27	11	54	37	29	59	31	0	17	0	882
NR7	126	21	16	50	61	13	10	19	8	17	0	0	341
EX	22	0	0	0	0	0	0	0	0	0	0	0	22
Total	40,649	13,549	930	614	1,578	1,021	772	1,904	775	885	343	22	63,042

Heavy Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	4,046	1,367	73	52	102	123	35	736	150	93	46	21	6,844
KD	1,368	94	16	0	48	28	0	61	8	0	0	0	1,623
PV	73	16	72	103	121	4	2	5	4	8	0	0	408
SR	52	0	103	0	238	4	1	2	4	0	0	0	404
KCM	102	44	121	239	102	7	3	18	7	68	10	0	721
NR2	123	28	4	4	7	0	0	11	8	8	0	0	193
NR3	35	0	2	1	3	0	0	0	0	4	0	0	45
NR4	736	61	5	2	18	11	0	0	0	20	4	0	857
NR5	151	8	4	4	7	8	0	0	0	9	0	0	191
NR6	93	0	8	0	68	8	4	20	9	0	0	0	210
NR7	47	0	0	0	10	0	0	4	0	0	0	0	61
EX	21	0	0	0	0	0	0	0	0	0	0	0	21
Total	6,847	1,618	408	405	724	193	45	857	190	210	60	21	11,578

Pedal Cycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	8,444	2,464	18	8	9	67	33	85	57	0	0	0	11,185
KD	2,465	702	1,228	22	49	7	2	9	4	4	0	0	4,492
PV	18	1,228	488	126	263	9	4	9	10	1	0	0	2,156
SR	8	22	126	0	508	5	2	5	5	8	2	0	691
KCM	9	49	264	508	26	4	2	7	304	1,694	135	0	3,002
NR2	67	7	9	5	4	0	0	6	1	13	2	0	114
NR3	32	2	4	2	2	0	0	0	0	11	1	0	54
NR4	85	9	9	5	7	6	0	0	0	26	3	0	150
NR5	57	4	10	5	304	1	0	0	0	471	24	0	876
NR6	0	4	1	8	1,691	12	11	26	471	0	40	0	2,264
NR7	0	0	0	2	136	2	1	3	24	40	0	0	208
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	11,185	4,491	2,157	691	2,999	113	55	150	876	2,268	207	0	25,192

Inland Waterway

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	0	0	0	0	2	0	0	0	0	2	0	0	4
KD	0	0	0	0	0	0	0	0	0	0	0	0	0
PV	0	0	0	0	0	0	0	0	0	0	0	1	1
SR	0	0	0	0	0	0	0	0	0	0	0	0	0
KCM	2	0	0	0	0	0	0	0	0	0	1	0	3
NR2	0	0	0	0	0	0	0	0	0	0	0	0	0
NR3	0	0	0	0	0	0	0	0	0	0	0	0	0
NR4	0	0	0	0	0	0	0	0	0	0	0	0	0
NR5	0	0	0	0	0	0	0	0	0	0	0	0	0
NR6	2	0	0	0	0	0	0	0	0	0	0	0	2
NR7	0	0	0	0	1	0	0	0	0	0	0	0	1
EX	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	4	0	1	0	3	0	0	0	0	2	1	1	12

Note: figures in the tables are not including the movements within the same traffic zone

Table F-1 (c) Trip Distribution by Large Zone (Vehicle OD - 2010)

Motorcycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	218,580	82,349	1,352	487	872	2,355	1,627	6,499	684	833	308	0	315,946
KD	82,348	15,244	1,952	351	1,104	883	234	981	425	607	163	0	104,292
PV	1,352	1,952	2,282	353	880	78	37	99	68	120	121	0	7,342
SR	487	351	353	0	1,153	34	16	43	30	37	352	0	2,856
KCM	874	1,099	882	1,151	582	76	37	107	179	89	378	0	5,454
NR2	2,353	883	78	34	76	0	0	311	60	85	34	0	3,914
NR3	1,626	234	37	16	37	0	0	0	0	48	24	0	2,022
NR4	6,493	984	99	43	107	309	0	0	0	115	50	0	8,200
NR5	685	430	68	30	181	61	0	0	0	272	73	0	1,800
NR6	838	612	119	37	89	87	48	115	272	0	67	0	2,284
NR7	310	163	123	352	378	36	24	50	73	66	0	0	1,575
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	315,946	104,301	7,345	2,854	5,459	3,919	2,023	8,205	1,791	2,272	1,570	0	455,685

Light Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	35,714	15,457	421	195	865	860	892	2,085	758	642	180	31	58,100
KD	15,457	2,022	285	131	477	267	107	259	181	241	42	0	19,469
PV	421	285	198	152	126	31	8	24	22	40	24	0	1,331
SR	195	131	152	0	258	13	5	11	17	17	71	0	870
KCM	867	473	126	259	120	51	38	98	49	78	89	0	2,248
NR2	860	267	31	13	51	0	0	135	36	52	17	0	1,462
NR3	889	105	8	5	38	0	0	0	0	40	14	0	1,099
NR4	2,084	261	24	11	98	134	0	0	0	84	28	0	2,724
NR5	758	183	22	17	48	36	0	0	0	45	16	0	1,125
NR6	645	241	40	17	76	52	40	82	43	0	26	0	1,262
NR7	180	42	24	71	87	17	14	28	16	26	0	0	505
EX	31	0	0	0	0	0	0	0	0	0	0	0	31
Total	58,101	19,467	1,331	871	2,244	1,461	1,104	2,722	1,122	1,265	507	31	90,226

Heavy Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	5,656	1,948	104	71	153	177	52	1,028	210	126	68	30	9,623
KD	1,950	152	29	0	81	44	0	92	13	0	0	0	2,361
PV	104	29	102	146	170	8	4	10	8	10	0	0	591
SR	71	0	146	0	332	5	2	4	5	0	0	0	565
KCM	153	79	170	334	144	11	6	27	11	97	14	0	1,046
NR2	177	44	8	5	11	0	0	16	10	10	0	0	281
NR3	52	0	4	2	6	0	0	0	0	5	0	0	69
NR4	1,028	92	10	4	27	16	0	0	0	25	8	0	1,210
NR5	212	13	8	5	11	10	0	0	0	12	0	0	271
NR6	126	0	10	0	97	10	5	25	12	0	0	0	285
NR7	70	0	0	0	14	0	0	8	0	0	0	0	92
EX	30	0	0	0	0	0	0	0	0	0	0	0	30
Total	9,629	2,357	591	567	1,046	281	69	1,210	269	285	90	30	16,424

Pedal Cycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	9,468	2,764	20	9	10	76	38	94	63	0	0	0	12,542
KD	2,764	796	1,378	25	55	8	2	9	4	4	0	0	5,045
PV	20	1,378	546	142	294	11	4	11	12	1	1	0	2,420
SR	9	25	142	0	569	6	2	6	6	9	2	0	776
KCM	10	55	295	569	30	4	2	7	341	1,895	152	0	3,360
NR2	76	8	11	6	4	0	0	7	1	15	2	0	130
NR3	37	2	4	2	2	0	0	0	0	13	1	0	61
NR4	94	9	11	6	7	7	0	0	0	28	3	0	165
NR5	63	4	12	6	341	1	0	0	0	528	27	0	982
NR6	0	4	1	9	1,891	14	13	28	528	0	45	0	2,533
NR7	0	0	1	2	153	2	1	3	27	45	0	0	234
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	12,541	5,045	2,421	776	3,356	129	62	165	982	2,538	233	0	28,248

Inland Waterway

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	0	0	0	0	3	0	0	0	0	3	0	0	6
KD	0	0	0	0	0	0	0	0	0	0	0	0	0
PV	0	0	0	0	0	0	0	0	0	0	0	1	1
SR	0	0	0	0	0	0	0	0	0	0	0	0	0
KCM	3	0	0	0	0	0	0	0	0	0	2	0	5
NR2	0	0	0	0	0	0	0	0	0	0	0	0	0
NR3	0	0	0	0	0	0	0	0	0	0	0	0	0
NR4	0	0	0	0	0	0	0	0	0	0	0	0	0
NR5	0	0	0	0	0	0	0	0	0	0	0	0	0
NR6	3	0	0	0	0	0	0	0	0	0	0	0	3
NR7	0	0	0	0	2	0	0	0	0	0	0	0	2
EX	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	6	0	1	0	5	0	0	0	0	3	2	1	18

Note: figures in the tables are not including the movements within the same traffic zone

Table F-1 (d) Trip Distribution by Large Zone (Vehicle OD - 2015)

Motorcycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	293,252	110,464	1,814	652	1,172	3,157	2,182	8,718	914	1,117	407	0	423,849
KD	110,462	20,378	2,613	473	1,479	1,187	315	1,304	565	787	188	0	139,751
PV	1,814	2,613	3,062	473	1,181	104	50	132	94	162	163	0	9,848
SR	652	473	473	0	1,546	45	22	57	42	49	473	0	3,832
KCM	1,174	1,473	1,184	1,544	782	101	50	142	241	118	507	0	7,316
NR2	3,155	1,187	104	45	101	0	0	417	82	115	45	0	5,251
NR3	2,180	315	50	22	50	0	0	0	0	64	32	0	2,713
NR4	8,714	1,308	132	57	142	415	0	0	0	153	62	0	10,983
NR5	913	568	94	42	241	81	0	0	0	364	94	0	2,397
NR6	1,122	791	159	49	118	117	64	153	364	0	86	0	3,023
NR7	409	188	165	473	507	47	32	62	94	84	0	0	2,061
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	423,847	139,758	9,850	3,830	7,319	5,254	2,715	10,985	2,396	3,013	2,057	0	611,024

Light Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	50,552	21,881	593	274	1,228	1,218	1,261	2,954	1,077	911	257	44	82,250
KD	21,881	2,904	406	187	679	379	154	365	264	346	63	0	27,628
PV	593	406	280	215	179	44	10	34	32	59	32	0	1,884
SR	274	187	215	0	365	18	8	15	23	24	101	0	1,230
KCM	1,229	673	179	368	170	72	54	139	73	108	128	0	3,193
NR2	1,218	379	44	18	72	0	0	192	51	75	23	0	2,072
NR3	1,259	151	10	8	54	0	0	0	0	57	18	0	1,557
NR4	2,952	368	34	15	139	189	0	0	0	119	41	0	3,857
NR5	1,078	267	32	23	71	51	0	0	0	64	24	0	1,610
NR6	914	346	59	24	105	75	57	116	62	0	35	0	1,793
NR7	257	63	32	101	125	23	18	41	24	35	0	0	719
EX	44	0	0	0	0	0	0	0	0	0	0	0	44
Total	82,251	27,625	1,884	1,233	3,187	2,069	1,562	3,856	1,606	1,798	722	44	127,837

Heavy Vehicles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	7,797	2,645	141	99	206	241	70	1,419	289	175	93	41	13,216
KD	2,647	190	35	0	100	58	0	120	17	0	0	0	3,167
PV	141	35	140	200	234	10	4	11	10	14	0	0	799
SR	99	0	200	0	458	7	2	4	7	0	0	0	777
KCM	206	96	234	461	198	15	7	36	14	133	19	0	1,419
NR2	241	58	10	7	15	0	0	22	14	14	0	0	381
NR3	70	0	4	2	7	0	0	0	0	7	0	0	90
NR4	1,418	120	11	4	36	22	0	0	0	35	10	0	1,656
NR5	292	17	10	7	14	14	0	0	0	17	0	0	371
NR6	175	0	14	0	133	14	7	35	17	0	0	0	395
NR7	95	0	0	0	19	0	0	10	0	0	0	0	124
EX	41	0	0	0	0	0	0	0	0	0	0	0	41
Total	13,222	3,161	799	780	1,420	381	90	1,657	368	395	122	41	22,436

Pedal Cycles

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	10,562	3,086	23	10	11	85	42	108	72	0	0	0	13,999
KD	3,087	886	1,545	28	61	9	3	10	4	5	1	0	5,639
PV	23	1,545	610	158	328	12	6	11	12	1	1	0	2,707
SR	10	28	158	0	635	7	3	6	6	10	2	0	865
KCM	11	61	330	635	32	6	2	9	380	2,113	170	0	3,749
NR2	85	9	12	7	6	0	0	8	1	18	2	0	148
NR3	41	3	6	3	2	0	0	0	0	15	1	0	71
NR4	108	10	11	6	9	8	0	0	0	32	3	0	187
NR5	72	4	12	6	380	1	0	0	0	590	32	0	1,097
NR6	0	5	1	10	2,111	16	15	32	590	0	52	0	2,832
NR7	0	1	1	2	171	2	1	3	32	52	0	0	265
EX	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	13,999	5,638	2,709	865	3,746	146	72	187	1,097	2,836	264	0	31,559

Inland Waterway

OD	PP	KD	PV	SR	KCM	NR2	NR3	NR4	NR5	NR6	NR7	EX	Total
PP	0	0	0	0	4	0	0	0	0	4	0	0	8
KD	0	0	0	0	0	0	0	0	0	0	0	0	0
PV	0	0	0	0	0	0	0	0	0	0	0	1	1
SR	0	0	0	0	0	0	0	0	0	0	0	0	0
KCM	4	0	0	0	0	0	0	0	0	0	3	0	7
NR2	0	0	0	0	0	0	0	0	0	0	0	0	0
NR3	0	0	0	0	0	0	0	0	0	0	0	0	0
NR4	0	0	0	0	0	0	0	0	0	0	0	0	0
NR5	0	0	0	0	0	0	0	0	0	0	0	0	0
NR6	4	0	0	0	0	0	0	0	0	0	0	0	4
NR7	0	0	0	0	3	0	0	0	0	0	0	0	3
EX	0	0	1	0	0	0	0	0	0	0	0	0	1
Total	8	0	1	0	7	0	0	0	0	4	3	1	24

Note: figures in the tables are not including the movements within the same traffic zone

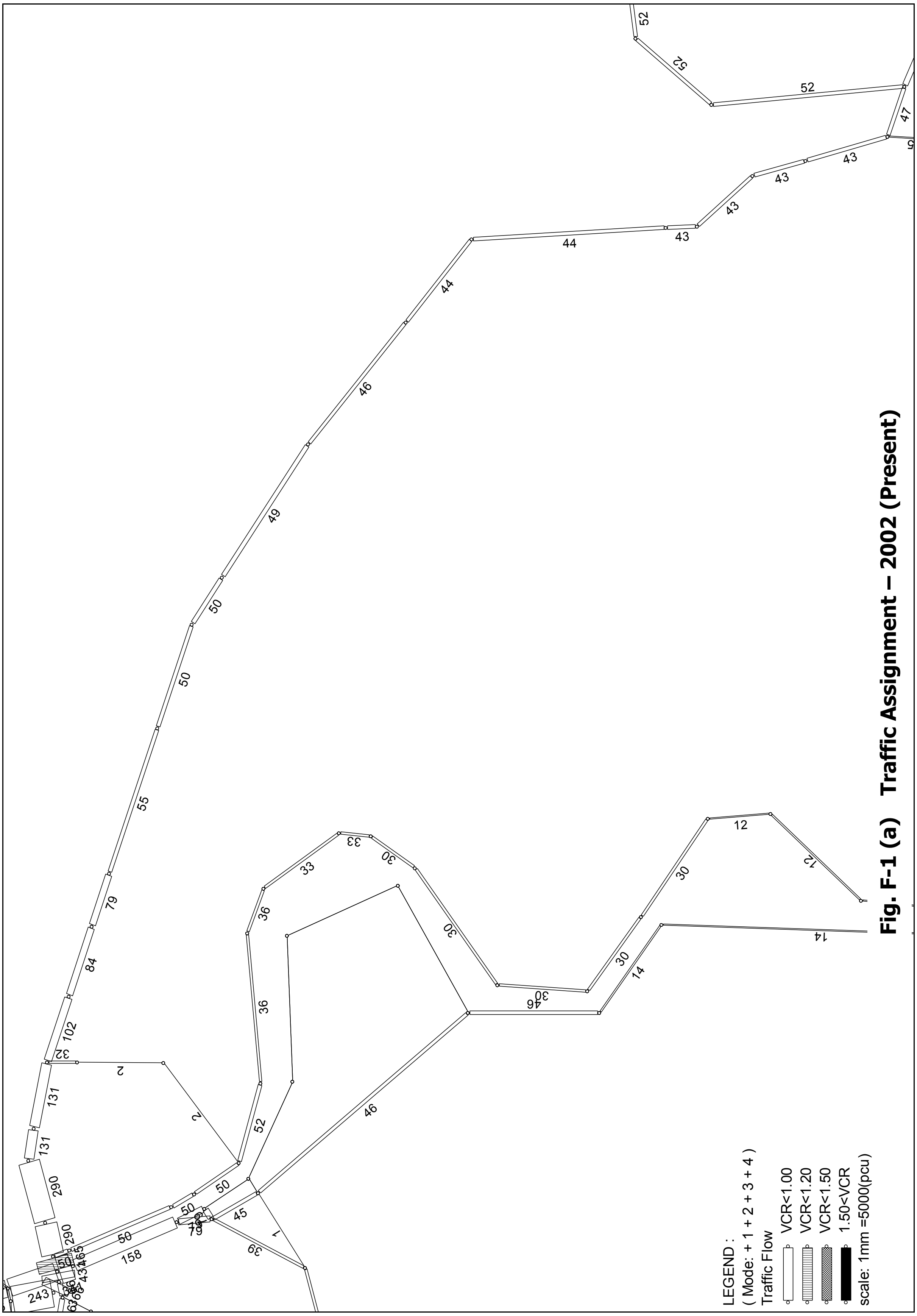


Fig. F-1 (a) Traffic Assignment – 2002 (Present)

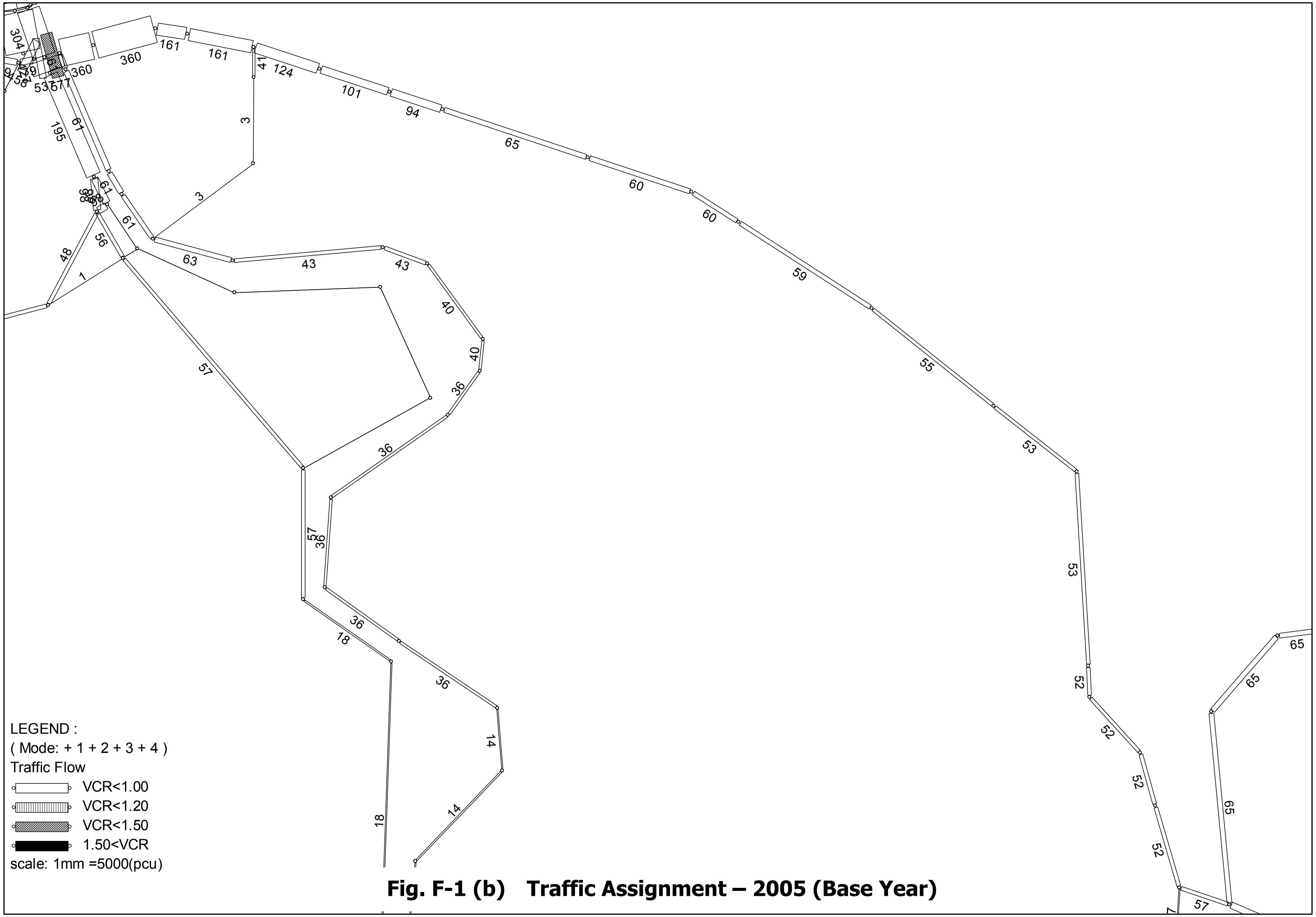


Fig. F-1 (b) Traffic Assignment – 2005 (Base Year)

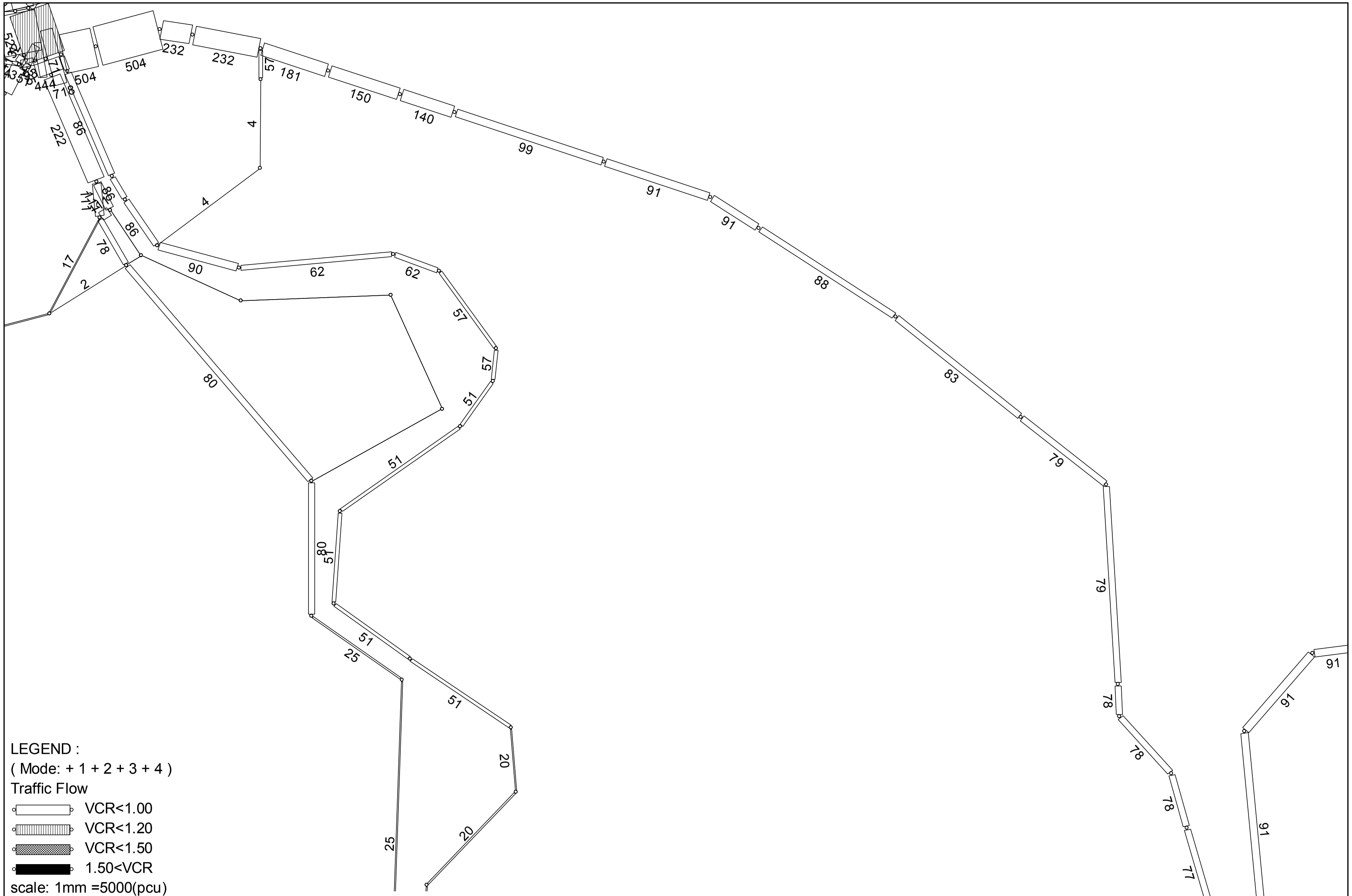


Fig. F-1 (c) Traffic Assignment – 2010 (With Project Case)

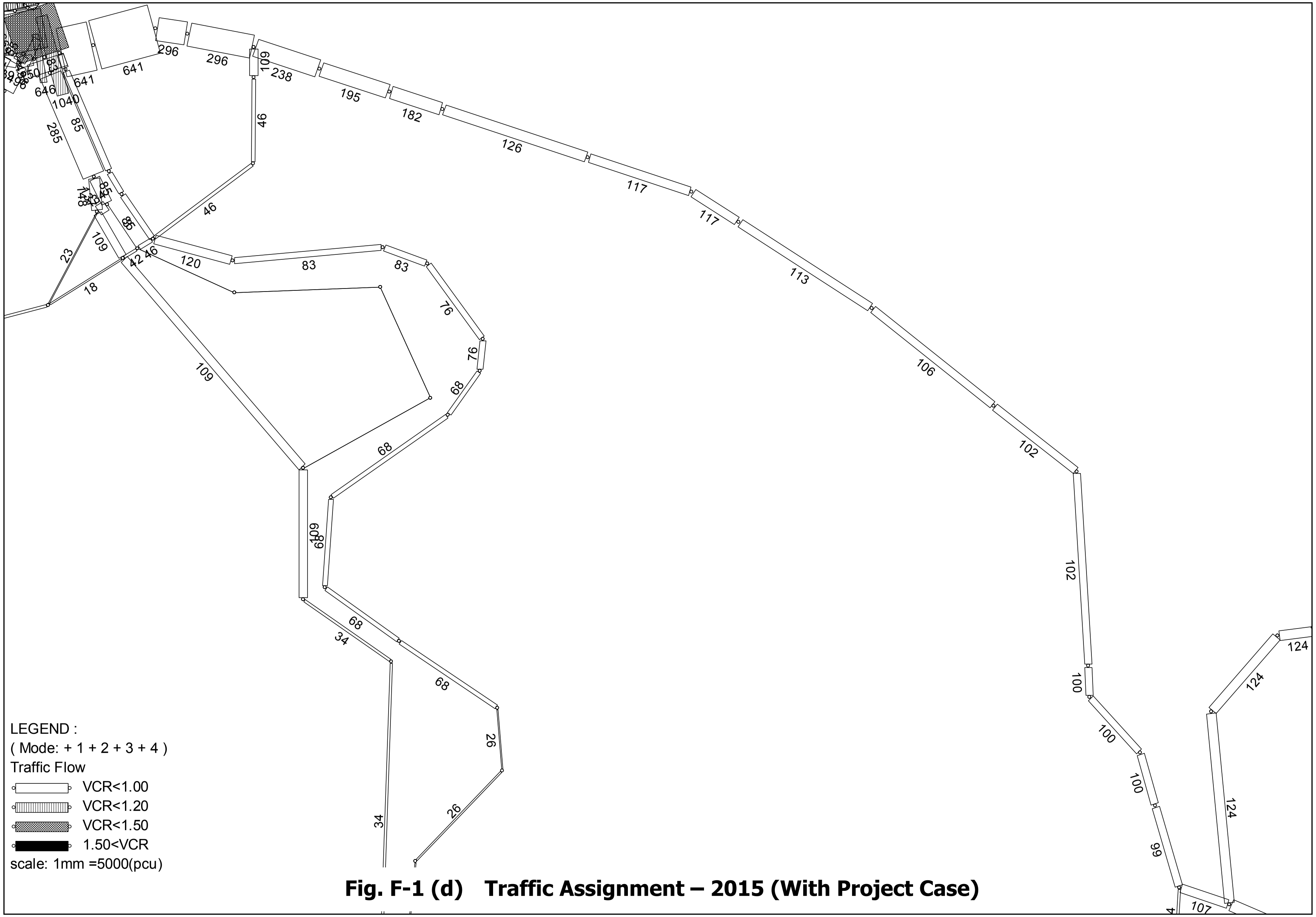


Fig. F-1 (d) Traffic Assignment – 2015 (With Project Case)

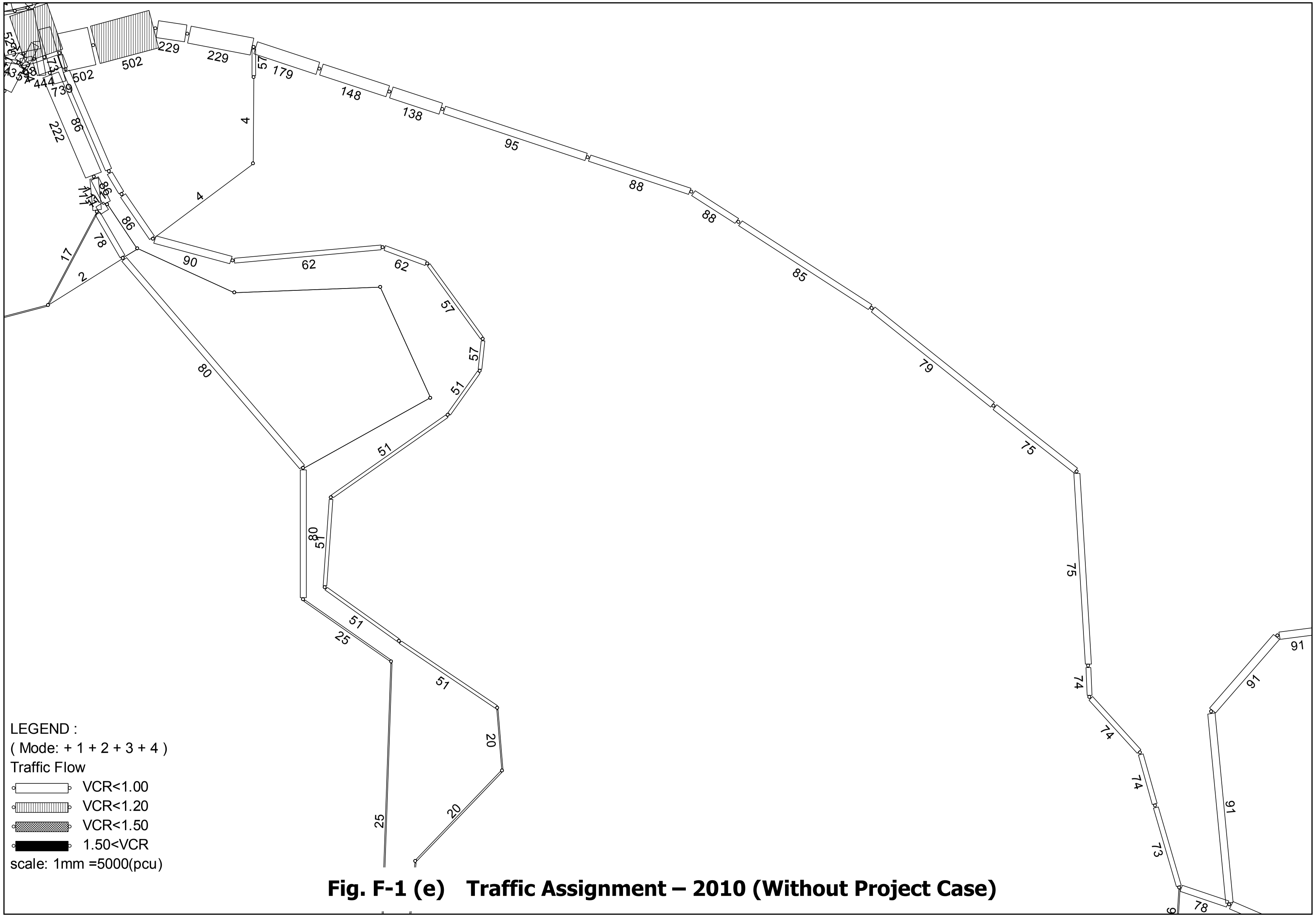


Fig. F-1 (e) Traffic Assignment – 2010 (Without Project Case)

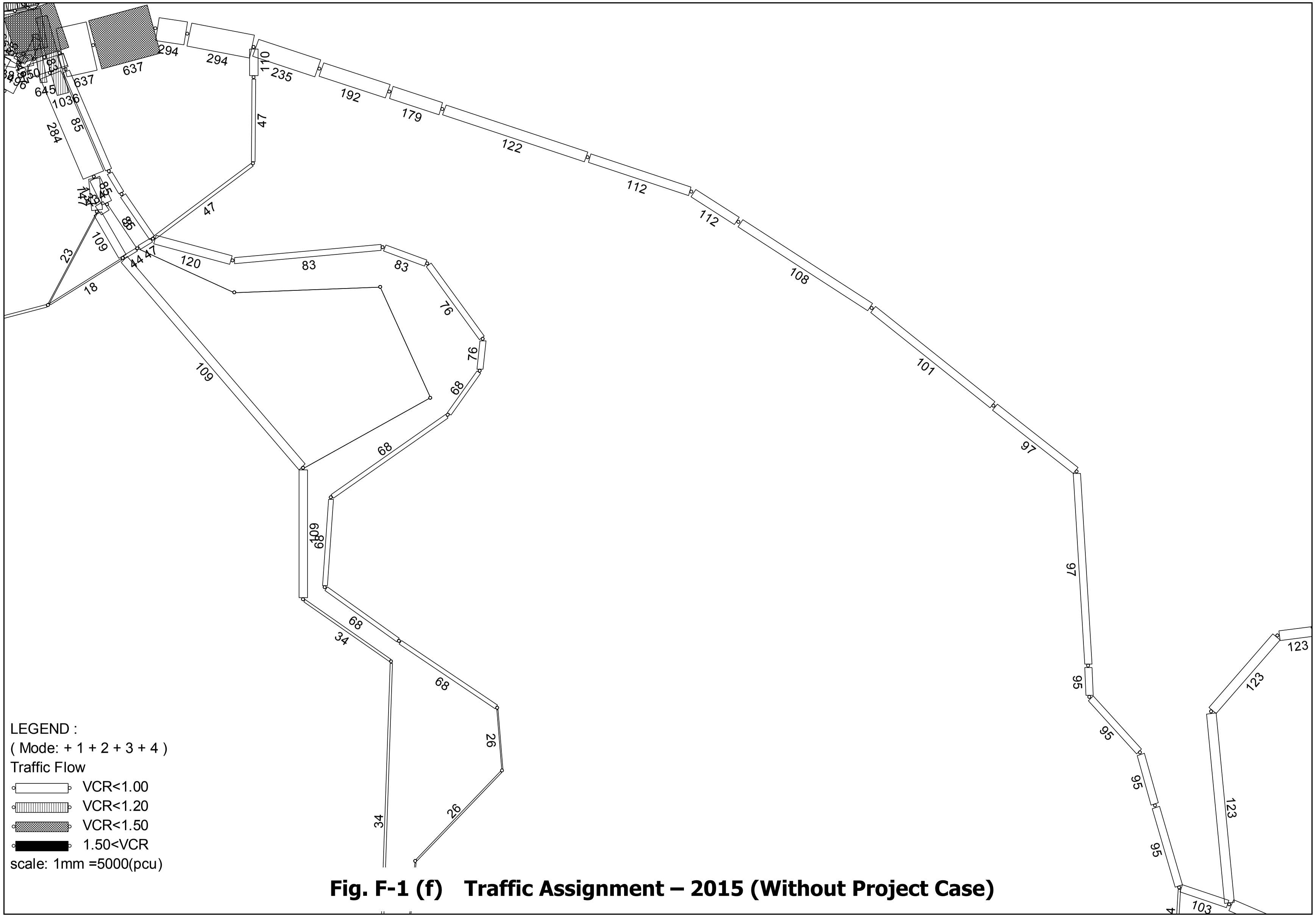


Fig. F-1 (f) Traffic Assignment – 2015 (Without Project Case)

G. ROAD

G-1. Criteria for Geometric Design

CRITERIA

FOR

GEOMETRIC DESIGN

FOR
THE FEASIBILITY STUDY
ON
THE IMPROVEMENT OF NATIONAL ROAD NO. 1
(PHNOM PENH – NEAK LOUENG SECTION)
IN THE KINGDOM OF CAMBODIA

1 BASIC FACTORS

1.1 Classification, Design Speed and Main Cross-sectional Elements

In deciding the basic design factors for the Study Road, some design standards are referred.

(1) Design Standard (for road), Part I: Geometry (Cambodian Standard), 1999

Major design factors of Cambodian Standard are summarized in the table below:

Table 1-1 Summary of Major Geometric Design Factors of Cambodian Standard

Road Category	Arterial		Collector		Local	
	Urban	Rural	Urban	Rural	Urban	Rural
	U6	R6	U4	R4	U3	R3
Access Control*	F	F	P	P	P/N	P/N
Design Speed (Level Terrain) (km/hr)	100	120	70	90	60	70
Lane Width (m)	3.50	3.50	3.25	3.25	3.00	3.00
Shoulder Width (m)	3.00	3.00	3.00	3.00	2.50	2.50
Min. Radius of Curve (Horizon.)** (m)	345	NA***	165	NA***	115	165

* F: Full access control P: Partial access control N: No access control
** the Standard gives values of radii in relation to superelevation.
Values shown here are minimum one in the table of the Standard.
*** Values of radii for these speeds are not given in the Standard.

The Study Road is an undivided, 2-lane road and also will be operated as non-access-controlled road. Therefore, it is not appropriate to apply the criteria for the Arterial or Collector to the Study Road in a straightforward manner.

(2) Design Standard of Asian Highway

The Study Road is a part of Asian Highway A1 Route. Design factors of Asian Highway (for level terrain) are summarized as shown below:

Table 1-2 Summary of Design Factors of Asian Highway (for Flat Terrain)

Highway Classification	Primary (Access controlled, divided 4 or more lanes)	Class I (4 or more lanes)	Class II (2 lanes)	Class III (2 lanes)
Design Speed (km/hr)	120	100	80	60
Lane Width (m)	3.75	3.50	3.50	3.00 (3.25)
Shoulder Width (m)	3.00	3.00	3.00	3.00
Width of Median (m)	4.00	3.00	N/A	N/A
Pavement Slope (%)	2	2	2	2
Shoulder Slope (%)	3 - 6	3 - 6	3 - 6	3 - 6
Max. Superelevation (%)	10	10	10	10

As stated above, the Study Road is operated as non-access-controlled, undivided, 2-lane road.

Therefore, application of the standards for "Primary Class" or "Class I" is considered to be inappropriate, at least under the present circumstances.

(3) AASHTO Standard

"A Policy on Geometric Design of Highways and Streets", 2001, AASHTO (AASHTO Standard) suggests the following design factors.

Table 1-3 Major Design Factors by AASHTO

	Rural Arterial	Urban Arterial
Design Speed (km/h)	100 - 120	50 - 100
Lane Width (m)	3.6	3.6
Shoulder Width	3.0 – 3.6	(Depend on ROW)
Pavement Slope	1.5 – 2.0	1.5 – 3.0

(4) Road Structure Ordinance of Japan (RSOJ)

Major design factors of RSOJ are summarized in the table below.

Table 1-4 Major Design Factors by RSOJ (Flat Terrain)

	Rural Arterial (Category 3, Class 1)	Urban Arterial (Category 4, Class 1)
Design Speed (km/h)	60 - 80	40 - 60
Lane Width (m)	3.5	3.25
Shoulder Width (m)	Minimum 1.25	Minimum 0.5
Pavement Slope (%)	1.5 – 2.0	1.5 – 2.0

(5) Consideration on the Design Criteria Applied to the Study Road

The followings are commonly considered in deciding criteria for geometric design of a road.

(i) Design Speed

Design speed is the maximum safe speed that can be maintained over a specified section of road when conditions are so favorable that design features of road govern. The design speed is to be determined logically considering such factors as;

- Type or classification of the road
- Road-side land use and degree of access control
- Type of terrain

- Available right of way, and especially in case of improvement of existing road, alignment of the existing road
- Design speed of adjacent section(s)

Although travel speed is the dominant consideration for regional arterial road, urban arterial roads should be capable of carrying high traffic volumes. Moreover, it is sometimes necessary to compromise on physical constraints and economic limitations to fit certain elements of design within availability of right-of-way. The followings may warrant the design speed of 80 km/h applied to the through traveled lanes for the NR-1:

- The Study road is not access controlled and there are many at-grade intersections. Accordingly, actual traffic operation will not allow 100 km/h of vehicle speed.
- Similarly, the Study Road is not divided 4-lane road which is common configuration for design speed of 100 km/h. Therefore, straightforward application of design speed of 100 km/h is hazardous.
- Application of high design speed may not allow the new (design) alignment closely follow the alignment of the existing road. This may result in unnecessary increase in construction cost and social impact.

(ii) Lane Width

3.0 m to 3.75 m lane widths are generally used, with 3.5 m lane predominant on most type of highways. 3.75 m lane width is internationally accepted as the widest possible lane width since the lane wider than 3.75 m is hard to regulate traffic flow. In case of the design speed of 80 km/h applied to highway, 3.50 m wide lane width is desirable on both rural and urban facilities.

Lane width of 3.50 m is adopted as the standard width in Cambodian Standard as described above, and is also commonly used as standard of national roads in foreign counties.

Table 1-5 Standard Lane Width in Major Countries

Countries	U.S.A.	Sweden	Holland	France	Japan	Cambodia
Lane width	3.66 m (12 ft)	3.50 m	3.63 m	3.50 m	3.50 m	3.50 m

Although the standard of Asian Highway stipulates the lane width of 3.75 m for “Primary Class”, it is based on assumption of other factors such as “access-controlled, divided 4-lane”. In case of the Study Road, access is not controlled and the intersections are at-grade intersections. In addition, Majority of the section of the Study Road is “undivided 2-lane” configuration. Accordingly, application of the standard of “Primary Class” is not appropriate. For the classes of

“Class I” or lower, lane width of 3.5 m or less is stipulated.

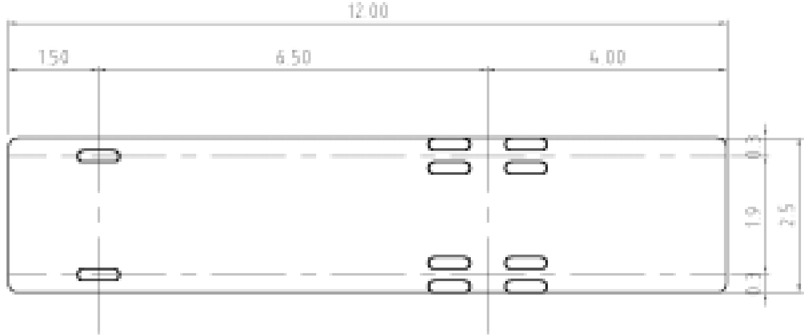
As for economic aspects, the construction cost of highway may increase up to 7% in general, if the lane width of 3.75 m be applied,

It should be noted that actual pavement structure used in Japan, includes marginal strips of 0.25 m which is outside of the lane width, and, therefore, the actual width of the pavement for lane width of 3.50 m is 3.75 m or wider. Accordingly, if the traffic situation changes in the future and the necessity to widen the lane width to 3.75 m, it will be still possible by changing the position of lane mark.

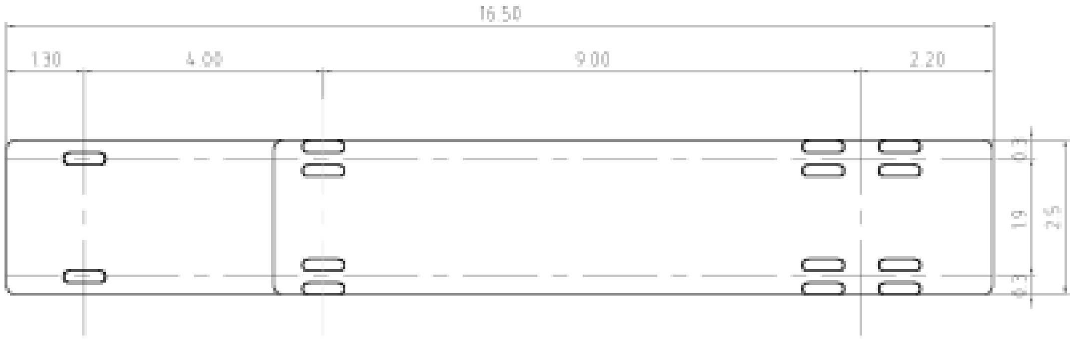
Considering these facts, it is proposed to use lane width of 3.5 m in the Study Road.

2 DESIGN VEHICLE

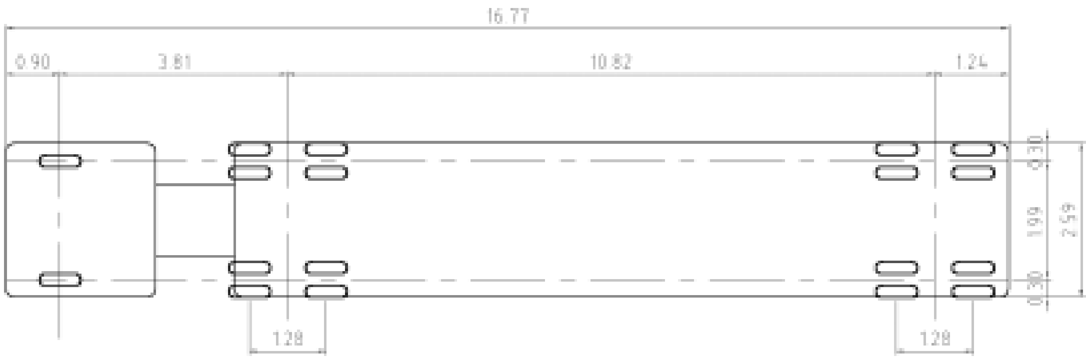
In geometric design, the most governing type of vehicle is semitrailer. Figure 2-1 shows the dimensions of single truck and semitrailer adopted in RSOJ and WB-15 semitailer adopted in AASHTO. Cambodian Standard stipulates WB-15 trailer of AASHTO. Accordingly, WB-15 semitrailer is adopted as the design vehicle.



(a) Single Unit Truck (RSOJ)



(b) Semi-trailer (RSOJ)



(a) WB-15 Semitrailer (42.5 feet Trailer, AASHTO)

Figure 2-1 Design vehicle

3. VERTICAL CLEARANCE

Presently, there are no structures spanning over the Study Road. Accordingly, there is no problem of obstruction in vertical clearance. However, criterion for vertical clearance becomes necessary when over-head type traffic signs or pedestrian crossing are to be constructed.

Criteria for vertical clearance of AASHTO, RSOJ and Cambodian Standard are compared in the table below.

Table 3-1 Criteria for Vertical Clearance

Standard	AASHTO	RSOJ	Cambodian Standard
Vertical Clearance	(4.1 m)*	4.5 m	(4.1 m)*

* Height of design vehicle

It is recommended to adopt 4.5 m as the vertical clearance.

4. HORIZONTAL ALIGNMENT

4. 1 Minimum Radius of Curve

4.1.1 Minimum Radius of Curve

The minimum radius is a limiting value of curvature for a given design speed and is determined from the maximum rate of superelevation and the maximum side friction factor selected for design (limiting value of *f*). Use of sharper curvature that design speed would call for superelevation beyond the limit considered practical or for operation with tire friction and lateral acceleration beyond what is considered comfortable by many drivers, or both. Although based on a threshold of driver comfort, rather than safety, the minimum radius of curvature is a significant value in alignment design. The minimum radius of curvature is also an important control value for determination of superelevation rates for flatter curves.

From the balance of the centrifugal force, superelevation and friction between the road surface and tire, the condition that the vehicle does not slip outward is expressed by the following equation:

$$Z \cos\alpha - G \sin\alpha \leq f(Z \sin\alpha + G \cos\alpha)$$

where;

Z = centrifugal force acting on the vehicle,

G = gross weight of the vehicle, and

f = coefficient of friction between the road surface and tire.

α = angle of superelevation

Substituting

$$Z = \frac{Gv^2}{gR}$$

where;

g = acceleration of gravity ($\simeq$ 9.81 m/s^2),

v = speed of the vehicle (m/s), and

R = radius of curve,

and

$$\sin\alpha / \cos\alpha = \tan\alpha = e \text{ (superelevation)},$$

we obtain

$$R \geq \frac{v^2}{g}\frac{1-fe}{f+e}$$

Since *f*e is small and can be ignored,

$$R \geq \frac{v^2}{g(f+e)}$$

Converting *v* from m/s into km/h and denoting as V, and substituting *g* = 9.81 (m/s^2),

$$R \geq \frac{V^2}{127(f+e)}$$

AASHTO Standard states that the normal value of coefficient of friction ranges *f* = 0.05 ~ 0.20.

Based on these considerations, AASHTO Standard stipulates the minimum radii of curve as shown in the table below.

Table 4-1-1 Minimum Radius of Curve for Various Design Speed (AASHTO)

Design Speed (km/h)	Maximum e (%)	Limiting Value of *f*	Total (e/100 + *f*)	Calculated98.4 Radius60.0 (m)	Rounded Radius (m)
20	4.0	0.18	0.22	14.3	15
30	4.0	0.17	0.21	33.7	35
40	4.0	0.17	0.21	60.0	60
50	4.0	0.16	0.20	98.4	100
60	4.0	0.15	0.19	149.1	150
70	4.0	0.14	0.18	214.2	215
80	**4.0**	**0.14**	**0.18**	**279.8**	**280**
90	4.0	0.13	0.17	375.0	375
100	4.0	0.12	0.16	491.9	490
20	6.0	0.18	0.24	13.1	15
30	6.0	0.17	0.23	30.8	30
40	6.0	0.17	0.23	54.7	55
50	6.0	0.16	0.22	89.4	90
60	6.0	0.15	0.21	134.9	135
70	6.0	0.14	0.20	192.8	195
80	**6.0**	**0.14**	**0.20**	**251.8**	**250**
90	6.0	0.13	0.19	335.5	335
100	6.0	0.12	0.18	437.2	435
110	6.0	0.11	0.17	560.2	560
120	6.0	0.09	0.15	755.5	755
130	6.0	0.08	0.14	950.0	950

20	8.0	0.18	0.26	12.1	10
30	8.0	0.17	0.25	28.3	30
40	8.0	0.17	0.25	50.4	50
50	8.0	0.16	0.24	82.0	80
60	8.0	0.15	0.23	123.2	125
70	8.0	0.14	0.22	175.3	175
80	**8.0**	**0.14**	**0.22**	**228.9**	**230**
90	8.0	0.13	0.21	303.6	305
100	8.0	0.12	0.20	393.5	395
110	8.0	0.11	0.19	501.2	500
120	8.0	0.09	0.17	666.6	665
130	8.0	0.08	0.16	831.3	830
20	10.0	0.18	0.28	11.2	10
30	10.0	0.17	0.27	26.2	25
40	10.0	0.17	0.27	46.6	45
50	10.0	0.16	0.26	75.3	75
60	10.0	0.15	0.25	113.3	115
70	10.0	0.14	0.24	160.7	160
80	**10.0**	**0.14**	**0.24**	**209.9**	**210**
90	10.0	0.13	0.23	277.2	275
100	10.0	0.12	0.22	357.7	360
110	10.0	0.11	0.21	453.5	455
120	10.0	0.09	0.19	596.5	595
130	10.0	0.08	0.18	738.9	740

(For e = 12 %, please see "A Policy on Geometric Design of Highways and Streets, 2001, AASHTO, p145)

Road Structure Ordinance of Japan (RSOJ), based on the same equation and adopting slightly smaller values of *f*, gives the calculated minimum radius of curve as shown in the following table.

Table 4-1-2 Calculated Minimum Radius of Curve (RSOJ)

Design Speed		Radius of Curve (m)		
V (km/h)	*f*	e = 6 %	e = 8 %	e = 10 %
20	0.15	15	14	13
30	0.15	34	31	28
40	0.15	60	55	50
50	0.14	98	89	82
60	0.13	149	135	123
80	**0.12**	**280**	**252**	**229**
100	0.11	463	414	375
120	0.10	709	630	567

RSOJ then stipulates the minimum radius of curve as shown in the table below.

Table 4-1-3 Stipulated Minimum Radius of Curve (RSOJ)

Design Speed (km/h)	Radius of Curve (m)*	
20	15	-
30	30	-
40	60	50
50	100	80
60	150	120
80	**280**	**230**
100	460	380
120	710	570

* Figures in the right column are allowed only under special condition, such as severe topography.

Road Design Standard of Cambodia (Cambodian Standard), also based on the same equation as AASHTO and RSOJ, stipulates the following values for minimum radius of curve.

Table 4-1-4 Minimum Radius of Curve (for Sealed Pavement) (Cambodian Standard)

Vehicle Speed	Superelevation Rate							
(km/h)	0.10	0.09	0.08	0.07	0.06	0.05	0.04	0.03
110	420	435	455	480	505	530	560	595
100	345	360	375	395	415	440	465	495
80	**210**	**220**	**230**	**240**	**255**	**265**	**280**	**300**
70	165	170	175	185	195	205	215	230
60	115	120	125	130	135	145	150	160
50	75	80	80	85	90	90	95	100
40	45	45	50	50	50	55	55	57
30	25	25	25	26	27	28	30	31

Considering the criteria described above and the existing horizontal alignment, it is proposed to **adopt 280 m as the minimum radius of curve.**

4.1.2 Minimum Curve Length

RSOJ stipulates minimum length of curve, considering the steering time of 6 sec. For design speed of 80 km/h, 70 m is stipulated.

AASHTO Policy and Cambodian Standard do not recommend or stipulate minimum curve length.

Considering the above, minimum curve length is not considered as an item of the geometric design criteria for the Study Road, but effort shall be made to maintain 70 m of minimum curve length wherever practical and does not result in large amount (say 1 m) of change in centerline and large increase in cost.

4.2 Transitional Curve

When a vehicle is entering or leaving a circular curve section, from/to tangent (straight) section, abrupt change in the steering angle occurs and degree of comfort is reduced. To avoid such situation, it is usual practice to provide a transitional curve between a curved section (with a single radius) and a straight section (or a section with a larger curve radius). Transitional curve section is necessary to allow the driver to gradually increase/decrease the steering angle with horizontal acceleration which does not hamper comfort of driver/passengers. According to AASHTO's "Policy on Geometric Design of Highways and Streets, 2001" (AASHTO Policy), the principal advantages of transition curve in horizontal alignment are the following:

(i) A properly designed transition curve provides a natural, easy-to-follow path for drivers, such that the lateral force increases and decreases gradually as a vehicle enters and leaves a circular curve. Transition curves minimize encroachment on adjoining traffic lanes and tend to promote uniformity in speed. A spiral transition curve simulates the natural turning path of a vehicle.

(ii) The transition curve length provides a suitable location for the superelevation runoff. The transition from the normal pavement cross slope on the tangent to the fully superelevted section on the curve can be accomplished along the length of the transition curve in a manner that closely fits the speed-radius relationship for vehicles traversing the transition. Where superelevation runoff is introduced without a transition curve, usually partly on the curve and partly on the tangent, the driver approaching the curve may have to steer opposite to the direction of the approaching curve when on the superelevated tangent portion in order to keep the vehicle within its lane.

(iii) A spiral transition curve also facilitates the transition in width where the traveled way is widened on a circular curve. Use of spiral transitions provides flexibility in accomplishing the widening of sharp curves.

(iv) The appearance of the highway or street is enhanced by the application of spiral curves. The use of spiral transitions avoids noticeable breaks in the alignment as perceived by drivers at the beginning and end of circular curves.

4.2.1 Transitional Curve Length

To achieve the above advantage, certain length is required for transitional curve. AASHTO's "Policy on Geometric Design of Highways and Streets, 2001" (AASHTO Policy) stipulates the following formula, known as "Shortt's Equation", for determining the length of transitional curve.

$$L = \frac{0.0214V^3}{RC} \qquad \text{(Eq. 4-2-1)}$$

Where:

L = minimum length of spiral (transitional) curve, m;

V = speed, km/hr;

R = curve radius, m;

C = rate of increase of lateral acceleration, m/s^3

Values ranging from 0.3 to 0.9 m/s^3 are usually used for C. For C = 0.9, V = 80 (km/hr) and R = 300 (m), L is obtained as;

$$L = 0.0214 \times 80^3 / (300 \times 0.9) = 40.9 \text{ (m)}$$

Length of transitional curve needs to be examined also from view point of time required for adjusting the steering from straight to curve. This length is simply calculated by multiplying the travel speed and time of steering. Thus,

$$L = \frac{V}{3.6} t, \qquad \text{(Eq. 4-2-2)}$$

where L = length of transitional curve (m),
V = vehicle speed (km/h) , and
t = time for steering.

Road Structure Ordinance of Japan (RSOJ) shows length of transitional curve for various steering time.

Table 4-2-1 Transitional Curve Length Calculated From Steering Time (RSOJ) (Unit: m)

Time for steering (sec)	Design Speed (km/h)							
	120	100	80	60	50	40	30	20
2.0	**67**	**56**	**44**	**33**	**28**	**22**	**17**	**11**
2.5	83	69	56	42	35	28	21	14
3.0	**100**	**83**	**67**	**50**	**42**	**33**	**25**	**17**
3.5	117	97	78	58	49	39	29	19
4.0	133	111	89	67	56	45	33	22
4.5	150	125	109	75	63	50	385	25
5.0	167	137	111	83	69	56	42	29

RSOJ uses t = 3.0 sec and the calculated values are used as the basis for determining the transitional curve length stipulated in Table 1. On the other hand, AASHTO Policy states that t = 2.0 sec is appropriate and recommends the lengths shown in the following table as desirable values of transitional curve length.

Table 4-2-2 Desirable Length of Transitional Curve (AASHTO)

Design Speed (km/h)	Transitional Curve Length
20	11
30	17
40	22
50	28
60	33
70	39
80	**44**
90	50
100	56
110	61
120	67
130	72

RSOJ adopts Eq. 4-2-1 as the base for determining minimum length of transitional curve. However, RSOJ uses C = 0.5 and, as a result 73m is desirable. RSOJ also uses t = 3 sec. for steering time as shown in Table 4-2-1 above. As a conclusion, RSOJ stipulates the following length for (spiral) transitional curve.

Table 4-2-3 Length of (Spiral) Transitional Curve (RSOJ)

Design Speed (km/hr)	Length of Transitional Curve (m)
120	100
100	85
80	**70**
60	50
50	40
40	35
30	25
20	20

Road Design Standard of Cambodia (Cambodian Standard) does not mention on the minimum length of transitional curve.

Considering the above discussions, it is recommended that **44 m is used as the absolute**

minimum value while 70 m is used as the desirable minimum value for transitional curve length.

<u>Omission of Transitional Curve</u>

When "shift" of horizontal alignment produced by transitional curve is small, as is the case where the radius of the circular curve is large, vehicle can enter/leave circular curve safely and comfortably by utilizing the available lane width which is in surplus of vehicle width. In Japan, such amount of shift is considered to be 20 cm. Magnitude of shift (of clothoid) transitional curve is calculated by the following equation:

$$S = \frac{1}{24}\frac{L^3}{R} \qquad \text{Eq. 4-2-3}$$

Where,

S = shift (m)
R = radius of curve
L = length of transitional curve as determined by Eq. 4-2-2

Substituting Eq. 4-2-2 into Eq. 4-2-3, S = 0.2 (m) and t = 3 (sec), we obtain

$$R = 0.145\ V^2 \qquad \text{Eq. 4-2-4}$$

Based on this, RSOJ stipulates **the minimum radii of curve for which or above** transitional curve can be omitted. The following table gives such minimum curve radii.

Table 4-2-4 Minimum Radius of Curve for Omitting Transitional Curve (RSOJ)

Design Speed (km/hr)	120	100	**80**	60	50	40	30	20
Calculated Min. Radius	2,100	1,450	**930**	520	360	230	130	58
Rounded Value	2,100	1,500	**900**	500	350	250	130	60

Based on the analysis of the actual cases used in the United States, AASHTO Policy lists **maximum curve radii below which safety and operational benefits from using transitional curves is obtained**.

Table 4-2-5 Maximum Radius for Use of Spiral Curve Transition (AASHTO)

Design Speed (km/hr)	Minimum Radius (m)
20	24
30	54
40	95
50	148
60	213
70	290
80	**379**
90	480
100	592
120	716
130	1,000

As can be seen in the above, there are substantial differences between the minimum curve radii of RSOJ and those of AASHTO Policy.

If t = 2 (sec) is used in Eq. 4-2-2 and substituted into Eq. 4-2-3, we obtain

$$R = \frac{1}{24}\left(\frac{V}{1.8}\right)^2 \frac{1}{S} = \frac{V^2}{77.76} \qquad \text{Eq. 4-2-5}$$

Cambodian Standard states that transitional curve can be omitted is shift is less than 0.25 m. Substituting S = 0.25, we obtain

$$R = 0.051\ V^2\ . \qquad \text{Eq. 4-2-6}$$

For V = 80 (km/h),

$$R = 329\ (m)$$

Considering the above discussion, it is recommended that absolute minimum value for radius of curve for which transitional curve is omitted 380 m and 900 m be used as maximum value above which transitional curve is not considered.

4.3 Stopping Sight Distance

Calculation of sight distance is made with a simple formula.

$$D = \frac{V}{3.6}t + \frac{V^2}{2gf(3.6)^2} \qquad \text{Eq. 4-3-1}$$

Where,

D = stopping distance (m),

V = vehicle speed (km/h),

t = response time of driver (sec)

g = gravitational acceleration (m/sec^3)

f = coefficient of friction between tire and road surface

Above equation is used in RSOJ assuming that stopping is governed by friction between tire and road surface. Similar formula is used in AASHTO Policy. AASHTO assumes degree of deceleration for stopping. Thus,

$$D = \frac{V}{3.6}t + 0.039\frac{V^2}{a} \qquad \text{Eq. 4-3-2}$$

AASHTO adopts the value for smooth stopping. Cambodian Standard uses same equation but with somewhat larger value of deceleration. The stipulated stopping sight distances for design speed of 80 km/h are as follows.

Table 4-3-1 Stopping Sight Distance of AASHTO, RSOJ and Cambodian Standard (Unit: m)

AASHTO	RSOJ	Cambodian Standard	Recommended
130	110	115	115

115 m is propowed as the criterion for the Study Road.

4.4 Proposed Criteria for Design Elements of Horizontal Alignment

Based on the above discussions, the following criteria are recommended for design elements of horizontal alignment.

Table 4-4-1 Criteria for Design Elements of Horizontal Alignment

Design Element	Unit	AASHTO	RSOJ*	Cambodian Standard	Recommended
Design Speed	Km/h	80	80	80	80
Design Vehicle		WB-20	Semitrailer	WB-15	WB-15
Stopping Sight Distance	m	130	110	115	115
Minimum Radius of Curve	m	280	280	280	280
Minimum Curve Length	m	-	140	-	Desirable: 140
Minimum Transitional Curve Length	m	44	70	-	Absolute: 44 Desirable: 70
Minimum Radius of Curve for Omitting Transitional Curve	m	379	900	-	Absolute: 380 Desirable: 900

5. VERTICAL ALIGNMENT

5.1 Maximum Grade

For design speed of 80 km/h, standards of AASHTO, RSOJ and Cambodian Standard are compared in the table below. AASHTO and RSOJ stipulate 4 % while Cambodian Standard stipulates 4 – 6 %. Accordingly, 4 % is recommended for the Study Road.

Table 5-1-1 Comparison of Maximum Grade for Design Speed 80 km/h (Unit: %)

AASHTO	RSOJ	Cambodian Standard	Recommended
4*	4	4 – 6**	4

*For rural freeway and level terrain ** Flat terrain

5.2 Minimum Curve Length

5.2.1 Crest Curve

RSOJ uses the following equation for calculating stopping sight distance at a crest:

$$L = \frac{AS^2}{398} \qquad \text{Eq. 5-2-1}$$

where

L = length of vertical curve

A = algebraic difference in grades, percent ($i_1 - i_2$)

S = sight distance.

AASHTO Standard uses similar equation.

$$L = \frac{AS^2}{658} \qquad \text{Eq. 5-2-2}$$

The difference of the value of the denominator comes from the difference in assumed height of the driver's eye (RSOJ; 1.2 m: AASHTO; 1.08 m) and object (RSOJ; 0.1 m: AASHTO; 0.6 m).

Using these equations, minimum curve length needed to secure required sight distances for the design speed of 80 km/h (RSOJ; 110 m: AASHTO; 130 m) are calculated as the following:

Table 5-2-1 Minimum Crest Curve Length to Secure Sight Distance (Unit: m)

Difference in Grade (%)	RSOJ	AASHTO
1	30.4	25.7
2	60.8	51.3
3	91.2	77.1
4	121.6	102.8

5.2.2 Sag Curve

In the case of crest curve, minimum length of sag curve in RSOJ is calculated by the following equation. (Vertical clearance; 4.5 m: Driver's eye height; 1.2 m: Height of object; 0.75 m)

$$L = \frac{AS^2}{2692}. \qquad \text{Eq. 5-2-3}$$

Similarly, AASHTO Standard gives the following equation:

$$L = \frac{AS^2}{800(C-1.5)}, \qquad \text{Eq. 5-2-4}$$

Where C = vertical clearance.

If C = 4.5 (m),

$$L = \frac{AS^2}{2400} \qquad \text{Eq. 5-2-5}$$

The difference in the denominators comes from the difference in the height of deriver's eye (AASHTO: 2.4 m) and height of object (AASHTO: 0.6 m).

Using these equations, minimum lengths of sag curve for the design speed of 80 km/h are calculated as the following.

Table 5-2-2 Minimum Length of Sag Curve (Unit: m)

Difference in Grade (%)	RSOJ	AASHTO
1	4.5	7.0
2	9.0	14.1
3	13.5	21.1
4	18.0	28.2

Length of sag curve is examined also from viewpoint of passenger comfort. RSOJ uses the following equation.

$$L = \frac{V^2 A}{360} \qquad \text{Eq. 5-2-6}$$

where

V = design speed

L and A are same as Eq. 5-2- 1

AASHTO Standard uses the following equation.

$$L = \frac{V^2 A}{395} \qquad \text{Eq. 5-2-7}$$

For design speed of 80 km/h, minimum sag curve lengths for RSOJ and AASHTO are as shown in the following table.

Table 5-2-3 Minimum Sag Curve Length for Passenger Comfort (m)

Difference in Grade (%)	RSOJ	AASHTO
1	17.8	16.2
2	35.6	33.2
3	53.3	48.6
4	71.1	64.8

Considering the above discussion, RSOJ stipulates 70 m as the minimum vertical curve length. The calculated values of AASHTO are not much different from this stipulated value of RSOJ, and **70 m is recommended in the Study Road**.

5.3 Minimum Radius of Curve

From viewpoint of sight distance and passenger comfort, RSOJ stipulates the following values for minimum radii of crest and sag curves. (Parabola is usually used for vertical curves. A parabola can be approximated by a circle when so-called the "K value" of parabola, or the radius of circle, is large.)

Table 5-3-1 Minimum Radius of Vertical Curve for Design Speed 80 km/h (RSOJ) (Unit: m)

Crest Curve	Sag Curve
3,000	2,000

AASHTO Standard stipulates the following value for "K value" of parabola used as vertical curve.

Table 5-3-2 Minimum K-Value of Vertical Curve (Parabola) for Design Speed of 80 km/h (AASHTO)

Crest Curve	Sag Curve
26	26

Cambodian Standard stipulates the following K-values for crest and sag curves.

Table 5-3-3 K-Value of Vertical Curves for Design Speed of (80 km/h) (Cambodian Standard)

Crest Curve	Sag Curve
30	28

From the equations used in RSOJ, AASHTO and Cambodian Standard, the following relation exists between K-value of AASHTO and R of RSOJ.

$$R = 100K \qquad \text{Eq. 5-3-1}$$

Accordingly, the standard of AASHTO can be expressed in terms of radius of circular curve as follows:

Table 2-3-4 AASHTO Standard Expressed in Terms of Radius of Circular Curve

Crest Curve	Sag Curve
2,600	2,600

Therefore, the stipulated values of RSOJ and AASHTO are within a similar range, and criteria of RSOJ are recommended for the Study Road for their simplicity in expression.

Table 5-3-5 Recommended Minimum Radius of Vertical Curve (Unit: m)

Crest Curve	Sag Curve
3,000	2,000

6. SUPERELEVATION AND CROSS FALL

6.1 Maximum Value of Superelevation

Road Structure Ordinance of Japan (RSOJ) stipulates standard values of superelevation corresponding radii of haorizontal curves.

Table 6-1-1 Standard for Superelevation (RSOJ) (for Design Speed 80 km/h)

R (m)	230-279	280-329	330-379	380-449	450-539	540-669	670-869	870-1,239	1,240-3,499
e (%)	10	9	8	7	6	5	4	3	2

R: Radius of curve (m)

e: Superelevation (%)

AASHTO Standard stipulates the following values for superelevation in relation to minimum radius of curve and design speed.

Table 6-1-2 Minimum Radius of Curve Using Limiting Values of e and f (AASHTO) (Part)

Design Speed (km/h)	Maximum e (%)	Limiting Values of f	Total (e/100 + f)	Calculated Radius (m)	Rounded Radius (m)
40	4	0.17	0.21	60.0	60
60	4	0.15	0.19	149.1	150
80	**4**	**0.14**	**0.18**	**279.8**	**280**
100	4	0.12	0.16	491.9	490
40	6	0.17	0.23	54.7	55
60	6	0.15	0.21	134.9	135
80	**6**	**0.14**	**0.20**	**251.8**	**250**
100	6	0.12	0.18	437.2	435
40	8	0.17	0.25	50.4	50
60	8	0.15	0.23	123.2	125
80	**8**	**0.14**	**0.22**	**228.9**	**230**
100	8	0.12	0.20	393.5	395

In this table, AASHTO stipulates that use of maximum e of 4 % be limited to urban section.

Cambodian Standard stipulates the following values.

Table 6-1-3 Minimum Radius of Horizontal Curves with Sealed Pavement (Cambodian Standard)

Vehicle Speed (km/h)	Superelevation Rate (%)							
	10	9	8	7	6	5	4	3
110	420	425	455	480	505	530	560	595
100	345	360	375	395	415	440	465	495
80	**210**	**220**	**230**	**240**	**255**	**265**	**280**	**300**
70	165	170	175	185	195	205	215	230
60	115	120	125	130	135	145	150	160
50	75	80	80	85	90	90	95	100
40	45	45	50	50	50	55	55	57
30	25	25	25	26	27	28	30	31

In the Study Road, majority of curves have radius larger than 700 meters which call for superelevation of 4 %. The smallest radius is used in Koki Market Section which is urban section. Next to this curve, the small radius of R = 400 m is used at the curve from St 14+150 to 14+300 (Pk 19.7 – 19.9). As shown above, AASHTO stipulate maximum superelevation 0f 6 % and above (except urban roads). Thus, **6 % shall be used as the maximum superelevation in this Study.**

6.2 Minimum Radius of Curve for Omitting Superelevation

Both AASHTO and RSOJ stipulate minimum radius of curve for which superelevatin can be omitted and normal cross fall can be maintained. .

Table 6-2-1 Minimum Radius of Curve for Omitting Superelevation

AASHTO	RSOJ
2500 m	3500 m

There is no stipulation on this subject in Cambodian Standard.

It is recommended to use R = 2,500 m as the minimum radius of curve for omitting superelevation.

6.3 Crossfall

Values of crossfall in various standards and recommended value are summarized in the table below. For pavement (travel way) and shoulder (unpaved), 2.0 % and 4.0 % are recommended, respectively.

Table 6-3-1 Values of Crossfall

Name of Standard		Cambodian Standard	AASHTO	RSOJ	Asian Highway	**Recommended**
Cross-fall (%)	Traveled Way	2.5 – 3.0	1.5 – 2.0	1.5 – 2.0	2.0	**2.0**
	Shoulder	4.0 – 5.0	2.0 – 6.0	3.0 – 5.0	3.0 – 6.0	**4.0**

7. SUMMARY

Recommended values of geometric design elements are summarized in the following table.

Table 7-1 Elements of Geometric Design

Design Elements	Unit	Recommended Value
Design Speed	km/h	80
Lane Width	m	3.50
Design Vehicle		WB-15
Minimum Radius of Horizontal Curve	m	280
Minimum Curve Length	m	(Desirable 70)
Minimum Transitional Curve Length	m	70
Minimum Radius of Curve for Omitting Transitional Curve	m	Absolute 380 Desirable 900
Stopping Sight Distance	m	115
Maximum Grade	%	4
Minimum Radius of Sag Curve	m	2000
Minimum Radius of Crest Curve	m	3000
Maximum Superelevation	%	6
Minimum Radius of Curve for Omitting Superelevation	m	2500
Crossfall: Traveled way & Paved Shoulder : Unpaved Shoulder	%	2 4

G-2. Estimation of ALEF for NR-1

ESTIMATION
OF
AXLE LOAD EQUIVALENCY FACTOR
(ALEF)
FOR
NATIONAL ROAD NO. 1
(PHNOM PENH – NEAK LOEUNG SECTION)

ESTIMATION OF AXLE LOAD EQUIVQALENCY FACTOR (ALEF)

1. Measurement of Vehicle Weight

As a part of the traffic survey, weights of heavy vehicles were measured using a portable truck scale owned by MPWT. The survey was conducted on 11 June 2002. The location of the survey site was around St. 7+550 (Pk 13.15), or about 500 meter towards Neak Loeung from the intersection with the Tiger Beer Road.

The Government of Cambodia recognizes the adverse influence of overloaded trucks on pavement and has started corrective actions. An inter-ministerial committee consisting of the representatives from MPWT, Ministry of Economy and Finance and Ministry of Interior (Police Department) has been established to administer the enforcement on overloaded trucks. Under the direction of this inter-ministerial committee, a special task force composing of MPWT officials and police officers has been established and routinely conducting measurement of weights of heavy vehicles. Vehicle weight survey was conducted with a cooperation of this special task force and JICA Study Team.

Since one of the two portable truck scales owned by MPWT was out of order, only one truck scale was available for the survey. The scale was placed on the paved surface and weights of centerline-side wheels were measured. Then, the axle loads were estimated by multiplying the measured centerline-side wheel load by two. (Later, corrections were made for more accurate estimation of axle load as described in the following section). The reason that only the loads of centerline-side wheels were measured is to minimize the time of measurement and avoid traffic congestion. (The vehicle weight survey was conducted at the same location and time with the cordon line survey which also needed to stop vehicle and interview.) The reason that the scale was centerline-side wheels were measured is that the pavement surface near the edge (right-side wheel track) was generally rough and it was difficult to find to a place to place the vehicle scale.

More than 100 vehicles were measured. After inspecting the data and doubtful data (such as mistake in recording) were discarded, data of 97 vehicles were used. Table 4 shows the data of vehicle weight obtained through the vehicle weight survey, after discarding the doubtful data and applying the correction as described in the following section.

2. Correction of Surveyed Data

In vehicle weight measurement, it is desired that the vehicle is placed on a level place to avoid abnormal distribution of vehicle weight among the wheels. However, this was not possible in this vehicle weight survey because of the fact that only one scale was available and also because of the site condition. The following corrections were made in an effort to make the data as accurate as practically possible.

2.1 Correction for the Cross Fall of the Road Surface

The road surface where the scale was placed was not level because of the cross fall. The scale was placed on the lane going to Phnom Penh. Therefore, for the vehicles coming from the Neak Loueng side (and going to Phnom Penh), the right-side (shoulder-side) wheels were lower than the left-side (centerline-side) wheels, and vice versa. Consequently, it was suspected that the vehicle weight was not equally distributed between the left-side wheels and right-side wheels (Figure 1).

Therefore, the loads of both the centerline-side and shoulder-side wheels were measured for 7 vehicles. Table 1 shows the ratio between the weights of shoulder-side and centerline-side wheels. The average of the ratio of the shoulder-side and centerline-side wheels was 1.12. Considering the magnitude of the fluctuation of the data, it was assumed that the loads of shoulder-side wheels were larger than those of the centerline-side by 10 %. The wheel loads of shoulder-side shown in Table 1 have calculated from those of centerline-side using this ratio.

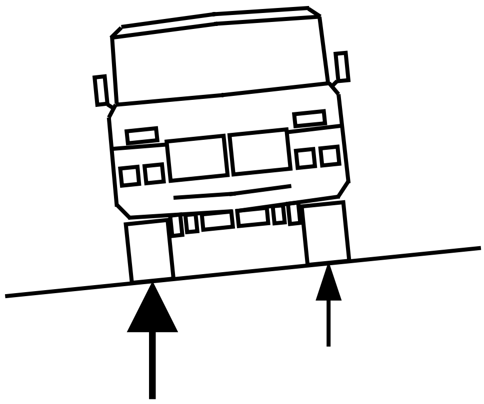


Figure 1 Influence of Cross Fall

Table 1 Comparison of Wheel Loads Between Shoulder-Side and Centerline-Side

	Front Axle (t)			Rear Axle (t)			
Sample No.	Shoulder-Side	Centerline-Side	Ratio of S/C	Shoulder-Side	Centerline-Side	Ratio of S/C	Average
85	1.79	1.75	1.02	4.67	4.09	1.14	1.08
86	3.12	2.97	1.05	4.17	3.91	1.07	1.06
87	2.80	2.73	1.03	7.20	6.46	1.11	1.07
88	2.88	2.65	1.09	8.20	6.90	1.19	1.14
93	1.49	1.28	1.16	2.95	2.67	1.10	1.13
96	0.82	0.78	1.05	0.93	0.78	1.19	1.12
99	1.83	1.69	1.08	4.74	3.84	1.23	1.16
100	1.87	1.63	1.15	4.32	3.50	1.23	1.19
						Total	8.95
						Average	1.12

2.2 Correction for the Influence of Protrusion of Truck Scale

When vehicle weights (wheel loads) were measured, the portable truck scale was placed on the road surface and vehicles were directed to the position so that only one wheel comes on top of the scale (Figure 2).

As a result, it was suspected that the wheel roads were not properly distributed when they were measured. To know the possible error of measurement, the portable truck scale was brought to the fixed vehicle weighing station located along National Road No. 6, near the town of Thnal Keng, and the wheel loads measured by the fixed truck scale and the portable scale were compared. Six single-axle trucks, three tandem-axle trucks and one double tandem-axle truck were measured. It was desired to measure more tandem trucks, but the number of tandem-axle trucks which passed the location of weighing station was very few and many of them were empty loaded.

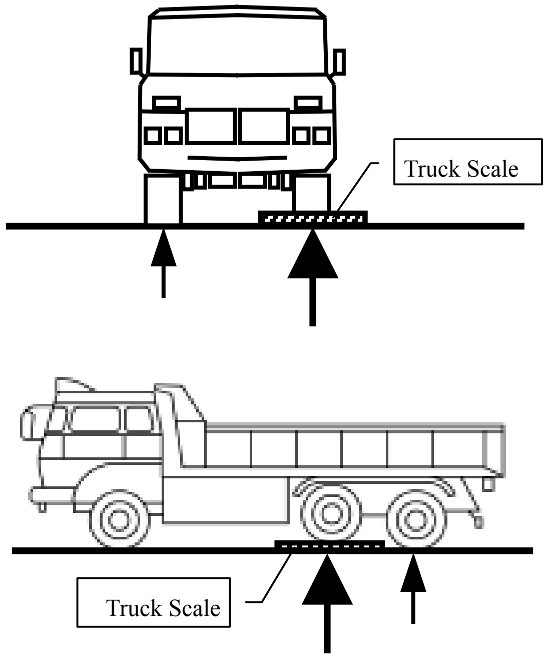


Figure 2 Influence of Extrusion of Truck Scale

As a result only three tandem-axle truck and one double tandem-axle truck could be measured. Table 3 shows the result of comparison between the fixed and portable scales. It was found that the axle loads measured by the portable scale were larger than those measured by the fixed scale, in general, with the ratio ranging from 0.925 to 1.258, depending on the type of vehicle (single axle, tandem axle, double tandem axle) and the location of axle (front or rear). Based on these data, the measured wheel loads of centerline-side were multiplied by the following ratios to estimate the wheel load of shoulder-side.

Table 2 Correction Factor for Estimating Shoulder-Side Wheel Load (Multiply Centerline-Side Wheel Load by the Ratios in the Table)

Type of Rear Axle	Single Axle		Tandem Axle		Double Tandem		
Axle	Front	Rear	Front	Rear	Front	Rear 1	Rear 2
Ratio	0.938	1.045	0.968	0.968	1.258	0.984	0.945

Table 3 Comparison of Fixed and Portable Truck Scales

I. TANDEM AXLES TRUCKS

No.1	Type	3b (Tank Lorry)		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	4.90	5.05	0.970
	Tandem	20.44	21.20	0.964
	Total:	25.34	26.25	

No.2	Type	3b		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	3.72	3.85	0.966
	Tandem	24.14	24.85	0.971
	Total:	27.86	28.70	

Average:	
Front Axle:	0.968
Tandem:	0.968

No.3	Type	4d		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	5.94	4.72	1.258
	Tandem1	12.60	12.80	0.984
	Tandem2	12.00	12.70	0.945
	Total:	30.54	30.22	

Average:	
Front Axle:	1.258
Tandem1:	0.984
Tandem2:	0.945

II. SINGLE AXLES TRUCKS

No.1	Type	3a		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	3.32	3.50	0.949
		9.60	9.60	1.000
	Total:	12.92	13.10	

No.2	Type	3a		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	3.60	3.85	0.935
		14.48	14.00	1.034
	Total:	18.08	17.85	

No.3	Type	3a		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	6.08	6.50	0.935
		17.34	15.90	1.091
	Total:	23.42	22.40	

No.4	Type	3a		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	4.72	5.10	0.925
		18.50	17.80	1.039
	Total:	23.22	22.90	

No.5	Type	3a		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	7.18	7.65	0.939
		17.56	16.50	1.064
	Total:	24.74	24.15	

No.6	Type	3a		
		Fixed Scale	Portable Scale	Ratio Fix/Port
	Front Axle	5.10	5.40	0.944
		15.14	14.55	1.041
	Total:	20.24	19.95	

Average:	
Front Axle:	0.938
Rear Axle:	1.045

Table 4 Measured Axle Load and ALEF Estimated from Them

(Selected SN = 3; Pt = 2.5)

No	Vehicle Type	Axle No.1 (t)					Axle No.2 (t)					Axle No.3 (t)					Axle No.4 (t)					Tandem Axle No.I (t)					Tandem Axle No.II (t)					Total Vehicle Weight	Total ALEF
		Center	Should	Total	Adjusted Total	ALEF1	Center	Should	Total	Adjusted Total	ALEF2	Center	Should	Total	Adjusted Total	ALEF3	Center	Should	Total	Adjusted Total	ALEF4	TAI-1	TAI-2	Total	Adjusted Total	ALEF I	TAII-1	TAII-2	Total	Adjusted Total	ALEF II		
1	3a	1.29	1.42	2.71	2.54	0.017	3.25	3.57	6.82	7.13	0.646																					9.53	0.663
2	4d	1.94	2.13	4.07	5.13	0.051																3.05	3.05	6.09	5.99	0.042	3.00	2.67	5.67	5.36	0.023	15.83	0.116
3	3a	1.30	1.43	2.73	2.56	0.017	3.62	3.98	7.60	7.94	0.646																					10.33	0.663
4	3a	2.09	2.30	4.39	4.12	0.118	2.46	2.71	5.17	5.40	0.229																					9.56	0.347
5	3a	1.25	1.38	2.63	2.46	0.017	2.40	2.64	5.04	5.27	0.229																					7.67	0.246
6	3b	1.96	2.16	4.12	3.98	0.118																2.79	2.90	5.69	5.51	0.023						9.81	0.141
7	3a	1.35	1.49	2.84	2.66	0.017	1.75	1.93	3.68	3.84	0.051																					6.51	0.068
8	3a	0.93	1.02	1.95	1.83	0.004	1.50	1.65	3.15	3.29	0.017																					5.10	0.021
9	3a	1.97	2.17	4.14	3.88	0.118	1.64	1.80	3.44	3.60	0.051																					7.58	0.169
10	3a	1.01	1.11	2.12	1.99	0.004	1.10	1.21	2.31	2.41	0.017																					4.43	0.021
11	3a	2.03	2.23	4.26	4.00	0.118	4.43	4.87	9.30	9.72	1.490																					13.57	1.608
12	3b	2.43	2.67	5.10	4.94	0.229																4.91	4.47	9.39	9.09	0.162						14.49	0.391
13	3a	3.47	3.82	7.29	6.84	0.646	8.69	9.56	18.25	19.07	28.50																					25.54	29.146
14	3a	1.41	1.55	2.96	2.78	0.017	1.76	1.94	3.70	3.86	0.051																					6.66	0.068
15	3a	2.40	2.64	5.04	4.73	0.229	2.31	2.54	4.85	5.07	0.118																					9.89	0.347
16	3b	1.94	2.13	4.07	3.94	0.051																3.23	2.73	5.96	5.77	0.042						10.04	0.093
17	3a	0.99	1.09	2.08	1.95	0.004	1.75	1.93	3.68	3.84	0.051																					5.75	0.055
18	3a	1.42	1.56	2.98	2.80	0.017	2.79	3.07	5.86	6.12	0.229																					8.84	0.246
19	3a	1.28	1.41	2.69	2.52	0.017	2.72	2.99	5.71	5.97	0.229																					8.40	0.246
20	3a	1.50	1.65	3.15	2.95	0.017	1.84	2.02	3.86	4.04	0.051																					7.01	0.068
21	3a	1.15	1.27	2.42	2.27	0.017	1.39	1.53	2.92	3.05	0.017																					5.33	0.034
22	3b	3.00	3.30	6.30	6.10	0.399																15.16	14.93	30.09	29.13	16.600						36.39	16.999
23	3a	2.95	3.25	6.20	5.81	0.399	5.32	5.85	11.17	11.67	3.090																					17.37	3.489
24	3b	1.64	1.80	3.44	3.33	0.051																3.26	3.26	6.51	6.30	0.042						9.95	0.093
25	3b	1.55	1.71	3.26	3.15	0.051																3.97	3.38	7.35	7.11	0.070						10.61	0.121
26	3a	1.21	1.33	2.54	2.38	0.017	1.19	1.31	2.50	2.61	0.004																					5.04	0.021
27	3b	2.17	2.39	4.56	4.41	0.118																12.14	12.01	24.15	23.38	6.950						28.71	7.068
28	3a	7.14	7.85	14.99	14.06	10.50	1.67	1.84	3.51	3.66	0.051																					18.50	10.551
29	3b	2.72	2.99	5.71	5.36	0.399																8.19	7.88	16.07	15.55	1.380						21.78	1.779
30	3b	4.12	4.53	8.65	8.12	1.490																10.52	10.58	21.11	20.43	3.580						29.76	5.070
31	3b	4.11	4.52	8.63	8.10	1.490																10.73	10.42	21.15	20.47	4.250						29.78	5.740
32	3b	3.49	3.84	7.33	6.87	0.646																7.77	9.32	17.09	16.55	1.690						24.42	2.336

No	Vehicle Type	Axle No.1 (t)					Axle No.2 (t)					Axle No.3 (t)					Axle No.4 (t)					Tandem Axle No.I (t)					Tandem Axle No.II (t)					Total Vehicle Weight	Total ALEF
		Center	Should	Total	Adjusted Total	ALEF1	Center	Should	Total	Adjusted Total	ALEF2	Center	Should	Total	Adjusted Total	ALEF3	Center	Should	Total	Adjusted Total	ALEF4	TAI-1	TAI-2	Total	Adjusted Total	ALEF I	TAII-1	TAII-2	Total	Adjusted Total	ALEF II		
33	3b	3.69	4.06	7.75	7.27	1.000																9.43	10.23	19.66	19.03	2.990						27.41	3.990
34	3a	3.39	3.73	7.12	6.68	0.646	6.52	7.17	13.69	14.31	7.900																					20.81	8.546
35	3b	2.81	3.09	5.90	5.71	0.229																9.01	9.45	18.46	17.87	2.060						24.36	2.289
36	3b	2.12	2.33	4.45	4.31	0.118																10.35	9.64	19.99	19.35	2.990						24.44	3.108
37	3b	3.70	4.07	7.77	7.52	1.000																10.79	10.42	21.21	20.53	3.580						28.98	4.580
38	3b	2.50	2.75	5.25	5.08	0.229																11.70	10.00	21.69	21.00	4.250						26.94	4.479
39	3a	1.33	1.46	2.79	2.62	0.017	3.39	3.73	7.12	7.44	0.646																					9.91	0.663
40	3b	2.93	3.22	6.15	5.96	0.399																15.56	11.24	26.80	25.94	9.400						32.95	9.799
41	3b	2.21	2.43	4.64	4.49	0.118																5.46	5.52	10.98	10.63	0.315						15.62	0.433
42	3a	1.59	1.75	3.34	3.13	0.051	4.37	4.81	9.18	9.59	1.490																					12.52	1.541
43	3b	2.57	2.83	5.40	5.22	0.229																9.11	8.76	17.87	17.30	2.490						23.27	2.719
44	3b	2.21	2.43	4.64	4.49	0.118																4.60	4.60	9.20	8.90	0.162						13.84	0.280
45	3b	1.92	2.11	4.03	3.90	0.051																4.37	4.16	8.53	8.25	0.109						12.56	0.160
46	3b	1.73	1.90	3.63	3.52	0.051																4.81	4.77	9.58	9.27	0.229						13.21	0.280
47	3b	3.69	4.06	7.75	7.50	1.000																10.46	10.46	20.92	20.25	3.580						28.67	4.580
48	3a	1.39	1.53	2.92	2.74	0.017	2.62	2.88	5.50	5.75	0.229																					8.42	0.246
49	3a	3.39	3.73	7.12	6.68	0.646	4.29	4.72	9.01	9.41	1.490																					16.13	2.136
50	3b	2.32	2.55	4.87	4.72	0.118																13.80	13.61	27.41	25.71	10.900						32.28	11.018
51	3b	2.56	2.82	5.38	5.20	0.229																3.61	3.42	7.04	6.60	0.070						12.41	0.299
52	3a	1.28	1.41	2.69	2.52	0.017	2.46	2.71	5.17	5.40	0.229																					7.85	0.246
53	3a	0.97	1.07	2.04	1.91	0.004	1.43	1.57	3.00	3.14	0.051																					5.04	0.055
54	3b	2.80	3.08	5.88	5.52	0.229																9.66	9.20	18.86	18.25	2.490						24.74	2.719
55	3b	2.27	2.50	4.77	4.47	0.118																4.56	4.20	8.76	8.48	0.162						13.52	0.280
56	3a	1.11	1.22	2.33	2.19	0.017	1.35	1.49	2.84	2.96	0.017																					5.17	0.034
57	3b	2.50	2.75	5.25	5.08	0.229																5.17	4.56	9.72	9.72	0.229						14.97	0.458
58	3a	0.96	1.06	2.02	1.89	0.004	1.10	1.21	2.31	2.41	0.017																					4.33	0.021
59	5a	3.05	3.36	6.41	6.41	0.399	5.02	5.52	10.54	10.54	3.090	3.69	4.059	7.75	7.75	1.000	3.62	3.982	7.60	7.60	0.646											32.30	5.135
60	3b	2.12	2.33	4.45	4.31	0.118																3.15	3.05	6.20	6.00	0.042						10.65	0.160
61	3a	1.55	1.71	3.26	3.05	0.051	3.39	3.73	7.12	7.44	0.646																					10.37	0.697
62	3b	2.22	2.44	4.66	4.51	0.118																8.17	7.16	15.33	14.84	1.110						19.99	1.228
63	3a	2.11	2.32	4.43	4.16	0.118	5.17	5.69	10.86	11.35	3.090																					15.29	3.208
64	3a	2.63	2.89	5.52	5.18	0.229	5.73	6.30	12.03	12.57	4.310																					17.56	4.539
65	3a	0.94	1.03	1.97	1.85	0.004	1.78	1.96	3.74	3.91	0.051																					5.71	0.055
66	3a	0.94	1.03	1.97	1.85	0.004	0.91	1.00	1.91	2.00	0.004																					3.89	0.008

No	Vehicle Type	Axle No.1 (t)					Axle No.2 (t)					Axle No.3 (t)					Axle No.4 (t)					Tandem Axle No.I (t)					Tandem Axle No.II (t)					Total Vehicle Weight	Total ALEF
		Center	Should	Total	Adjusted Total	ALEF1	Center	Should	Total	Adjusted Total	ALEF2	Center	Should	Total	Adjusted Total	ALEF3	Center	Should	Total	Adjusted Total	ALEF4	TAI-1	TAI-2	Total	Adjusted Total	ALEF I	TAII-1	TAII-2	Total	Adjusted Total	ALEF II		
67	3b	1.78	1.96	3.74	3.62	0.051																2.90	5.80	8.69	8.42	0.162						12.43	0.213
68	5b	2.28	2.51	4.79	4.79	0.102	9.60	10.56	20.16	20.16	44.000	9.11	10.02	19.13	19.13	35.600						14.32	13.19	27.51	27.51	10.900						71.59	90.602
69	3a	1.93	2.12	4.05	3.80	0.051	3.75	4.13	7.88	8.23	1.000																					11.93	1.051
70	3a	2.00	2.20	4.20	3.94	0.051	2.18	2.40	4.58	4.78	0.118																					8.78	0.169
71	3a	1.70	1.87	3.57	3.35	0.051	2.75	3.03	5.78	6.03	0.229																					9.35	0.280
72	3a	1.48	1.63	3.11	2.92	0.017	2.62	2.88	5.50	5.75	0.229																					8.61	0.246
73	3a	1.63	1.79	3.42	3.21	0.051	1.78	1.96	3.74	3.91	0.051																					7.16	0.102
74	3b	1.99	2.19	4.18	4.05	0.118																4.24	4.07	8.32	8.05	0.109						12.50	0.227
75	3a	3.48	3.83	7.31	6.85	0.646	7.56	8.32	15.88	16.59	13.700																					23.18	14.346
76	3a	4.20	4.62	8.82	8.27	1.490	7.17	7.89	15.06	15.73	13.700																					23.88	15.190
77	3a	2.38	2.62	5.00	4.69	0.229	5.83	6.41	12.24	12.79	4.310																					17.24	4.539
78	3b	3.47	3.82	7.29	7.05	0.646																11.82	11.53	23.35	22.60	5.93						30.64	6.576
79	3b	2.10	2.31	4.41	4.27	0.118																5.33	5.21	10.54	10.20	0.315						14.95	0.433
80	3a	3.50	3.85	7.35	6.89	0.646	4.16	4.58	8.74	9.13	1.490																					16.09	2.136
81	4b	2.69	2.96	5.65	5.65	0.229	3.98	4.38	8.36	8.36	1.000											8.30	6.53	14.83	14.83	0.889						28.83	2.118
82	3a	1.95	2.15	4.10	3.84	0.118	1.95	2.15	4.10	4.28	0.118																					8.19	0.236
83	3a	1.79	1.97	3.76	3.53	0.051	4.09	4.67	8.76	9.15	1.490																					12.52	1.541
84	3a	2.97	3.12	6.09	5.71	0.399	3.91	4.17	8.08	8.44	1.000																					14.17	1.399
85	3a	2.90	2.73	5.63	5.28	0.229	6.46	7.20	13.66	14.27	7.900																					19.29	8.129
86	3a	2.65	2.88	5.53	5.19	0.229	6.90	8.20	15.10	15.78	13.700																					20.63	13.929
87	4b	3.09	3.40	6.49	6.49	0.399	4.31	4.74	9.05	9.05	1.470											8.65	8.09	16.74	16.74	1.380						32.28	3.249
88	3b	3.40	3.74	7.14	6.91	0.646																10.19	10.90	21.08	20.41	3.580						28.22	4.226
89	3a	2.50	2.75	5.25	4.92	0.229	5.67	6.24	11.91	12.44	4.310																					17.16	4.539
90	3b	2.31	2.15	4.46	4.32	0.118																8.39	7.85	16.24	15.72	1.380						20.70	1.498
91	3a	1.28	1.49	2.77	2.60	0.017	2.67	2.95	5.62	5.87	0.229																					8.39	0.246
92	3a	0.87	0.78	1.65	1.55	0.004	0.78	0.93	1.71	1.79	0.004																					3.36	0.008
93	3a	1.75	1.96	3.71	3.48	0.051	1.48	2.84	4.32	4.51	0.118																					8.03	0.169
94	3b	2.13	2.54	4.67	4.52	0.118																11.00	10.92	21.92	21.22	4.250						26.59	4.368
95	3a	1.83	1.69	3.52	3.30	0.051	4.74	3.84	8.58	8.97	1.000																					12.10	1.051
96	3a	1.63	1.87	3.50	3.28	0.051	4.32	4.36	8.68	9.07	1.490																					12.18	1.541
97	3a	1.12	1.10	2.22	2.08	0.004	1.24	1.46	2.70	2.82	0.017																					4.92	0.021

Grand Total *352.391*

I. Original Result:

Total number of Samples: 97 vehicles	
Grand Total of ALEF:	**352.391**
Average of ALEF:	**3.633**

II. Result after adjusment through the comparision of Fixed Scale with Portable Scale: (see next page)

Total number of Samples: 97 vehicles	
Grand Total of ALEF:	**372.168**
Average of ALEF:	**3.837**

Adjusment Ratio:

Single Axles Trucks	
Front Axle:	0.938
Rear Axle:	1.045

Single Tandem Trucks	
Front Axle:	0.968
Tandem:	0.968

Double Tandem Trucks	
Front Axle:	1.258
Tandem1:	0.984
Tandem2:	0.945

Note: No adjusment for other type of vehicles.

III. Result after discarding Sample No. 68:

Total number of Samples: 96 vehicles	
Grand Total of ALEF:	**281.548**
Average of ALEF:	**2.933**

No.68 Total Weigth: 71.59t and Total ALEF: 90.602

IV. Result after discard 6 more samples:

Total number of Samples: 90 vehicles	
Grand Total of ALEF:	**169.610**
Average of ALEF:	**1.885**

Discard :

No. 13	Total Weigth: 25.91t	and	Total ALEF: 36.246
No. 22	Total Weigth: 35.23t	and	Total ALEF: 14.899
No. 75	Total Weigth: 23.45t	and	Total ALEF: 18.346
No. 76	Total Weigth: 24.01t	and	Total ALEF: 14.700
No. 81	Total Weigth: 20.97t	and	Total ALEF: 13.929
No .85	Total Weigth: 20.04t	and	Total ALEF: 13.818

Total 111.938

Table 5 Axle Load Equivalency Factors for Flexible Pavements, Single Axles and pt of 2.5

Axle Load	Pavement Structural Number (SN)					
(Kips)	1	2	3	4	5	6
2	0.0004	0.0004	0.0003	0.0002	0.0002	0.0002
4	0.003	0.004	0.004	0.003	0.002	0.002
6	0.011	0.017	0.017	0.013	0.010	0.009
8	0.032	0.047	0.051	0.041	0.034	0.031
10	0.078	0.102	0.118	0.102	0.088	0.080
12	0.168	0.198	0.229	0.213	0.189	0.176
14	0.328	0.358	0.399	0.388	0.360	0.342
16	0.591	0.613	0.646	0.645	0.623	0.606
18	1.00	1.00	1.00	1.00	1.00	1.00
20	1.61	1.57	1.49	1.47	1.51	1.55
22	2.48	2.38	2.17	2.09	2.18	2.30
24	3.69	3.49	3.09	2.89	3.03	3.27
26	5.33	4.99	4.31	3.91	4.09	4.48
28	7.49	6.98	5.90	5.21	5.39	5.98
30	10.3	9.5	7.9	6.8	7.0	7.8
32	13.9	12.8	10.5	8.8	8.9	10.0
34	18.4	16.9	13.7	11.3	11.2	12.5
36	24.0	22.0	17.7	14.4	13.9	15.5
38	30.9	28.3	22.6	18.1	17.2	19.0
40	39.3	35.9	28.5	22.5	21.1	23.0
42	49.3	45.0	35.6	27.8	25.6	27.7
44	61.3	55.9	44.0	34.0	31.0	33.1
46	75.5	68.8	54.0	41.4	37.2	39.3
48	92.2	83.9	65.7	50.1	44.5	46.5
50	112.0	102.0	79.0	60.0	53.0	55.0

Table 6 Axle Load Equivalency Factors for Flexible Pavements, Tandem Axles and pt of 2.5

Axle Load	Pavement Structural Number (SN)					
(Kips)	1	2	3	4	5	6
2	0.0001	0.0001	0.0001	0.0000	0.0000	0.0000
4	0.0005	0.0005	0.0004	0.0003	0.0003	0.0002
6	0.002	0.002	0.002	0.001	0.001	0.001
8	0.004	0.006	0.005	0.004	0.003	0.003
10	0.008	0.013	0.011	0.009	0.007	0.006
12	0.015	0.024	0.023	0.018	0.014	0.013
14	0.026	0.041	0.042	0.033	0.027	0.024
16	0.044	0.065	0.070	0.057	0.047	0.043
18	0.070	0.097	0.109	0.092	0.077	0.070
20	0.107	0.141	0.162	0.141	0.121	0.110
22	0.160	0.198	0.229	0.207	0.180	0.166
24	0.231	0.273	0.315	0.292	0.260	0.242
26	0.327	0.370	0.420	0.401	0.364	0.342
28	0.451	0.493	0.548	0.534	0.495	0.470
30	0.611	0.648	0.703	0.695	0.658	0.633
32	0.813	0.843	0.889	0.887	0.857	0.834
34	1.06	1.08	1.11	1.11	1.09	1.08
36	1.38	1.38	1.38	1.38	1.38	1.38
38	1.75	1.73	1.69	1.68	1.70	1.73
40	2.21	2.16	2.06	2.03	2.08	2.14
42	2.76	2.67	2.49	2.43	2.51	2.61
44	3.41	3.27	2.99	2.88	3.00	3.16
46	4.18	3.98	3.58	3.40	3.55	3.79
48	5.08	4.80	4.25	3.98	4.17	4.49
50	6.12	5.76	5.03	4.64	4.86	5.28
52	7.33	6.87	5.93	5.38	5.63	6.17
54	8.72	8.14	6.95	6.22	6.47	7.15
56	10.3	9.6	8.1	7.2	7.4	8.2
58	12.1	11.3	9.4	8.2	8.4	9.4
60	14.2	13.1	10.9	9.4	9.6	10.7
62	16.5	15.3	12.6	10.7	10.8	12.1
64	19.1	17.6	14.5	12.2	12.2	13.7
66	22.1	20.3	16.6	13.8	13.7	15.4
68	25.3	23.3	18.9	15.6	15.4	17.2
70	29.0	26.6	21.5	17.6	17.2	19.2
72	33.0	30.3	24.4	19.8	19.2	21.3
74	37.5	34.4	27.6	22.2	21.3	23.6
76	42.5	38.9	31.1	24.8	23.7	26.1
78	48.0	43.9	35.0	27.8	26.2	28.8
80	54.0	49.4	39.2	30.9	29.0	31.7
82	60.6	55.4	43.9	34.4	32.0	34.8
84	67.8	61.9	49.0	38.2	35.3	38.1
86	75.7	69.1	54.5	42.3	38.8	41.7
88	84.3	76.9	60.6	46.8	42.6	45.6
90	93.7	85.4	67.1	51.7	46.8	49.7

3. Estimation of Axle Load Equivalency Factors (ALEF)

ALEF of each vehicle was estimated using the tables shown in "AASHTO Guide for Design of Pavement Structure, 1993" (AASHTO Pavement Design Guide), which are shown in the following pages. Structure Number (SN) of 3 and Terminal Serviceability Level (p_t) of 2.5 were assumed in applying the method of AASHTO Pavement Design Guide (Tables 5 and 6).

The result of estimation is shown in Table 4. The Average of ALEF is 3.84 which is considered to be very large as an average ALEF. It should be noted that there are a few vehicles with exceptionally large ALEF values. For example, ALEF of the vehicle with Sample No. 68 exceeds 90. If this exceptional case is discarded, the average ALEF becomes 2.933. Further, there are 6 vehicle with ALEF larger than 13 (Figure 4). ALEF value next to these seven samples is 11.018 of Sample No. 50. If these data of seven extreme cases are discarded, the **average ALEF is estimated at 1.885**.

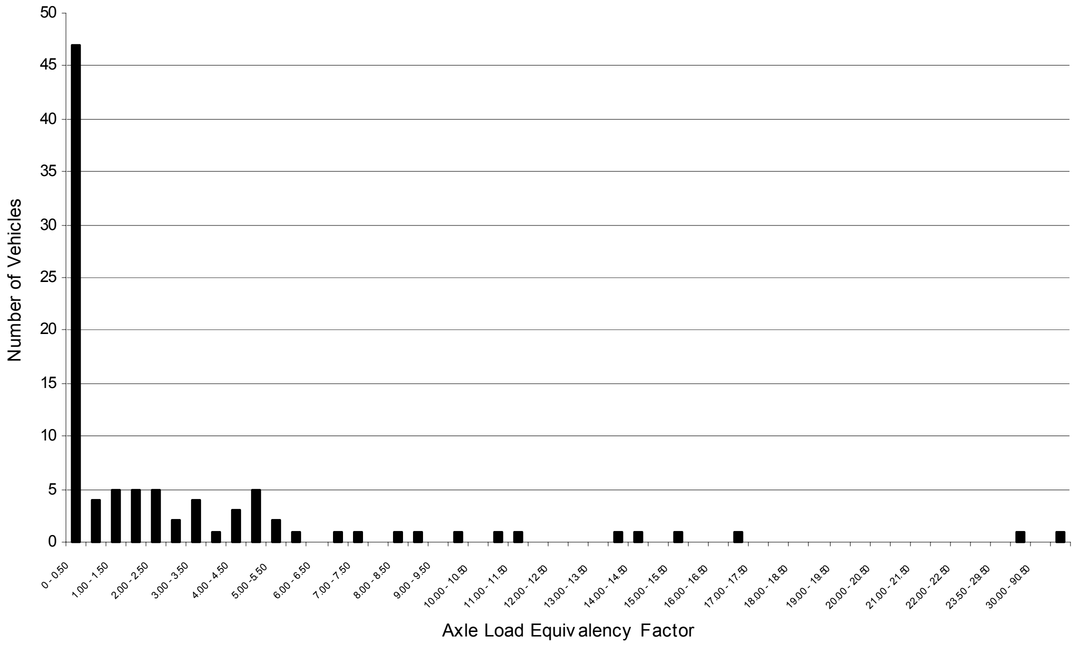


Figure 4 Histogram of Measured Axle Load Equivalency Factor

As a comparison, ALEF data measured in the Design of NR-1 by ADB are shown below:

Table 7 ALEF Measured in the Design of NR-1 by ADB

Vehicle Type	Weighted Average ALEF (Both Direction)	Average ALEF (From Phnom Penh) (Two Day Average)	Average ALEF (To Phnom Penh) (One Day Average)
Large Bus	1.0	1.0	1.0
Medium Truck (2 Axles)	0.7	0.8	0.4
Large Truck (3 axles)	3.5	5.1	2.8
Articulated Truck	5.8	5.8	ND*

*ND: No data

The average ALEF over entire heavy vehicles cannot be calculated because there is no information given on the composition of vehicle types for entire heavy vehicles. If the following composition can be arbitrarily assumed, based on the composition as surveyed in this Study, as the following, the average ALEF is estimated as shown below:

Assumed composition

Bus: 1 % Medium Track: 55 % Large Truck: 39 % Articulated Truck: 5 %

Average ALEF

$ALEF_{AVE}$ = 1 x 0.01 + 0.7 x 0.55 + 3.5 x 0.39 + 5.8 x 0.05 = 1.754

This figure seems to be in a similar range with the data obtained by the vehicle weight survey of this Study.

As stated before, the Royal Government of Cambodia recognizes the adverse effect of overloaded trucks on pavement, and implementing the corrective actions against them. Therefore, it is expected that the number of extremely overloaded trucks will be decreased in the future. Considering this, ALEF = 1.89 is used in this Study.

4. Estimation of ALEF of Light Vehicles

ALEF of light vehicles were estimated with the following procedures.

4.1 Estimation of ALEF of Light Trucks.

Axle loads of five trucks were measured in the vehicle weight survey, as shown in the Table 6. Average ALEF per vehicle was estimated at 0.02166.

Average ALEF of passenger cars was estimated by assuming the gross weight of typical passenger car such as Toyota Camry as shown below.

Vehicle weight: 1.4 t

Passenger: 0.06 x 5 = 0.3 t

Gross weight: 1.7 t

Axle load: $1.7 \times \frac{1}{2} = 0.85$ t

ALEF: $\left(\frac{0.85}{8.165}\right)^4 = 0.000171$

The result of the traffic count indicated that composition of light vehicles was as follows.

Passenger car: 84 %

Light Truck: 16 %

Thus, the average ALEF of entire light vehicles were calculated as shown below.

$$ALEF_{LV} = \frac{0.000171 \times 84 + 0.02166 \times 16}{100} = 0.0036$$

Table 8 Measured Axle Load of Light Vehicles and ALEF

No.	Vehicle Type	Axle 1				Axle 2				Total ALEF	Total Veh. Weight
		L (t)	R (t)	Total	ALEF1	L (t)	R (t)	Total	ALEF2		
1	2a	0.93	1.02	1.95	0.004	1.50	1.65	3.15	0.051	0.055	5.10
2	2a	1.55	1.71	3.26	0.017	1.78	1.96	3.74	0.051	0.068	6.99
3	2a	0.98	1.08	2.06	0.004	1.56	2.21	3.77	0.051	0.055	5.83
4	2a	1.03	1.16	2.19	0.004	2.54	3.26	5.80	0.229	0.233	7.99
5	2a	0.53	0.54	1.07	0.000	0.40	0.46	0.86	0.000	0.001	1.93

Total 0.4116

ALEF per Veh.=(0.4116)/5= 0.02166

Table 4-9 Summary of Pavement Structure

Section		1	2	3	4	5
Station		Start – 3.5	3.5 - 7	7 - 14	14 - 36	36 - End
Pk (MPWT)		5.6 – 9.1	9.1 – 12.6	12.6 – 19.6	19.6 – 41.6	41.6 - End
Pavement Type		A	B	C	D	E
Surface	Thick. (cm)	10	10	10	5	5
	SN	1.654	1.654	1.654	0.827	0.827
Base	Thick. (cm)	15	15	15	25	20
	SN	0.620	0.620	0.620	1.033	0.827
Subbase	Thick. (cm)	30	27	24	29	32
	SN	1.087	0.978	0.869	1.050	1.159
Total SN		3.360	3.252	3.143	2.911	2.813
Total Thickness (cm)		55	52	49	59	57
Required SN		3.345	3.231	3.111	2.906	2.815

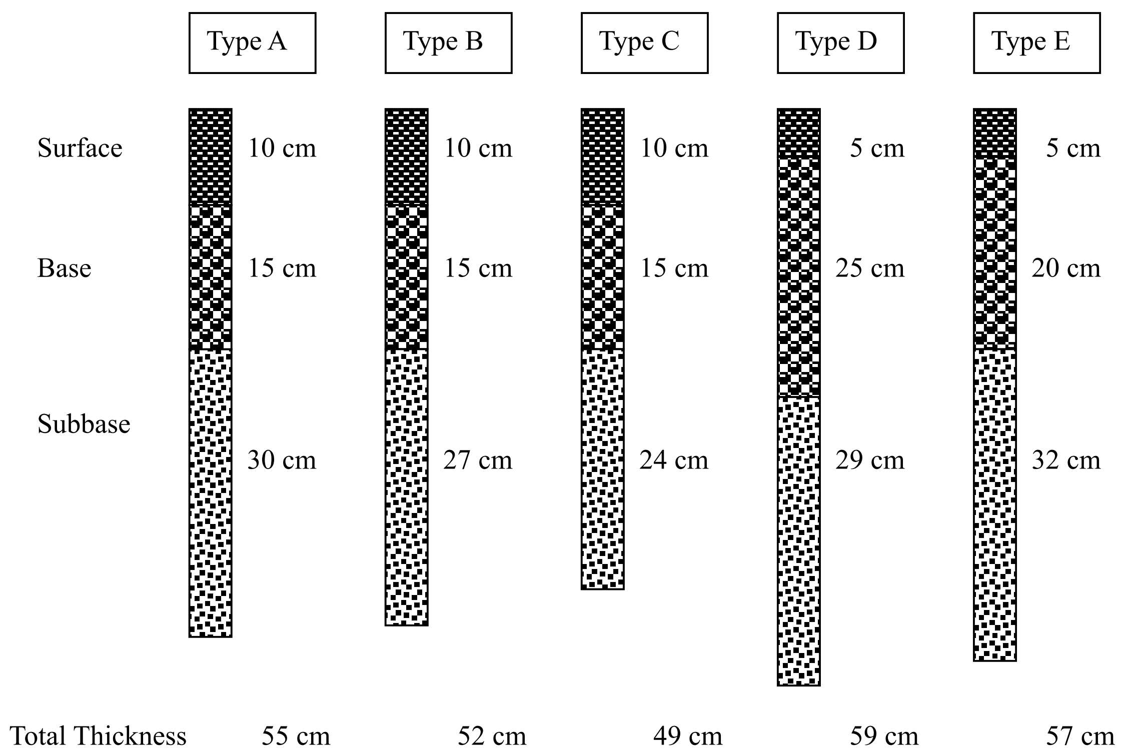


Figure 4-1 Pavement Structure

4.2.3 Comparison of Costs for Various Design Life Periods

Although design life period of pavement is set at 10 years in usual practice, life cycle cost (LCC) of design life of 5, 10 and 15 years are compared to verify the justification of design life period. Table 4-10 shows the design factors and price indices of pavement of Section 1 and 5 for design life of 5, 10 and 15 years.

Section		1			5		
Design Life (Year)		5	10	15	5	10	15
Total ESAL		3.07	6.56	10.89	1.03	2.22	3.72
Required SN		2.965	3.345	3.621	2.487	2.815	3.057
Surface	Thck. (cm)	10	10	10	5	5	5
	SN	1.654	1.654	1.654	0.827	0.827	0.827
Base	Thck. (cm)	15	15	20	15	20	25
	SN	0.620	0.620	0.827	0.620	0.827	1.033
Subbase	Thck. (cm)	19	30	32	29	32	33
	SN	0.688	1.087	1.159	1.050	1.159	1.195
Total SN		2.962	3.360	3.639	2.497	2.813	3.056
Total Thickness (cm)		44	55	62	49	57	63
Actual Design Life (Year) Price Index as Surface (T = 5 cm) = 1.000							
Surface		2.067	2.067	2.067	1.000	1.000	1.000
Base		0.544	0.544	0.544	0.544	0.766	0.926
Subbase		0.607	0.984	1.012	0.927	1.041	1.070
Total		3.218	3.595	3.845	2.471	2.807	2.996

Tables 4-11 and 4-12 show the comparison of LCC for these pavement designs.

Table 4-11 Comparison of Life Cycle Cost for Section 1

Section		1					
Design Life (Year)		5		10		15	
Year	Discount Rate	Cost					
		Nominal	Disc'td	Nominal	Disc'td	Nominal	Disc'td
0	1.00000	3.2180	3.2180	3.5950	3.5950	3.8450	3.8450
1	0.89286	0.0322	0.0287	0.0322	0.0287	0.0322	0.0287
2	0.79719	0.0322	0.0257	0.0322	0.0257	0.0322	0.0257
3	0.71178	0.0322	0.0229	0.0322	0.0229	0.0322	0.0229
4	0.63552	0.0322	0.0205	0.0322	0.0205	0.0322	0.0205
5	0.56743	0.0322	0.0183	0.0322	0.0183	0.0322	0.0183
6	0.50663	1.0000	0.5066	0.0322	0.0163	0.0322	0.0163
7	0.45235	0.0322	0.0146	0.0322	0.0146	0.0322	0.0146
8	0.40388	0.0322	0.0130	0.0322	0.0130	0.0322	0.0130
9	0.36061	0.0322	0.0116	0.0322	0.0116	0.0322	0.0116
10	0.32197	0.0322	0.0104	0.0322	0.0104	0.0322	0.0104
11	0.28748	1.0000	0.2875	1.0000	0.2875	0.0322	0.0093
12	0.25668	0.0322	0.0083	0.0322	0.0083	0.0322	0.0083
13	0.22917	0.0322	0.0074	0.0322	0.0074	0.0322	0.0074
14	0.20462	0.0322	0.0066	0.0322	0.0066	0.0322	0.0066
15	0.18270	0.0322	0.0059	0.0322	0.0059	0.0322	0.0059
16	0.16312	0.0322	0.0052	0.0322	0.0052	1.0000	0.1631
17	0.14564	1.0000	0.1456	0.0322	0.0047	0.0322	0.0047
18	0.13004	0.0322	0.0042	0.0322	0.0042	0.0322	0.0042
19	0.11611	0.0322	0.0037	0.0322	0.0037	0.0322	0.0037
20	0.10367	0.0322	0.0033	0.0322	0.0033	0.0322	0.0033
21	0.09256	0.0322	0.0030	0.0322	0.0030	0.0322	0.0030
22	0.08264	1.0000	0.0826	1.0000	0.0826	0.0322	0.0027
23	0.07379	0.0322	0.0024	0.0322	0.0024	0.0322	0.0024
24	0.06588	0.0322	0.0021	0.0322	0.0021	0.0322	0.0021
25	0.05882	0.0322	0.0019	0.0322	0.0019	0.0322	0.0019
Salvage value	0.05882	0.9804	0.0577	0.7000	0.0412	0.4000	0.0235
Total		6.8812	4.4022	5.6030	4.1644	5.1851	4.2317

Cost of overlay = Surface (5 cm) = 1.000

Cost of Maintenance = 1 %of Cost of New Construction

Table 4-12 Comparison of Life Cycle Cost for Section 5

Section		5					
Design Life (Year)		5		10		15	
	Discount	Cost					
Year	Rate	Nominal	Disc'td	Nominal	Disc'td	Nominal	Disc'td
0	1.00000	2.5850	2.5850	2.8070	2.8070	2.9100	2.9100
1	0.89286	0.0259	0.0231	0.0259	0.0231	0.0259	0.0231
2	0.79719	0.0259	0.0206	0.0259	0.0206	0.0259	0.0206
3	0.71178	0.0259	0.0184	0.0259	0.0184	0.0259	0.0184
4	0.63552	0.0259	0.0164	0.0259	0.0164	0.0259	0.0164
5	0.56743	0.0259	0.0147	0.0259	0.0147	0.0259	0.0147
6	0.50663	1.0000	0.5066	0.0259	0.0131	0.0259	0.0131
7	0.45235	0.0259	0.0117	0.0259	0.0117	0.0259	0.0117
8	0.40388	0.0259	0.0104	0.0259	0.0104	0.0259	0.0104
9	0.36061	0.0259	0.0093	0.0259	0.0093	0.0259	0.0093
10	0.32197	0.0259	0.0083	0.0259	0.0083	0.0259	0.0083
11	0.28748	1.0000	0.2875	1.0000	0.2875	0.0259	0.0074
12	0.25668	0.0259	0.0066	0.0259	0.0066	0.0259	0.0066
13	0.22917	0.0259	0.0059	0.0259	0.0059	0.0259	0.0059
14	0.20462	0.0259	0.0053	0.0259	0.0053	0.0259	0.0053
15	0.18270	0.0259	0.0047	0.0259	0.0047	0.0259	0.0047
16	0.16312	1.0000	0.1631	0.0259	0.0042	1.0000	0.1631
17	0.14564	0.0259	0.0038	0.0259	0.0038	0.0259	0.0038
18	0.13004	0.0259	0.0034	0.0259	0.0034	0.0259	0.0034
19	0.11611	0.0259	0.0030	0.0259	0.0030	0.0259	0.0030
20	0.10367	0.0259	0.0027	0.0259	0.0027	0.0259	0.0027
21	0.09256	1.0000	0.0926	1.0000	0.0926	0.0259	0.0024
22	0.08264	0.0259	0.0021	0.0259	0.0021	0.0259	0.0021
23	0.07379	0.0259	0.0019	0.0259	0.0019	0.0259	0.0019
24	0.06588	0.0259	0.0017	0.0259	0.0017	0.0259	0.0017
25	0.05882	0.0259	0.0015	0.0259	0.0015	0.0259	0.0015
Salvage value	0.05882	0.4000	0.0235	0.6000	0.0353	0.4000	0.0235
Total		7.5279	3.7869	6.0016	3.3447	4.9304	3.2481

Cost of overlay = Surface = 1.000

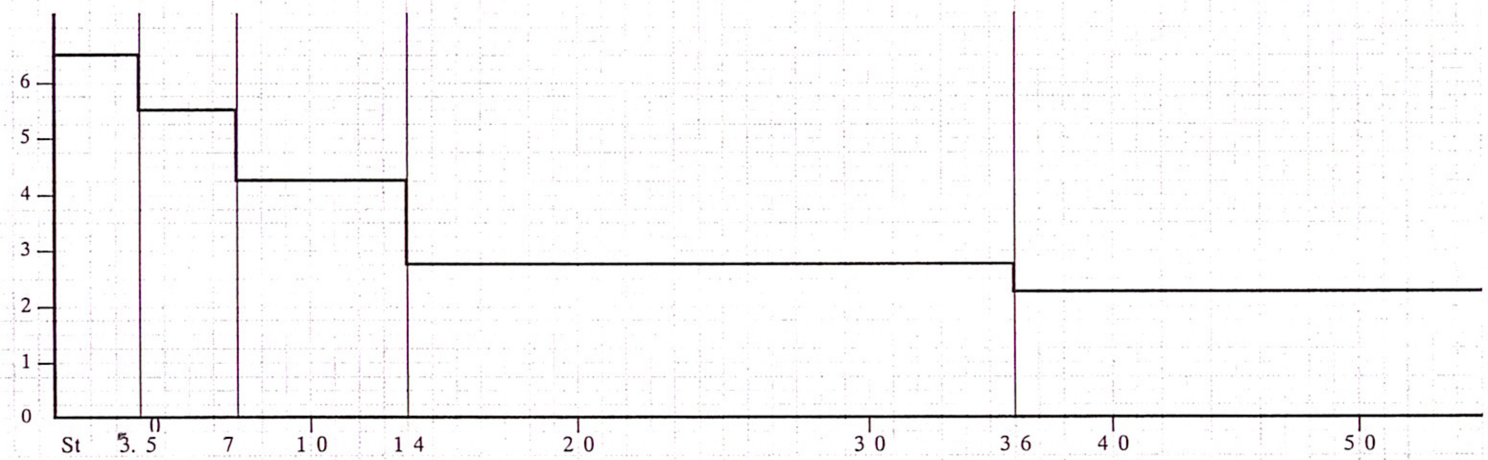
Cost of Maintenance = 1 %of Cost of New Construction

As can be seen in the tables, 10-year life period design is most economical for Section 1, and 15-year design is slightly more economical than 10-year design for Section 5. As stated before, it is usual practice to set the design life period at 10 years. Considering that the difference between the 10-year design and 15-year design foe Section 5 is small and that the 10-year design is a little more economical for Section 1, it is considered to be reasonable to adopt wo years as the design life period of the pavement for the Study Road.

5. Summary

Design traffic volume, ESAL, CBR and pavement type for each section are summarized in Figure 5-1.

	St–3.5	3.5–7	7–14	14–36	36–
Daily Traffic Volume (2005)					
L. V.	11,234	5,530	3,613	2,080	1,722
H. V.	1,197	969	739	482	399
ESAL (mil)	6.56	5.57	4.15	2.71	2.22



	St–3.5	3.5–7	7–14	14–36	36–
Design CBR					
Existing Embankment	CBR = 2				
Improved Subgrade	CBR = 9				
Required SN	3.345	3.231	3.111	2.906	2.815
Pavement Type	A	B	C	D	E
Anticipated SN	3.360	3.252	3.143	2.911	2.838

Figure 5-1 Summary Diagram of Pavement Design